2014 IDEAS² awards

INNOVATIVE DESIGN in ENGINEERING and ARCHITECTURE with STRUCTURAL STEEL

THE DESIGN AND CONSTRUCTION INDUSTRY recognizes the importance of teamwork, coordination and collaboration in fostering successful construction projects today more than ever before. In support of this trend, AISC is proud to present the results of its annual IDEAS² Awards competition. This program is designed to recognize all team members responsible for excellence and innovation in a project's use of structural steel.

Awards for each winning project were presented to the project team members involved in the design and construction of the structural framing system, including the architect, structural engineer of record, general contractor, detailer, fabricator erector and owner. New buildings, as well as renovation, retrofit or expansion projects, were eligible. The projects also had to display, at a minimum, the following characteristics:

- A significant portion of the framing system must be wide-flange or hollow structural steel sections.
- Projects must have been completed between January 1, 2011 and December 31, 2013.
- Projects must be located in North America.
- Previous AISC IDEAS² award-winning projects are not eligible.

The judges considered each project's use of structural steel from both an architectural and structural engineering perspective, with an emphasis on:

- Creative solutions to the project's program requirements
- Applications of innovative design approaches in areas such as connections, gravity systems, lateral load resisting systems, fire protection and blast
- The aesthetic and visual impact of the project, particularly in the coordination of structural steel elements with other materials
- Innovative uses of architecturally exposed structural steel
- Advances in the use of structural steel, either technically or in the architectural expression
- The use of innovative design and construction methods such as 3D building models, interoperability, early integration of specialty contractors such as steel fabricators, alternative methods of project delivery, sustainability considerations and other productivity enhancers

A panel of design and construction industry professionals judged the entries in three categories, according to their constructed value in U.S. dollars:

- Less than $15 million
- $15 million to $75 million
- Greater than $75 million

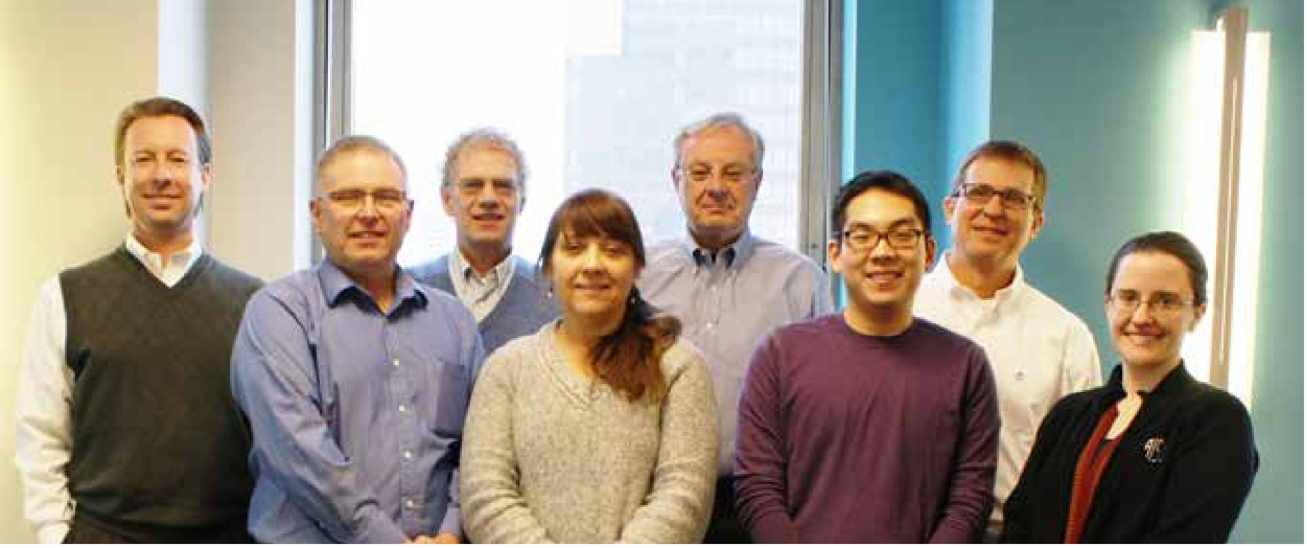
Both national and merit honors were awarded in each category. The jury also selected one project for the Presidential Award of Excellence in recognition of distinguished structural engineering.

2014 IDEAS² AWARDS JURY

- **Lindsay Anderson**, a licensed architect and structural engineer, is the president of Lindsay Anderson Consulting, Ltd., in Park Ridge, Ill. His 40-plus years of practice have encompassed a wide range of services in the design, evaluation and construction of buildings and other structures. He has investigated building enclosure and structure failures and has provided expert witness services in domestic and international disputes. He prepares and presents seminars on building systems and structures to architects and structural engineers and has presented the structural steel portion of the "Structural Engineers Refresher Course" for 26 years. He has also provided consulting services to the Chicago Department of Buildings and Law Department for over 10 years.

- **Steve Anrod** is a senior project manager with Clayco Corporation's Real Estate Group in Chicago and has over 30 years of experience in commercial construction and multi-family real estate development. He has been active in the development of high-rise and mid-rise projects in tight urban environments and has also been successful in finding unique solutions to the physical and political issues that are inherent to urban venues. With his dual background in construction and development, he has lead teams in all project phases, from initial concept through final occupancy.

- **Chad Clinehens**, P.E., is the executive vice president of ZweigWhite in Fayetteville, Ark., and has been working in



The 2014 AISC IDEAS^2 Awards jury, from left: Chad Clinehens, David Sailing, Lindsay Anderson, Diana Erickson Nishi, Philip Tobey, Matthew Kan, Steve Anrod and Erin Criste.

the A/E/P (architecture, engineering and planning) industry since 1995. He has been involved in many aspects of consulting engineering, including everything from engineering design and project management to top leadership. He has spent the past seven years as CMO and CSO for a prominent consulting engineering firm with offices across the central and southern United States, aiding in a successful rebranding and growth campaign that doubled the company's size during the recent recession. He has a Master's Degree in Business Administration as well as a Bachelor of Science in Civil Engineering from the University of Arkansas.

➤ **Erin Criste** is a staff engineer in AISC's education department, where her responsibilities include managing the creation and maintenance of AISC faculty teaching aids, planning and organizing faculty workshops and related activities and developing a sabbatical plan to involve faculty in AISC activities. Erin attended Vanderbilt University for her undergraduate studies and completed her graduate studies at Rice University. After graduation, she worked as a forensic graduate engineer for Nelson Architectural Engineers and also worked at LSC Design, Inc., in York, Pa., before joining AISC in 2008 as a specialist in the Steel Solutions Center.

➤ **Matthew Kan** is a graduate student at Northwestern University, pursuing his MS in structural engineering and infrastructure materials and currently serving as a graduate advisor; he received his BS in civil engineering with a minor in art history from Northwestern. As an undergraduate he was involved with Northwestern's chapter of ASCE, serving as an executive officer for three years. He was also involved with the National Student Steel Bridge Competition and Concrete Canoe teams.

➤ **Diana Erickson Nishi**, S.E., P.E., is vice president of Englekirk in Los Angeles, joining the company in 1988 upon receiving a BS from California Polytechnic State University, San Luis Obispo in architectural engineering and an MS from the University of California, Los Angeles in Civil: Earthquake Engineering. She has been responsible for a diverse range of projects including hotels, regional malls, parking structures, office buildings, mixed-use buildings and institutional facilities. Most notably, she was instrumental in the structural design of the San Jose Civic Center, the Getty Center and Hollywood and Highland. Diana has been active in professional organizations throughout her career and is currently serving as a Board Member for the Structural Engineers Association of Southern California.

➤ **David Sailing** is vice president of operations with Zalk Josephs Fabricators (an AISC member and Certified fabricator) in Stoughton, Wisc., and has been with the company for nearly 40 years. He has served on several AISC committees; he is currently an active member of AISC's Safety Advisory Committee and is also in charge of his company's safety program.

➤ **Philip Tobey**, FAIA, is senior vice president and a national healthcare leader of SmithGroupJJR in Washington, D.C. He has over 45 years of experience in healthcare planning and design for the country's leading academic medical centers and hospital systems, and was recently appointed to the U.S. Defense Health Board. He is the recipient of the 2012 national Urbahn Medal for "eminent and notable contributions in the field of architecture" from the Society of American Military Engineers. Widely recognized and highly regarded as one of the profession's leaders in healthcare architecture, Phil has addressed many national and regional organizations concerning issues and trends that affect healthcare. Prior to entering private practice, Phil served as an officer with the U.S. Air Force's Office of the Surgeon General with review responsibility for medical projects worldwide; for almost a year, he was on special assignments to the White House. A registered architect and interior designer, Phil received his Bachelor of Architecture degree from the Rhode Island School of Design and his Master of Architecture degree from Harvard University.

National Award—Greater than $75 Million

NEWPORT BEACH CIVIC CENTER AND PARK, NEWPORT BEACH, CALIF.

For a city like Newport Beach, Calif., it just makes sense to bring the form of an ocean wave into a new civic building.

The new Newport Beach Civic Center and Park incorporates an iconic wave-shaped roof that covers the city hall portion of the building and provides ample outdoor shelter. Created by bending W10 sections in double curvature with multiple radii, each wave roof perches over a Vierendeel truss crafted from W10s that allows for operable, north-facing clerestory windows and a place to nestle dimmable lighting. Penetrations in the webs of wide-flanges were used for conduit and fire sprinklers. The flexibility and control over the lighting and mechanical systems, made possible by the carefully coordinated structural steel design, is expected to save the LEED Gold city hall building an anticipated $85,000 a year on operating costs.

The City of Newport Beach offices are on display alongside perimeter public corridors stretching the entire length of the building, as well as the vertical circulation cores. To complement this open expression, the majority of the steel structure is proudly on display to exhibit its purpose and function. The aesthetic desire for slender vertical supports around the perimeter of the building is achieved with tapered-end round hollow structural sections (HSS) and a simple pin connection at the base built up from steel plates.

The buckling restrained brace (BRB) frames were made to fit the structurally required core area within the architecturally desired round HSS casing size. Exposed BRBs with pin connections are prominently displayed at the entrance to the Community Room, in all of the repeated cores and in private offices. The steel skeleton forms a sculpture that demonstrates to occupants how both gravity and lateral earthquake forces flow from the roof down to the foundations.

To prevent obstruction of sightlines to the Pacific Ocean, the already-sloping site was carved away so that the two-story structure steps down 18 in. at every bay. This led to a stepped diaphragm at the second floor, which, coupled with the discontinuous wave roof diaphragms, provided the challenge of delivering diaphragm forces to the BRBs located in the cores. Diaphragm forces from each wave roof segment are collected through pin-ended round HSS collectors that double as chords. The gusset plates of these pinned collectors were highlighted by the architect by elongating the plate further into the core areas. At the steps in the second floor where the public edge of the core has very few horizontal connection points, the pedestrian bridge ramps, designed with wide-flange girders, were used as sloped funnels for diaphragm forces. The scissor stair in each core was carefully detailed with a ground floor sliding base plate to allow for the 2 in. of inter-story drift.

The 60-ft span pair of tensioned cable trusses allows for a column-free, 150-seat space in the council chambers during city council meetings. The unobtrusive trusses are constructed with a thin-tensioned-rod bottom chord, cruciform struts made from steel plate and a built-up plate and back-to-back MC section top chord. The wall behind the dais bench is the formwork for an iconic sail. The curved-in-plan sail support wall is assembled out of vertically canted rectangular HSS sections and square HSS special concentric braced frames.

The existing public library was expanded to create an area for children and private reading spaces in the 17,000-sq.-ft, two-story, wide-flange steel moment frame addition. A café and credit union will serve the community in the new main entrance that opens up to the new Civic Green. The tapered steel plate girders of the roof cantilever more than 50 ft in two directions over a single exposed steel built-up column prominently displayed at the entry doors, forming a dramatic entry canopy that thins down to a 6-in. architectural fascia.

Scattered through the 14 acres of restored wetland park are three simple-profile steel pedestrian bridges and a steel girder bridge that connects two parcels of park land that are separated by a main thoroughfare. The sightline-friendly, low-profile San Miguel Bridge was designed with two major wide-flange girders that span 150 ft from the abutment anchored on the north end to the elevator tower on the south parcel. The main girders fly over the top of a pair of wide-flange cantilever beams embedded in the concrete shear wall elevator tower and cantilever out to form a 52-ft observation platform that has striking views of Catalina Island.

Owner
City of Newport Beach, Newport Beach, Calif.

Architect
Bohlin Cywinski Jackson, San Francisco

Structural Engineer
Arup, San Francisco

General Contractor
C.W. Driver, Irvine, Calif.

"What a **wonderful vibe** created by the curved roofs and light structure. Makes me want to go sailing!"
—Steve Anrod

Steel Team

Fabricators
SME Steel Contractors, Inc., West Jordan, Utah (AISC Member/AISC Certified Fabricator/ Advanced Certified Steel Erector)
Southwest Steel, Henderson, Nev. (AISC Member/AISC Certified Fabricator)

Erector
SME Steel Contractors, Inc.

Bender/Roller
Albina Pipe Bending Company, Inc., Tualatin, Ore. (AISC Member)

Photographs
David Wakely Photography, Nic LeHoux Photographie Architecturale and Yvonne Riggie-BCJ

Merit Award—Greater than $75 Million

KRISHNA P. SINGH CENTER FOR NANOTECHNOLOGY, PHILADELPHIA

Poised at the western edge of Philadelphia and the eastern edge of the University of Pennsylvania campus, the newly opened Krishna P. Singh Center for Nanotechnology demonstrates the university's leadership in the emerging field of nanotechnology; nano-scale research is at the core of cutting-edge breakthroughs that transcend the boundaries of engineering, medicine and the sciences. At the physical and ideological convergence point of these disciplines, the new $92 million center contains a rigorous collection of advanced lab spaces woven together by collaborative public spaces that enable interaction between different fields. The university's first cross-disciplinary building, the new nanotech research facility encourages the exchange and integration of knowledge that characterizes the study of this emerging field.

Defined by a new 1.7-acre central campus green, the 78,000-sq.-ft facility ascends as a spiral of research, reaching its highest elevation at the forum, a cantilevered meeting space over the quad. The building contains state-of-the-art lab spaces, distributed over three floors, including a 10,000-sq.-ft clean room lab chase for nano-fabrication, a 6,500-sq.-ft characterization suite and a 12,000-sq.-ft laboratory program. Connecting all four levels, the light-filled 54-ft-tall galleria includes collaborative lounge spaces and conference rooms that complement the research conducted within the labs.

"The project takes what could have been a pedestrian building and celebrates science with the **dramatic use of color and form.**"

—Phil Tobey

The center's most dramatic and complex structural design feature is the forum, a 4,000-sq.-ft assembly space that cantilevers 68 ft over the courtyard and includes multi-purpose functions such as lectures, receptions and meetings. Strength and vibration were core design parameters, and the vibration of the floor under dynamic human loading is the controlling criteria of the structure. The vibration of the floor beams and the overall rhythmic vibration of the room are controlled by the stiffness of the steel trusses and lateral restraint of the braced frame. The cantilever is constructed of two inverted trusses with hang columns to capture the horizontal floor diaphragm.

The south-facing curtain wall façade of the center's galleria has a sloping roof that slices through the curtain wall plane stepping it in two directions. A horizontal truss diaphragm is employed at the sloping roof plane to resist the horizontal wind loads on the curtain wall. The north side of the horizontal truss is supported by steel columns on the foundation wall. The south side of the horizontal truss is more structurally dynamic and is supported by cantilevered beams with hanging columns that suspend the north edge of the truss from above. The hangers and columns are all architecturally exposed structural steel (AESS). In order to match the construction tolerances of the AESS, slip connections are provided where the hangers meet the upper roof steel. The lower roof between the hangers and the columns is constructed with AESS tolerances.

The monumental stair is unusual because it is a 55-ft-long free-span stair stringer supported by a 24-in.-deep, 20-ft cantilever. Though deflection and strength were considerations, similar to the forum, vibration parameters controlled the design. Five 24-in.-deep steel wide-flange members frame the 10-ft wide stair.

The laboratories require very strict vibration tolerances for maximum equipment performance. The lower level transmission electron microscope (TEM) rooms require a completely isolated six-sided box construction. The clean room bay and chase have 52-ft free-span beams that create a column-free space for maximum flexibility, and the general labs contain 34-ft free-span beams to allow for a column-free space. This design resulted in an actual vibration criterion that exceeded the anticipated design criteria.

Owner
University of Pennsylvania, Philadelphia

Architect
WEISS/MANFREDI, New York

Structural Engineer
Severud Associates, New York

General Contractor
Gilbane, Inc., Philadelphia

Steel Team

Fabricator
Lynchburg Steel & Specialty Company, Monroe, Va. (AISC Member/AISC Certified Fabricator)

Erector
Steel Suppliers Erectors, Inc., Wilmington, Del. (AISC Member/Advanced Certified Steel Erector)

Detailer
Delta Structural Steel Services, Idaho Falls, Idaho (AISC Member)

Photographs
Albert Večerka - Esto

“This unique structure couples challenging engineering with an architecturally **complex scheme** to provide a truly fascinating building.”
—Erin Criste

Merit Award—Greater than $75 Million

U.S. COURTHOUSE, SAN DIEGO

The $300 million, 463,700-sq.-ft U.S. Courthouse in San Diego adds 14 courtrooms, chambers and general office and support space as a freestanding tower adjacent to the existing Schwartz U.S. Courthouse. Located at the western edge of a growing downtown San Diego, the project integrates the new and existing buildings with gardens, plazas, a water feature and pedestrian paths that support downtown urban design goals. To balance program requirements and civic amenities, the 100,000-sq.-ft site creatively uses below-grade support and service areas, while the courthouse's plaza-level footprint is a modest 20,000 sq. ft. This planning strategy allows the heart of the site to be developed as a significant new public plaza, serving as an active center of the federal building complex and an important new civic space.

The architectural massing of the new courthouse combines a slender 16-story tower that rises above a transparent and translucent building base. The tower is clad in wafer-like layers of terra cotta and glass composed in response to the program and orientation. The ultrathin massing supports sustainable design strategies to daylight the entire building. Adjacent to the lobby is a large jury assembly space, which opens to an outdoor jury assembly terrace with views to the plaza and gardens.

In juxtaposition to the rectilinear tower, the building lobby is an iconic elliptical volume carefully positioned to be visible from all approaches to the site. The lobby's form serves to receive and redirect staff and visitors to the multiple courthouse destinations and is filled with filtered daylight from a south-facing two-story glass curtain wall. The lobby expresses its San Diego roots by paying homage to the locally beloved 1915 Balboa Park Botanical Building. Curved HSS and exposed steel framing in this new structure mirror the lath-house design employed in the original.

At the tower floors, public circulation is oriented along the glazed east elevation offering exceptional views to the plaza, city and south bay. The two-courts-per-floor design eliminates traditional internal corridors and gives human scale to the procession from entry to courtroom. This activity is visible from the public plaza and, through the building façade, expresses a dynamic and accessible judicial process.

The palette of materials and "color" are inspired by the city itself. The warm off-whites, which turn golden at sunset, help set the Mediterranean stage that makes San Diego unique. To achieve this color, façade materials include painted structural steel, natural stone, terra cotta and concrete. Architecturally exposed structural steel is expressed prominently in the architecture, including the lobby curtain wall and screen, as well as in site amenities such as the trellis along the main entrance ramp. Weathering steel plate edging the accessible path between the plaza and entrance lobby boldly complements the subdued colors of the building.

High seismicity, a narrow plan that contrasted with a significant overall height, requisite column-free jury assembly areas at Level 1 and blast and progressive collapse requirements all posed the primary structural challenges. These were met by working creatively with the design and construction team to develop a functional structural geometry that was validated using a performance-based design methodology to achieve a cost-effective seismic solution.

Concrete-filled metal deck supported by steel wide-flange beams and columns resist gravity loads. Open space requirements at the public level call for a relatively small number of columns and result in typical spans on the order of 45 ft. Quiet seating in the courtrooms demands stringent floor vibration criteria, which were satisfied by carefully analyzing selected applications of framing continuity in concert with progressive collapse requirements.

Security considerations required that no essential part of the building's resistance to catastrophic blast loads encroach beyond the blast setback zone, yet urban design goals pushed to bring the north and west building lines as close as possible to the property edge to maintain alignment with adjacent buildings. Double cantilevered girders at the northwest corner, for example, allow the building to project beyond the blast setback while protecting the lower portions of the building. An eccentrically braced frame (EBF) provides seismic stability and offsets drift problems created by courtroom floor-to-floor heights in excess of 22 ft that made moment frames impractical.

At 320 ft in height, the building exceeds the 240-ft maximum for an EBF. Although some dual systems using concrete and steel do not have building code height limitations, the construction manager advised that mixing major subcontracting trades would result in cost premiums. In addition, trial designs of various dual systems suggested that moment frames would not participate cost-effectively in the overall lateral system due to their flexibility relative to other stiff elements in the dual system. The owner approved performance-based design criteria developed by the structural engineer, which demonstrated that a steel EBF was an effective seismic system, saving several million dollars.

The project benefited from early retention of the CM-at-risk, which is not always possible on publicly funded projects, and the team reduced overall construction time by carefully coordinating building systems within the tight envelope demanded by the high-ceilinged spaces, as well as with continuous on-site coordination of shop drawings. This up-front work paid significant dividends because the project was completed a month ahead of the completion date established before construction began.

Cost efficiency demanded different foundation systems under the tower and other subterranean areas, which can lead to unacceptable differential settlements. Introducing a joint around the tower to minimize adverse consequences would have reduced construction productivity as well as become an ongoing maintenance problem. Using a detailed project schedule developed by the CM-at-risk, the structural engineer developed multi-stage structural models to investigate and discount differential settlement concerns, thereby eliminating the need for a plaza-level joint. (For more on this project, see the June 2013 issue).

Owner
U.S. General Services Administration, Region 9, San Francisco

Architect
Richard Meier & Partners Architects LLP, Los Angeles

Structural Engineer
Englekirk, Los Angeles

General Contractor
Hensel Phelps Construction Co., Irvine, Calif.

Steel Team

Fabricator and Erector
SME Steel Contractors, Inc., West Jordan, Utah (AISC Member/AISC Certified Fabricator/Advanced Certified Steel Erector)

Detailer
Prodraft, Inc., Chesapeake, Va. (AISC Member)

Photographs
Sibylle Allgaier, ©Heliphoto.net
Hensel Phelps

Merit Award—Greater than $75 Million

SALT LAKE CITY PUBLIC SAFETY BUILDING, SALT LAKE CITY, UTAH

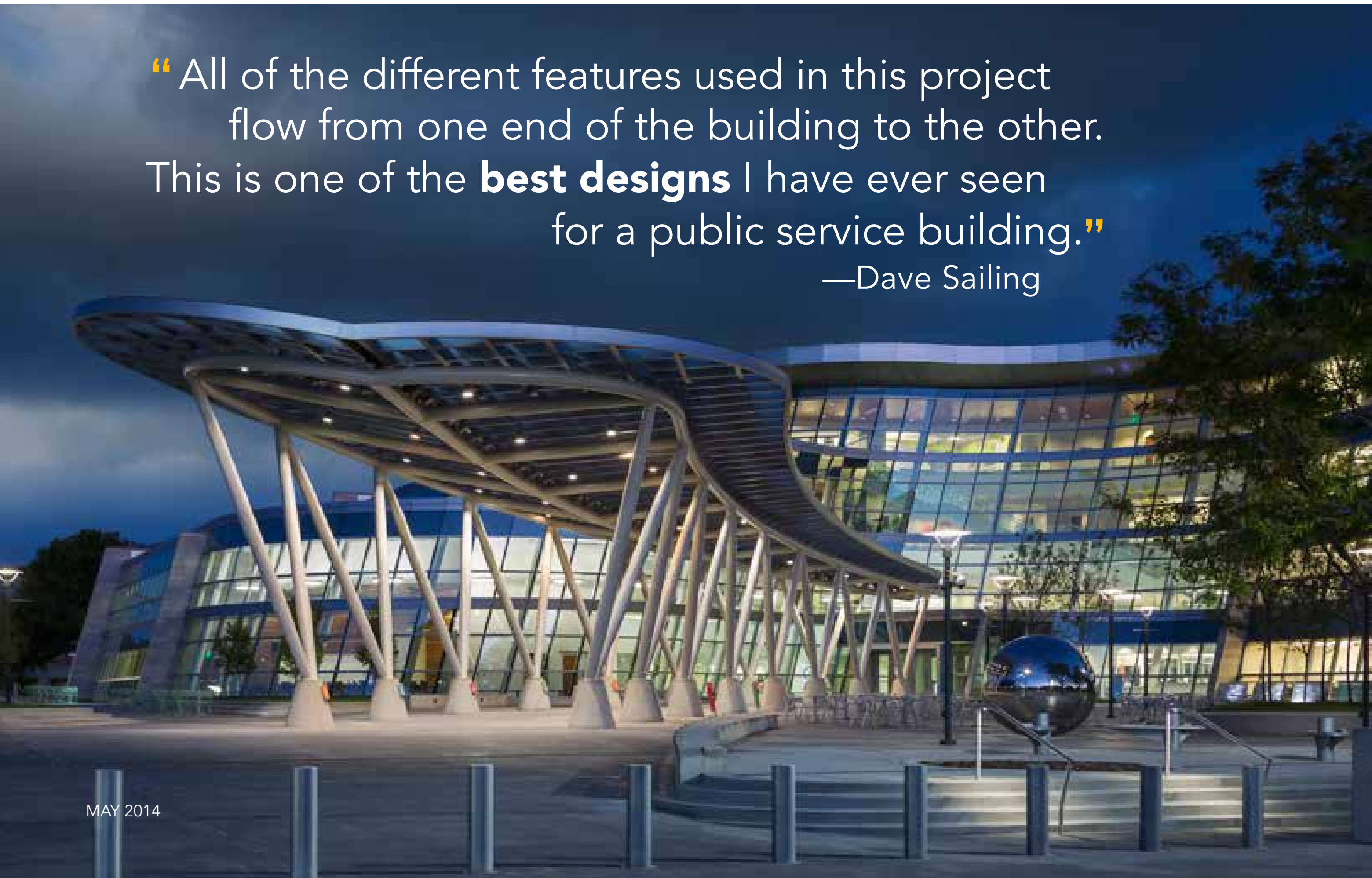
Salt Lake City made a bold statement locating its new Public Safety Building as part of the Salt Lake City Civic Center. The building is an emblematic statement inviting the public to use and explore its plazas, spatially complex lobby and transparent meeting rooms to interact with police and fire administration in open dialogue and action.

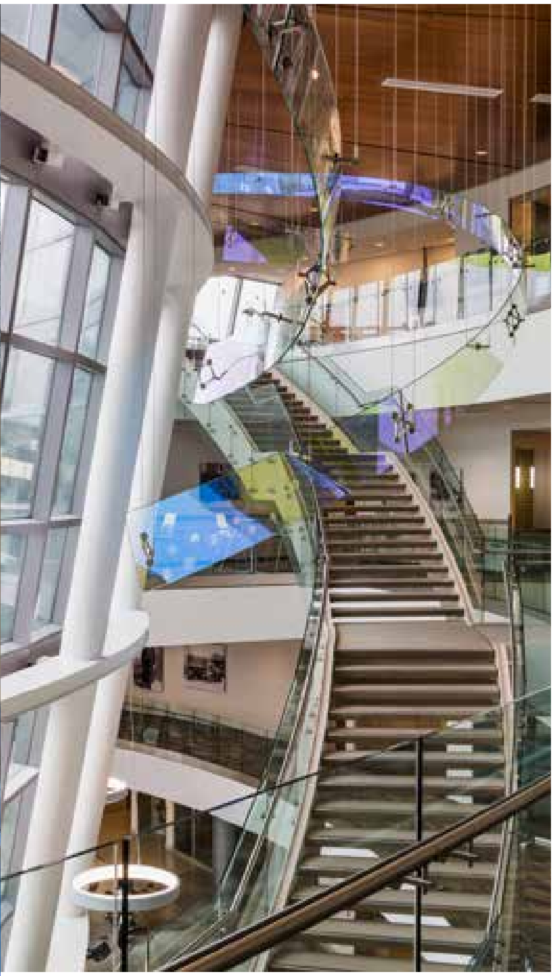
The building houses the city's police, fire and emergency management departments. The 172,000-sq.-ft project was designed to achieve the city's goals of providing an open and inviting public safety facility that will remain operational after a maximum credible earthquake (2,500 year return period), provide a high level of security to its staff and operate as a net zero energy building and sustainable site; the building is slated for a LEED Platinum rating and is the first net zero public safety building in the U.S.

Key to the ultimate design solution was an iterative non-linear dynamic analysis and design procedure to arrive at a structural design capable of meeting the seismic requirements of the project within the budget. The structural system ultimately selected is comprised of a steel moment frame with viscous dampers that act like shock absorbers. All building components are designed to meet rigorous non-structural seismic standards, allowing building equipment and systems to function after the maximum credible earthquake.

Upon selecting a system, the team then proceeded with an iterative evaluation procedure to model the structure using special three-dimensional non-linear dynamic response history analyses to verify the required performance of the structure. Seven suites of site-specific scenario ground motions were used to verify the required operational performance in accordance with ASCE-41 criteria. The team was then able to deliver a structural steel frame that was designed to resist the highest level of design seismic risk with the required high-performance objective. They were also able to provide blast resistance by employing SidePlate connections that ensure frame continuity and resistance to progressive collapse after a bomb attack.

The seismic/blast requirements for the building resulted in an elegant structure that presented a unique challenge for the mechanical, electrical, plumbing and fire protection routing. The complexity of the structure, coupled with the sheer volume of piping necessary to feed the buildings central plant and equipment, made building information modeling (BIM) an absolute necessity. BIM was implemented during the design phase to locate and design beam penetrations—a vital component to the mechanical design— that would meet the strict seismic/blast requirements of the project. During the construction phase, BIM ensured all the piping, duct and conduit would fit within the allotted space without the need to lower ceilings. Typically, a 14-ft, 6-in. floor-to-floor height would be more than adequate to fit equipment and piping. However, the size of structure substantially reduced the amount of available space. By working through clashes prior to construction, the team was able to avoid costly rework in the field and as a result, eliminated schedule delays.





Owner
Salt Lake City Corporation, Salt Lake City

Owner's Representative
MOCA Systems, Salt Lake City

Architects
GSBS Architects, Salt Lake City
MWL Architects, Phoenix

Structural Engineers
Dunn Associates, Salt Lake City
Holmes Culley, San Francisco

General Contractor
Okland Construction, Salt Lake City

Steel Team

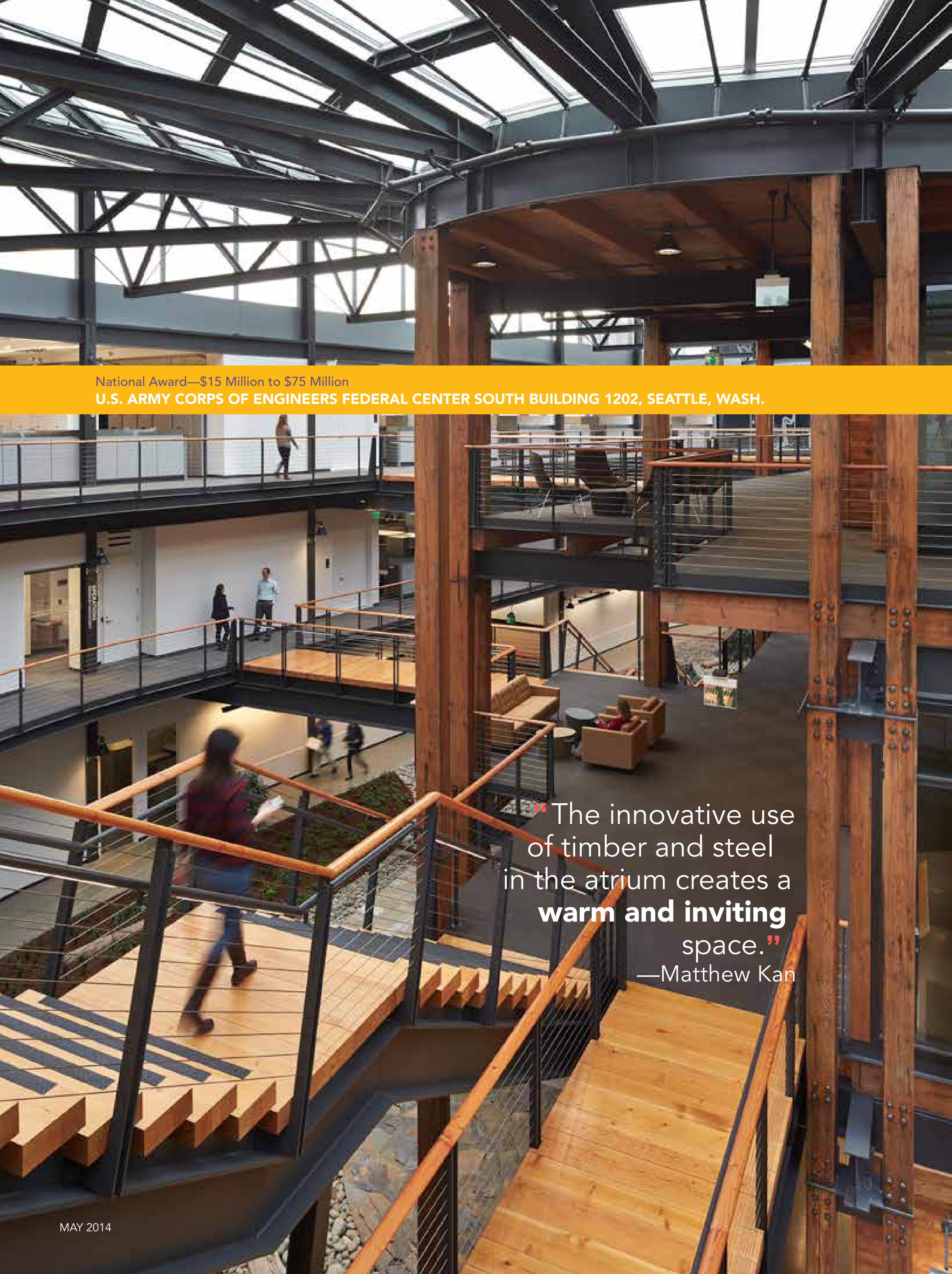
Fabricator and Erector
SME Steel Contractors, Inc., West Jordan, Utah (AISC Member/AISC Certified Fabricator/Advanced Certified Steel Erector)

Detailer
SNC Engineering, Inc., Compton, Calif. (AISC Member)

Photographs
Jeff Goldberg - Esto Photographics, Okland Construction

National Award—$15 Million to $75 Million

U.S. ARMY CORPS OF ENGINEERS FEDERAL CENTER SOUTH BUILDING 1202, SEATTLE, WASH.



"The innovative use of timber and steel in the atrium creates a **warm and inviting** space."
—Matthew Kan

In the Emerald City, it's not surprising to see things turn from brown to green.

Recently completed by the U.S. General Services Administration (GSA) for the Seattle District of the U.S. Army Corps of Engineers (USACE), the Federal Center South Building 1202 transforms a 4.6-acre brownfield site into a highly flexible and sustainable 209,000-sq.-ft regional headquarters. The building has achieved LEED Gold status and ranks in the top 1% of the most energy-efficient buildings in the U.S.

The building, which meets USACE's need for a more productive and collaborative workspace, used steel to creatively solve a number of specific program criteria and site challenges: a perimeter diagrid to defend against progressive collapse, architecturally exposed floor framing synchronized with mechanical and other building systems, integration with reclaimed timber floor framing in the building's "Commons," blast protection at the building envelope and "Energy Piles."

Building 1202 responds to both the 2009 American Recovery and Reinvestment Act (ARRA), which focused on improving the country's infrastructure and creating jobs, and the GSA's Design Excellence program, which establishes nationwide procedures for selecting the finest architects and integrated design teams for GSA commissions. Building 1202 was planned, designed and constructed in less than 2.5 years, and stayed within its original $68 million design and construction budget.

The design organizes functions into two distinct forms, each with its own structural system and innovative approach. Open offices take shape around an oxbow-shaped exposed steel structure and perimeter diagrid. In the central core, conference and teaming rooms are constructed of reclaimed lumber and an innovative composite wood and concrete assembly supported on steel girders. These diverse structural systems not only meet the demanding structural requirements, but are also key contributors to the overall architectural expression and performance of the project. And the building's form pays tribute to the site; it is located at one of the last remaining oxbows of the original Duwamish Waterway and is actually situated on fill deposited when the Corps dredged and straightened the waterway in the early 1900s.

A perimeter diagrid was employed to serve against the progressive collapse design requirement. The diagrid consists of sloping columns and spandrel beams with bolted (pinned) connections between the members and creates an efficient and inherently redundant structure. Compared to a conventional moment frame approach for solving progressive collapse, the diagrid system achieved savings (and used less labor) by eliminating pile foundations, reducing the steel tonnage by 30%, accelerating the erection schedule and eliminating full-penetration welds at connections between the spandrels and the columns. It also acheived smooth transitions through the curved portions of the building, facilitated by the diagrid, by using a tangential variation at each floor line. This allows the exterior skin to easily transition through the corners of the U-shape, resulting in a smoother appearance. The diagrid is painted white throughout in order to assist in diffusing both natural and artificial light inside the building and also to be prominently visible through the exterior glazing. It is celebrated as an integral part of the building's architectural expression as well as a physical manifestation of the Corps' motto of "Building Strong."

Since the steel floor framing is exposed, the layout of the steel members was synchronized with the workstation sizes and the ceiling solutions for the lighting, chilled beams (mechanical system) and acoustics. In addition, steel girders and connection materials were integrated with an innovative composite reclaimed timber-concrete beam framing system in the central Commons; steel and timber were also integrated on the stairs and pedestrian bridges.

Structural steel framing was used in combination with light-gauge steel to resist blast loads on the building's perimeter envelope, and the steel trusses in the atrium were also design to meet blast requirements. The building is supported by 205 steel pipe piles that extend through soft, liquefaction-prone fill and alluvial soil. The piles are 150 ft to 175 ft long and derive support in dense glacial soil; 135 of the piles contain ground source heat exchange loops, creating "Energy Piles" that form the backbone of a geothermal system that works in concert with the building's high-performance mechanical systems. This is one of the first projects in the region to combine geothermal heating and cooling systems with structural piles.

Owner
U.S. General Services Administration, Northwest/Arctic Region

Architect
ZGF Architects LLP, Seattle

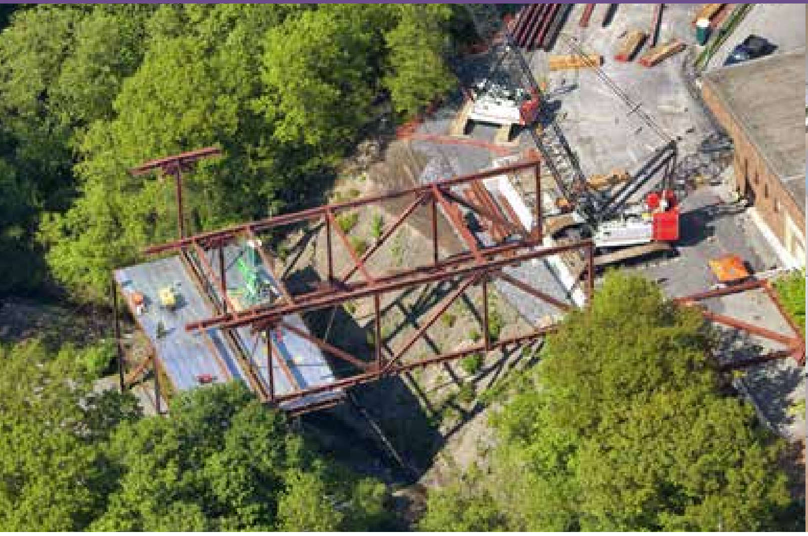
Structural Engineer
KPFF Consulting Engineers, Seattle

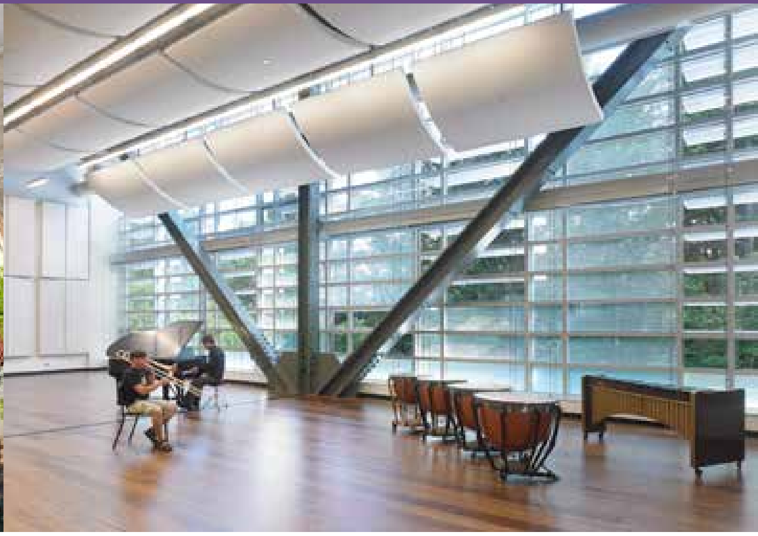
General Contractor
Sellen Construction, Seattle

Photographs
Benjamin Benschneider

Merit Award—$15 Million to $75 Million

ONONDAGA COMMUNITY COLLEGE, FERRANTE HALL ACADEMIC II ADDITION, SYRACUSE, N.Y.





The new Ferrante Hall Academic II connects two facilities, a classroom building and student center, on Onondaga Community College's campus in Syracuse, N.Y.—both on opposite sides of a gorge.

The two-story addition affirms the college's commitment to growing its arts programs, cultivating its music curricula and enhancing the cultural environment both on campus and in the community. Spaces include a 150-seat music recital hall with a 9,000-sq.-ft stage and chorus balcony, a music resource center, a 2,500-sq.-ft instrumental and choral rehearsal room that can seat up to 110 musicians, a 1,200-sq.-ft percussion rehearsal room, practice rooms of various sizes, 16 faculty teaching offices and eight music-oriented smart classrooms.

Physically connected to both a classroom building and the student center, the 45,000-sq.-ft, two-story Academic II "bridge building" unites the east and west campuses, which are divided by a 60-ft-deep fissure that previously was spanned by only a narrow bridge that was open to the elements. It connects the campus spine on the south with public, staff and student parking to the north. The building also shares the student center's loading dock and other support functions.

Use of bridge construction materials and techniques was essential in achieving the architectural vision. Three two-story, 200-ft trusses supporting the building incorporated some of the largest rolled steel elements available (up to W14×665). Structural steel elements and connections are embraced in the architectural space design, and bridge bearings are used to transfer loads to the building's foundations.

The building's 200-ft span relies on three 30-ft-high trusses that, due to limited working space on both sides, were erected with the help of a support tower built in the middle of the gorge, allowing trusses to be erected in two halves and spliced in the middle. This piecewise approach allowed field assembly of the trusses to occur in a smaller area and enabled use of a smaller crane.

Designers were challenged to create a structure stiff enough to span 200 ft without observable deflection or vibration, as well as address uneven loading issues due to different program requirements. Deflection also posed another, more general, challenge: If trusses were loaded after placement of the curtain wall or exposed concrete floors, the deflection of the trusses could cause windows to pop out and the concrete to crack excessively. A combination of two options was used to solve the deflection issue. The trusses were preloaded to neutralize deflections and unloaded sequentially as the building was completed, and non-deflection-critical items were installed first to help deflect the trusses.

Because the recital hall was a two-story space on one end of the building and the rest of the building was composed of two one-story layers, the load on the structure was unbalanced. While the north truss supported the weight of the roof and two lower levels, the south truss only supported a roof and one lower level, and the center truss supported a two-story space on one side and two one-story spaces on the other. To ensure compatible deflection, each truss was designed relative to the stiffness of the others as well as to its specific loading conditions.

When unexpected rock fragmentation was discovered on one side of the gorge during excavation, drilled micropiles and rock anchors were installed by a specialty contractor to supplement the building's original 7-ft-diameter caissons.

The unusually large steel members posed another issue regarding bolt installation. During steel fabrication, the team learned that the 1½-in. A490 bolts specified in the design had a tendency to fail if they were installed by turning the head end of the bolt instead of the nut end. In the building's design, however, the bolts were an architectural feature specifically designed to be installed in one direction, requiring rotation of the bolt head—and because the bolts were so large they couldn't be installed any other way. This installation proceeded under careful examination with successful results. (For more on this project, see the January 2013 issue.)

Owner
Onondaga Community College, Syracuse, N.Y.

Architects
CannonDesign, New York
C&S Companies, Syracuse, N.Y.

Structural Engineer
CannonDesign, Grand Island, N.Y.

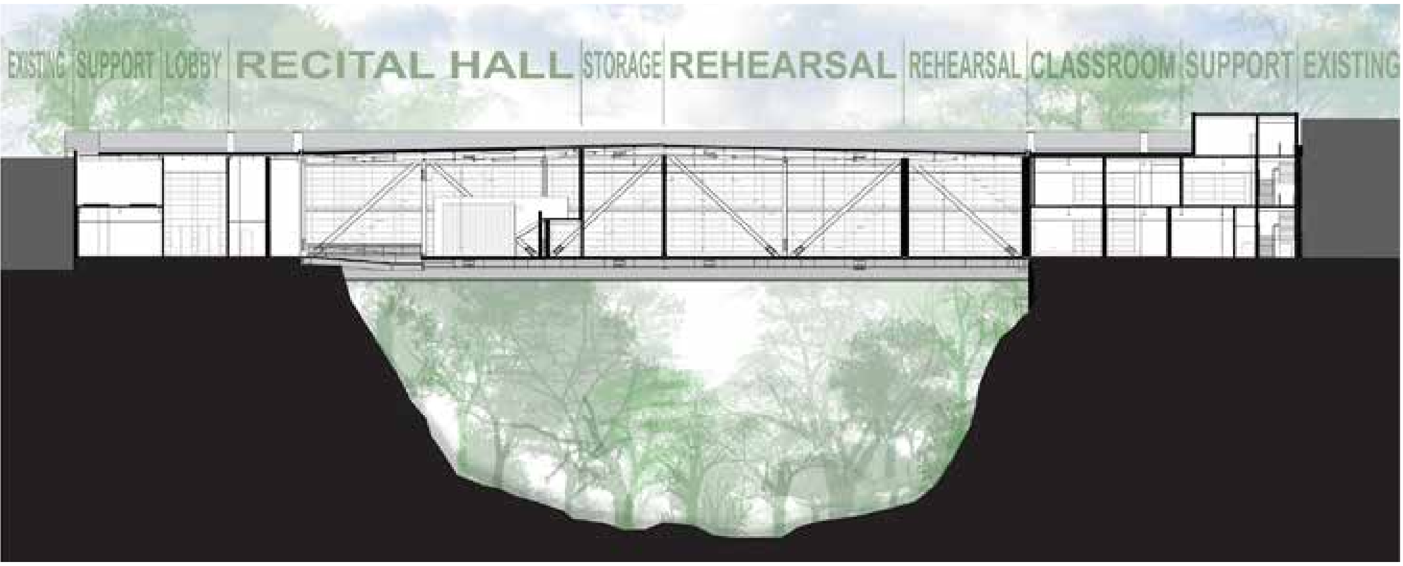
General Contractor
Hueber-Breuer Construction Co., Inc., Syracuse, N.Y.

Steel Team

Fabricator and Erector
Raulli & Sons, Inc., Syracuse, N.Y. (AISC Member/AISC Certified Fabricator/Advanced Certified Steel Erector)

Steel Detailer
JCM & Associates Limited, Frankford, Ontario, Canada (AISC Member)
Raulli & Sons, Inc.

Photographs
Tim Wilkes - Tim Wilkes Photography, David Revette - Revette Studio, Inc. and CannonDesign



BROOKFIELD PLACE ENTRY PAVILION, NEW YORK

In the fall of 2013, the World Financial Center was renamed Brookfield Place as part of Brookfield Properties' $250 million renovation to improve and expand the retail and public spaces for this waterfront complex.

The centerpiece for this renovation is a new glass and steel entry pavilion that will serve as the connector between the underground pedestrian passageway from the World Trade Center and Fulton Street transportation hubs to Brookfield Place and the Hudson River to the west.

The pavilion was conceived as a clear glass box with minimal structural supports, acting as the new front door for the entire complex and making its public spaces and offices more accessible to pedestrian traffic. Central to the structural and architectural integrity of the pavilion are two 53-ft sculptural steel columns that support the 8,000-sq.-ft space. The shape of the columns and their placement within the pavilion were influenced by complex site constraints. Located above the new passageway tunnel, an existing train tunnel relieving platform and a former pedestrian bridge pile cap, the supports for the entire structure had to be focused to only two points of contact underground. These constraints guided the design team towards the idea of two funnel shaped columns, which grow from small footprints at the foundation to support the large roof area overhead.

The architect's vision for the sculptural columns consisted of continuous pipes woven together in a basket-like fashion. Unlike typical diagrid structures where members are in a common plane and intersect at joints, the pipes for the sculptural columns were arranged in two separate layers and passed uninterrupted at each joint location. At each of the five vertical tiers, the pipes were held together by a continuous elliptical steel ring plate, and at intersections between each tier a hidden solid steel pin was used to connect the inner and outer pipes.

The structural system for the pavilion is independent from the adjacent steel and concrete superstructure of the main building. The two sculptural columns work together with deep beams concealed within the roof to support the weight of the hung glass façade, while also providing the entire lateral resistance for wind and seismic loads. In one direction, the deep beams tie the two sculptural columns together to act as a moment frame, while in the other direction the columns act as cantilevers to resist overturning.

Starting from the early phases of design, the structural engineer collaborated closely with the architect and steel subcontractor to develop connection details that were capable of transferring high structural loads while also maintaining tight erection tolerances for architecturally exposed structural steel and achieving a seamless finished appearance. The structural engineer rationalized the complex curved geometry of the double-layer diagrids into individual pipe segments with constant curvature to meet fabrication requirements, and collaborated with the steel subcontractor on a welded pipe

splice detail with temporary clamps that allowed adjacent sculptural column tiers to be shop assembled for fit-up and later reassembled on site in precise alignment. All exposed welds were ground smooth and flush to provide a high-quality finish, and full size mock-ups of various joint conditions were made to allow the owner and architect to evaluate the appearance of key details.

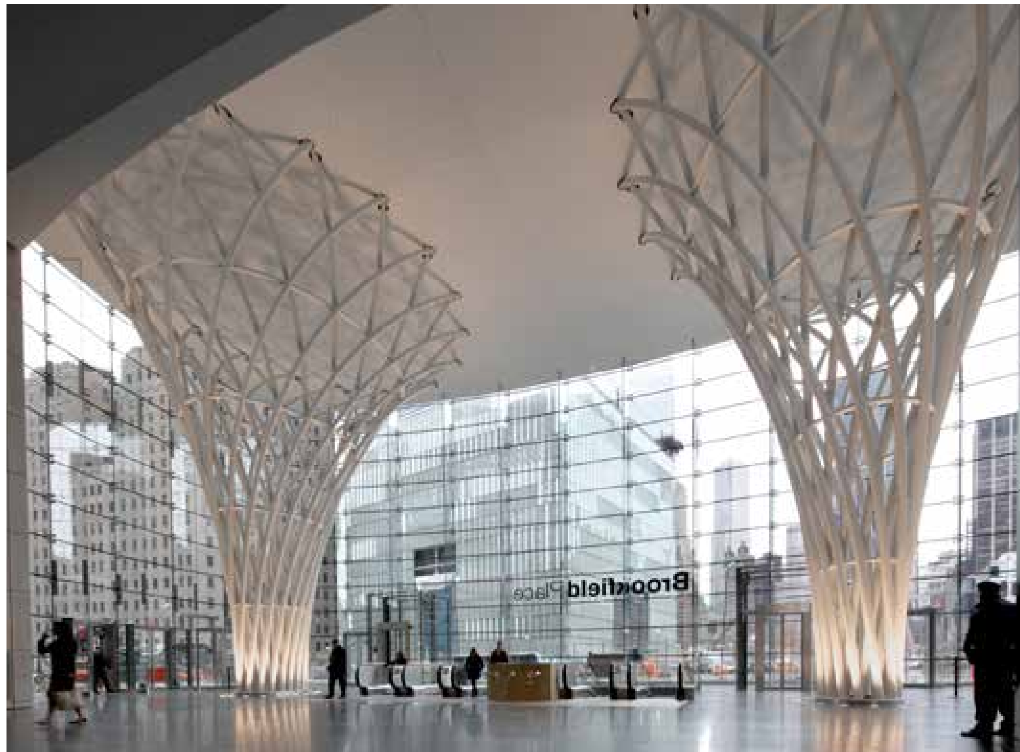
Owner
Brookfield Properties, New York

Architects
Pelli Clarke Pelli Architects, New York
Spector Group, New York

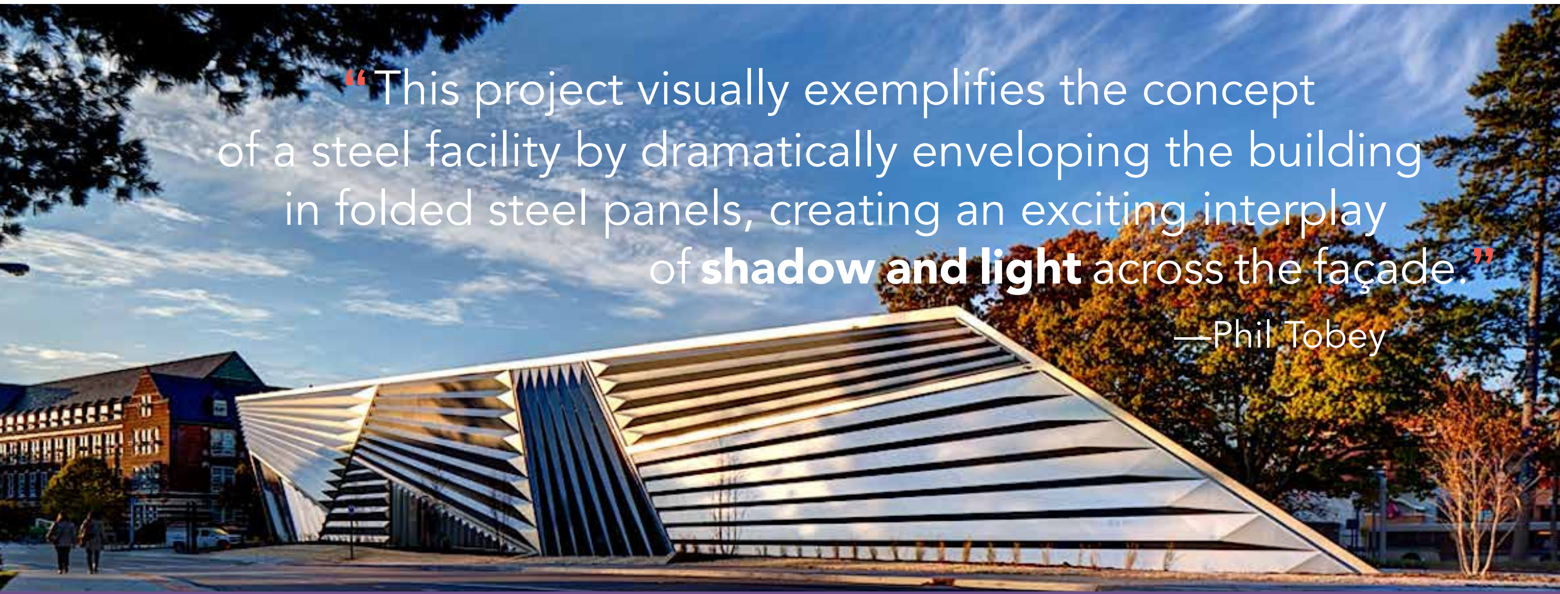
Structural Engineer
Thornton Tomasetti, New York

General Contractor
Plaza Construction, New York

Photographs
Bess Adler, Thornton Tomasetti



"The architecturally exposed steel trees are aptly named as they are similar to trees **found in nature** and function in a manner similar their natural counterparts."
—Lindsay Anderson



"This project visually exemplifies the concept of a steel facility by dramatically enveloping the building in folded steel panels, creating an exciting interplay of **shadow and light** across the façade."
—Phil Tobey

Merit Award—$15 Million to $75 Million

ELI AND EDYTHE BROAD ART MUSEUM, EAST LANSING, MICH.

Philanthropist and art collector Eli Broad envisioned a new museum at Michigan State University as a world-class venue for the display of modern art. The vision is more than just volume, surfaces and forms; it's also gesture, expression and intent. So it wasn't enough to merely bring physicality to the imagined form; it also needed to be done in a way that preserves the spirit in which the design was conceived.

Thus, the engineering of the museum became an exercise in communicating with the architect about exceedingly complex geometry in a most nuanced way, communication that took place across three building information modeling (BIM) software platforms: Rhino, Revit and Tekla. As the project developed it became evident that, because of the complex geometry, the most challenging phase of communication would be encountered during the production of steel shop drawings.

For this reason, the engineer of record advocated moving away from traditional shop drawings and instead prepared them in Tekla concurrently with the construction documents. Steel bidders then had the opportunity to bid the project and also to bid for use of the drawings, which provided confidence to the owner by ensuring that a fair price was being paid for the drawings that the design team had prepared. As the Tekla-based drawings developed, the model was continually checked against the architect's Rhino and Revit models so that when steel bidding occurred, the shop drawings were essentially already checked for every aspect of conformance with the architect's still-developing details. With the glazing being hundreds of unique shapes shipped from Germany, and the stainless steel skin being many more hundreds of individually fabricated forms, the tolerances for construction were extremely tight. The careful BIM coordination allowed each piece to come together in a precise way.

The building frame itself is made up of a series of non-parallel sloping walls that interface with architectural concrete walls that are also non-parallel and sloping. Wide-flange shapes with gussets in the plane of the flange are used frequently, as are castellated beams. The stairs are HSS frames encased in architectural metal handrails, and cantilever off of the floor slabs and return without landing supports. HSS also served as window mullions.

Owner
Michigan State University, East Lansing, Mich.

Owner's Representative
Eli & Edythe Broad Art Museum, East Lansing, Mich.

Architects
Integrated Design Solutions, Troy, Mich.
Zaha Hadid Architects, London, U.K.

Structural Engineers
AKT, London, U.K.
SDI Structures, Ann Arbor, Mich.

General Contractor
Barton Malow, Southfield, Mich.

Steel Team

Fabricator and Erector (Miscellaneous)
Douglas Steel Fabricating Corporation, Lansing, Mich. (AISC Member/ AISC Certified Fabricator/Advanced Certified Steel Erector)

Detailers
The Steel Detailers, Inc., Seminole, Fla., (AISC Member)
Douglas Steel Fabricating Corporation (Miscellaneous)

Photographs
Justin Maconochie - Maconochie Photography, Kevin Marshall and Paul Dannels - SDI Structures

A prominent structure in the San Diego skyline, this is a **monument to steel** as a building material, providing both aesthetic and functional benefits to the many patrons of this iconic library.

—Chad Clinehens

National Award—Less than $15 Million

SAN DIEGO MAIN PUBLIC LIBRARY DOME, SAN DIEGO

A 140-ft diameter post-tensioned steel-leaved dome serves as a beacon for San Diego's 10-story, $185 million downtown main library, and adds a new focal point to the city's skyline. Conceptual designs of the dome spanned eight years and explored six different circumferential and segmented options. The final scheme resulted in eight intersecting post-tensioned, moon-shaped truss elements with a saddle-shaped cable net on each. Adjacent to the dome, the vertical stair tower forms a strong structural core that anchors the two wings of the building. Thrusting outward and upward from this anchor are projecting triangulated arms that catch a few of the dome rib bases. The computer model of the dome enlisted more than 6,000 "tension only" members and required programs written specifically for post-processing filtering.

The dome, believed to be the largest steel post-tensioned segmental dome in the world, rises 221 ft above ground level to provide shade and acclimatize the reading room. It is constructed of more than 3,000 individual steel members, weighing 285 tons in all, and is clad in 1,500 perforated aluminum panels to shade the eighth floor reading room beneath it. The dome is made up of eight unique truss "ribs" that rise from base to apex in varying heights (from 72 ft to 113 ft) and eight "sail" structures located between the ribs.

Sails are oriented in plan with a pinwheel configuration, an effect created by offsetting each of the sails' vertical leading edges to the outside of the ribs, while the sails' trailing vertical edges are connected to the inside rib surfaces. Each sail has an external pipe grid that is spherical at the upper part of the dome. However, the spheres are tipped vertically and horizontally so the center of each sail does not coincide with the center of the dome. Unfurled, the largest sail is 123 ft by 53 ft wide and comprised of 175 HSS and 60 cable segments.

Due to its discontinuous circular form and peaked pinnacle, the dome behaves as a series of intersecting three-hinged arches. At the base, each rib is supported on a large pin that allows the ribs to rotate or expand with increasing temperature, and each pin falls on a fixed rectangular grid. Four of the sails were configured at equal plan angles and the other four were configured at different angles, giving a unique condition at each connection.

The erection process was challenging not only because of its inconsistent geometry, but also because large curved trusses had to be lifted and erected after their assembly. In addition, the fabricator and erector, SME Steel, expressed the desire to erect the sails in one piece.

Each sail was assembled with tubes, cables and intricate parts all welded and bolted on the ground. Due to the curvature of each sail, ground assembly would require temporary racks to support the sail parts. Furthermore, working off of aerial lifts would be both cumbersome and costly. Instead, a temporary ramp was proposed in order to hold the members in place and provide access for the work. The ramp followed, as closely as practicable, the curvature of the sails. The erection crew could then work on the decked platform under much safer conditions. Posts protruded through the deck, where needed, to support the shop assemblies that were shipped to the site.

Once the sails were assembled, they each needed a picking scheme. The upper end of the sail was ultimately hung with four lines when erected into the dome ribs. However, in order to get the sail into position, it required a second crane to lift it from its resting position on the sail rack. The lower crane was fitted with two rolling blocks on four lower pick points. Once the sail was high enough, the lower hook elevation remained constant as the upper crane continued to lift, until the four upper lines were all engaged. The lower lines were then released so that the sail was hanging true, ready to erect.

Erection of the sails was expected to be difficult due to the many connection points between the two ribs. However, after the first sail was erected, more specific geometry checks were done on the racks before picking, and this eased the erection. SME planned its schemes well in advance with the erection engineering team, Hassett Engineering, Inc., and also included input from structural engineer Endrestudio, based on its knowledge of the analysis and final design. Many different options were considered, and collaboration was crucial for each step of the process. There was important constructive criticism given by the field crew throughout the assembly of this new San Diego landmark. The constant communication within the erection team greatly accelerated the erection process, allowing the project to be a success for all parties as well as the public. (For more on this project, see the November 2012 issue.)

Owner
City of San Diego Main Library, San Diego

Architects
Rob Wellington Quigley Architects, San Diego
Tucker Sadler, San Diego

Structural Engineer
Endrestudio, Emeryville, Calif.

Construction Engineer
Hassett Engineering, Inc., Castro Valley, Calif.

General Contractor
Turner Construction, San Diego

Steel Team

Fabricator, Erector and Detailer
SME Steel Contractors, Inc., West Jordan, Utah (AISC Member/AISC Certified Fabricator/Advanced Certified Steel Erector)

Bender-Roller
Albina Pipe Bending Company, Inc., Tualatin, Ore. (AISC Member)

Photographs
Rob Quigley - Rob Wellington Quigley Architects

Merit Award—Less than $15 Million
UNITED THERAPEUTICS PEDESTRIAN CONNECTOR, SILVER SPRING, MD.

United Therapeutics' campus in downtown Silver Spring, Md., includes multiple buildings within close proximity to one another in a mixed-use urban setting.

A new eight-story, 100,000-sq.-ft office building was recently added to support the company's existing laboratory and corporate headquarters functions. Due to site constraints, however, the new facility is separated from the core campus by a busy street. So, the design team proposed an enclosed skywalk to link both sites.

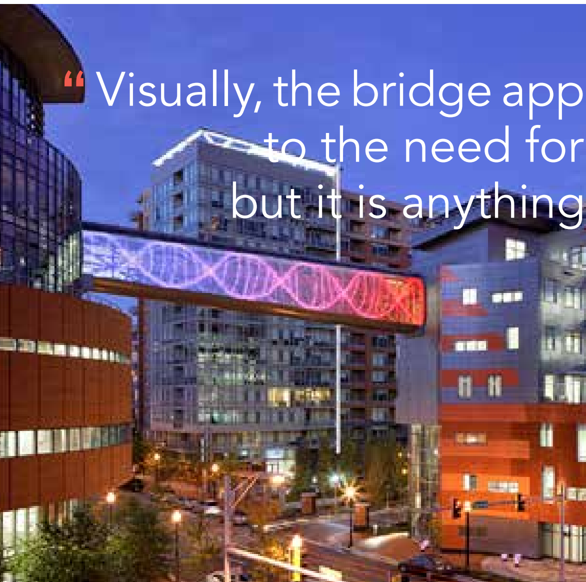
Completed in 2012, the $2 million connector spans more than 90 ft across the street and connects to the sixth floor of each structure, allowing unencumbered access to new conference rooms and dining and office areas. Architecturally, the initial design concept for the connector included a glass-clad circular cross section that increases in depth as the floor slopes, to accommodate a 4-ft elevation change between the two buildings, while the top of the connector remains flat. As the project progressed, the full cross section of the connector was developed as a truss, with the walking path "floating within it." This approach created a visually stimulating experience as pedestrians travel through the exposed, curving structural members, while also maximizing the structural efficiency of the connector.

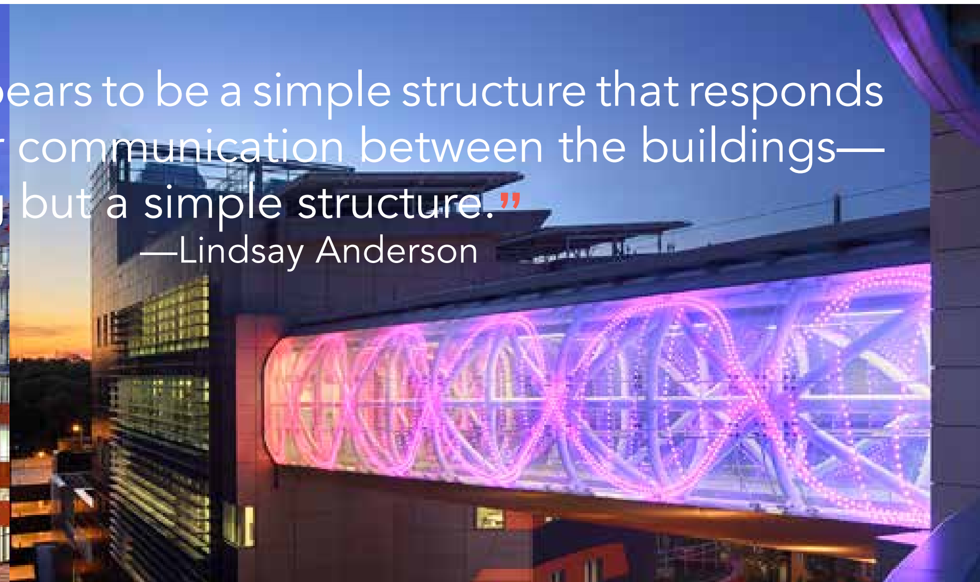
Comprised of exposed 7-in. round HSS, the truss includes 11 HSS rings that follow the extended circular cross section of the connector and are spaced at 9-ft centers. Each ring includes two half-circular sections (top and bottom) with a 5-ft radius, separated by straight sections of varying length to match the slope of the floor slab. The rings are connected with eight HSS longitudinal chords that are located at the topmost and bottommost points of the connector, at mid-height of the sides, and at 45° from each spring point of the top and bottom arched sections. HSS diagonals frame between node points created at the ring/chord intersections and follow the curvature of the ring members between nodes, resulting in diagonals that curve in two planes. Computer-controlled LED lighting traces the symbolic pattern of a DNA strand and reinforces the facility's biotechnology focus.

The connector was designed to support a 100-psf occupant load on the walking deck, a 40-psf catwalk live load and loads due to snow, ice, wind, seismic and OSHA safety requirements for glass cleaning. AISC Design Guide 24 and AISC 360-05 Chapter K were used to check all limit states of HSS members due to localized effects of round HSS connections. Welds were checked for the combined effects of bending and axial member end forces. Deflection and vibration serviceability requirements were carefully evaluated, and an expansion joint with a slide bearing connection was introduced at the one end of the connector to account for differential building movements due to thermal expansion and contraction and lateral loading conditions.

The fabrication of the 28-ton connector required careful planning with as many as eight round members joined together at a single node, six of which are curving. The round HSS required elliptical end cuts of curved members that were then chamfered to accommodate varying dihedral angles for partial penetration welds. Qualification of welding procedures was required for round HSS partial penetration "K" connections that did not meet the geometry requirements for prequalified AWS welded joint designations. Qualification testing included transverse cutting of welded joint mockups and macro-tech testing of the weld cross sections.

“Visually, the bridge appears to be a simple structure that responds to the need for communication between the buildings—but it is anything but a simple structure.”
—Lindsay Anderson





Owner
United Therapeutics Corp., Silver Spring, Md.

Owner’s Representative
Stranix Associates, Vienna, Va.

Architect
EwingCole, Inc., Philadelphia

Structural Engineer
EwingCole, Inc., Philadelphia

General Contractor
DPR Construction, Inc., Falls Church, Va.

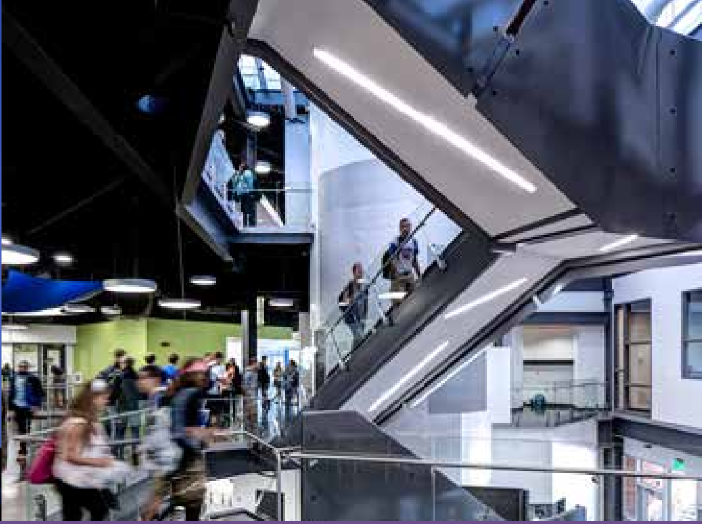
Steel Team

Erector
Baltimore Steel Erectors, White Marsh, Md.
(AISC Member/AISC Certified Fabricator)

Detailer
Cartee-Berry & Associates, LLC, Florence, S.C. (AISC Member)

Photographs
©Ron Blunt 2011 and Peter Welsh, EwingCole, Inc.

Through close collaboration with the fabricator, the structural engineer suggested a staggered fabrication sequence that allowed assembly of the connector without cutting the diagonal members and eliminated 80 full-penetration welds. Prior to fabrication, the attachment points to each building were surveyed to ensure that the connector would fit between the two buildings. The connector was fabricated and shipped in one piece. The connector was erected in one lift by a single crane with only 3 in. of clearance to the existing concrete structures at each end of the connector.



Merit Award—Less than $15 Million

BATTLE CREEK AREA MATHEMATICS AND SCIENCE CENTER, BATTLE CREEK, MICH.

Students and teachers alike embrace the new Battle Creek Area Mathematics and Science Center's mantra of "Innovation Through Inspiration." Unlike other math and science institutions, the center serves dual functions: education for exceptionally talented high school students from 16 neighboring school districts, and the design, manufacture and distribution of science curriculum materials.

In 2013, the center's new home—an $11 million adaptive reuse facility (a former cereal museum donated by the Kellogg Company)—was completed, housing the learning center and a separate distribution center. The design team was charged with achieving the new program while transforming the agrarian aesthetic of a museum dedicated to the invention of corn flakes into a cutting-edge, 64,000-sq.-ft learning facility. The concept removed six existing barn roof forms and created cantilevered second and third floor additions over the entry plaza. Fortunately, the original building was steel-framed, allowing the architects the opportunity to achieve all of the center's goals. A new expressive "V" column support was added at the building's entry to support the new floors and act as a source of inspiration for students at the entry. A glass curtain wall envelops the exterior of the second floor and facilitates a greenhouse at the corner, floating over the entry and showcasing the center's commitment to research-based learning. The new third floor is shrouded in two-tone steel panels in a pattern inspired by mathematical arrays.

The interior design concept draws on biological science where walls are an expression of organic form set in motion by a three-story pendulum swinging inside the central stair. On the third floor, the pendulum is hung from a severed cone of structural steel so that students may see its inner workings. While both of the stairs' landings are cantilevered into space, the higher one is a longer cantilever and particular source of inspiration. The structural engineer designed a steel cable support to take the bounce out of the landing, which invites students to touch and wonder about the physics of steel.

Classrooms are bounded by monolithic walls with entries created by a serpentine structural glass weaving around a three-story atrium. This Collaboration Space is connected by new elliptical holes cut between floors and bounded by steel cable-rails. It is filled with museum-like places for study, collaboration and reflection, including a building-system display case. Scientific installations including sustainability monitors tied to building systems, suspended molecular models, interactive technology exhibits and the students' solar car project further enhance the space. The third-floor physics lab includes a steel cantilevered perch from which to drop objects and measure results through space.

The site is situated on 600 ft of riverfront space and a public park. The building acts as a visual anchor to north edge of historic Battle Creek, and there is a riverfront bike path directly to Battle Creek High school three blocks away. Additional exterior spaces were developed to provide safe access to the river for biology students to study, sample and analyze the ecosystem. In addition, food science engineers from nearby Kellogg will be able to cross a bridge directly to the center to make presentations, meet with students and tour them through Kellogg's real-world lab environments.

Owner
Battle Creek Public Schools, Battle Creek, Mich.

Architect
Tower Pinkster, Grand Rapids, Mich.

Structural Engineer
Teton Designs, Grand Rapids, Mich.

General Contractor
Schweitzer Inc., Battle Creek, Mich.

Steel Fabricator and Detailer
Steel Supply & Engineering, Grand Rapids, Mich. (AISC Member/AISC Certified Fabricator)

Photographs
Justin Maconochie

"This building encompasses both a structure and a **learning tool** for its students."
—Erin Criste

Presidential Award of Excellence in Engineering

ONE WORLD TRADE CENTER, NEW YORK

One World Trade Center (1WTC) is the tallest of the four buildings planned as part of the Ground Zero reconstruction master plan for Lower Manhattan. It is the tallest building in the Western Hemisphere with an overall height, from ground level to the top of the spire, of 1,776 ft. At 1,368 feet above ground, the main roof is designed to be the same height as the original towers.

The project's program includes 3 million sq. ft of new construction above ground and 500,000 sq. ft at new subterranean levels. The tower consists of 71 levels of office space and eight levels of MEP space. It also contains a 50-ft high lobby, tenant amenity spaces, a two-level observation deck at 1,242 ft above ground, a sky restaurant, parking, retail space and access to public transportation networks.

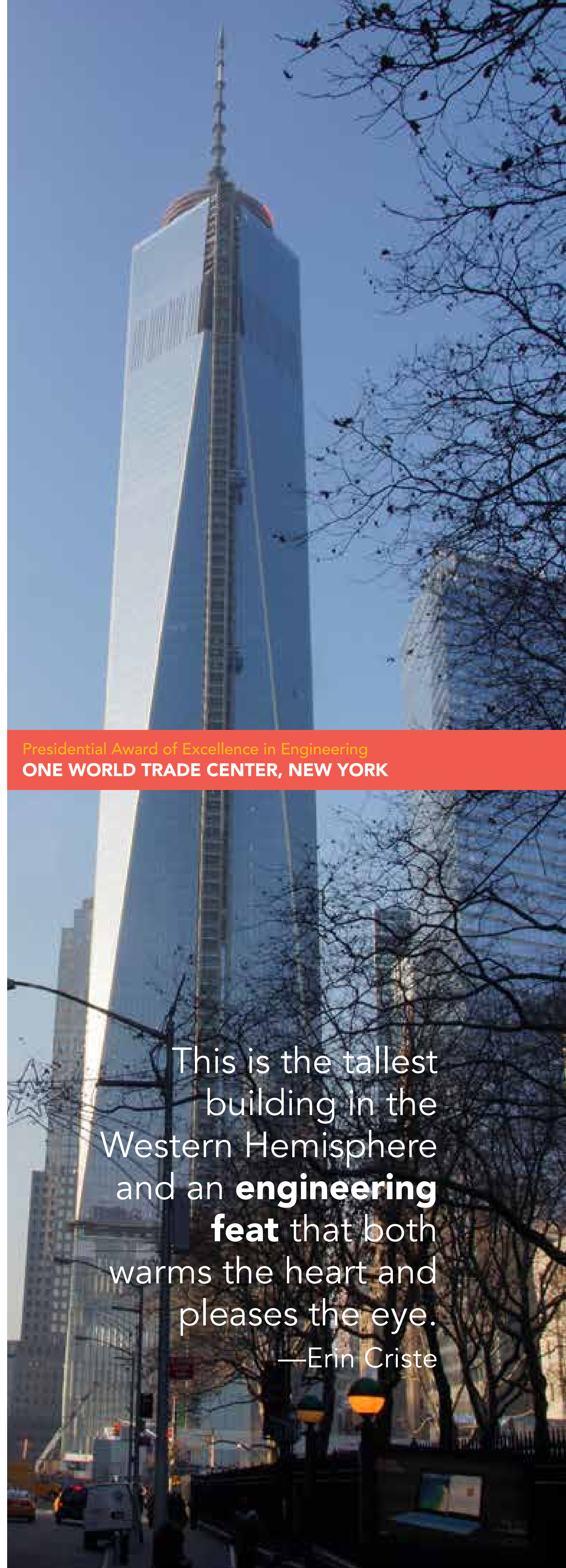
The tower structure is comprised of a hybrid system combining a robust concrete core with a perimeter ductile steel moment frame. The reinforced concrete core wall system at the center of the tower acts as the main spine of the tower, providing support for gravitational loads as well as resistance to wind and seismic forces; it houses mechanical rooms and all means of egress. The core structure is compartmentalized with additional internal shear walls in orthogonal directions.

A ductile perimeter moment frame system is introduced for redundancy and to further enhance the overall building performance under lateral wind and seismic loads. The perimeter moment frame wraps around all vertical and sloped perimeters, forming a tube system.

The tapering of the building geometry reduces the wind effect on the tower. Generally, tall building design in New York is governed by wind load. However, this tower shape has an innate positive effect on the building performance under the wind loading. Along the height of the tower, the tapering multifaceted geometry creates unique structural conditions, which necessitated the design and fabrication of special nodal elements using relatively large plating with significant capacity for load transfer.

For further enhancement of the lateral load resisting system, the concrete core at the upper mechanical levels is connected to the perimeter columns via a series of multilevel outrigger trusses in both orthogonal directions. While the floor system within the concrete core zone is made of cast-in-place concrete beams, the floor area outside the core is concrete on composite metal deck supported on steel beams and connected via shear connectors acting as a composite system. The construction was sequenced by first erecting an all-steel framing system throughout the floor, both inside and outside the core, preceding the concrete core construction. The steel framing within the core is primarily an erection system, which is embedded in the concrete core walls.

The tower structure extends 70 ft below grade, passing through four subterranean levels where some of its structural components required repositioning to clear the PATH train tracks that pass beneath the building at the lowest basement level. The tower foundation sits on Manhattan rock using spread and strip footings with bearing capacities of 60 tons per sq. ft or better. At selected locations, due to space constraints such as the proximity of the existing operating train lines, it was necessary to excavate deeper into the rock to achieve a higher bearing capacity. (For more on this project, see the February 2014 issue.)



This is the tallest building in the Western Hemisphere and an **engineering feat** that both warms the heart and pleases the eye.
—Erin Criste

Owner
The Port Authority of New York and New Jersey, New York

Owner's Representative
STV, New York

Architect
Skidmore Owings and Merrill, New York

Structural Engineer
WSP, New York

General Contractor
Tishman Construction, New York

Steel Team

Fabricators
MRP, LLC, South Plainfield, N.J. (AISC Member/AISC Certified Fabricator)
Banker Steel Company, LLC, Lynchburg, Va., (AISC Member/AISC Certified Fabricator)

Detailers
Dowco Consultants, Ltd., Mississauga, Ontario, and Surrey, British Columbia (AISC Member)
Automated Steel Detailing Associates, Ltd., Toronto (AISC Member)

Photographs
Yoram Eilon and Nicola Evans (courtesy of WSP), Port Authority of New York and New Jersey and DCM Erectors