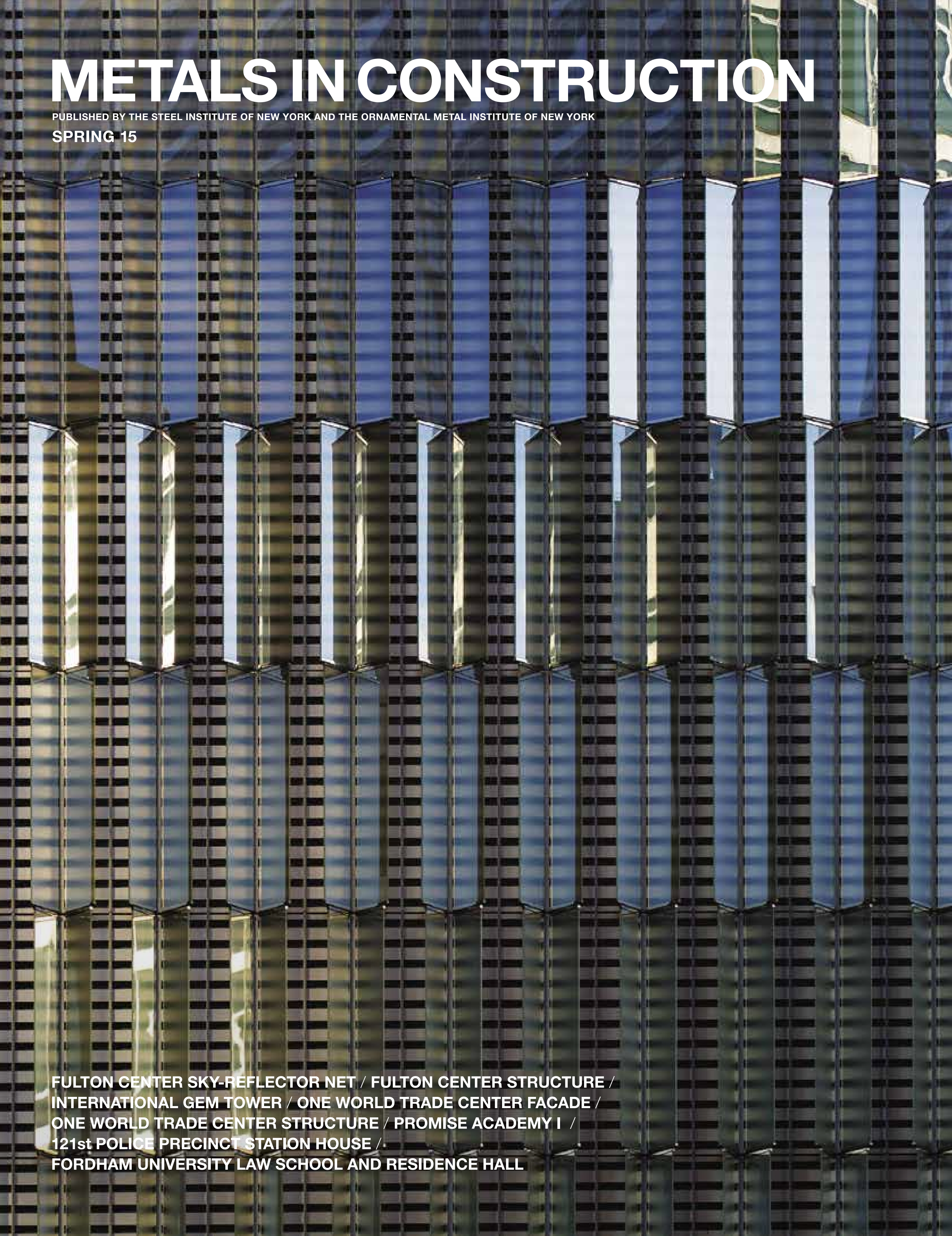
METALS IN CONSTRUCTION

PUBLISHED BY THE STEEL INSTITUTE OF NEW YORK AND THE ORNAMENTAL METAL INSTITUTE OF NEW YORK

SPRING 15



FULTON CENTER SKY-REFLECTOR NET / FULTON CENTER STRUCTURE / INTERNATIONAL GEM TOWER / ONE WORLD TRADE CENTER FACADE / ONE WORLD TRADE CENTER STRUCTURE / PROMISE ACADEMY I / 121st POLICE PRECINCT STATION HOUSE / FORDHAM UNIVERSITY LAW SCHOOL AND RESIDENCE HALL

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Above *Sky Reflector-Net*, an integrated artwork by James Carpenter Design Associates, Grimshaw Architects, and Arup at Fulton Center.
Cover The facade of One World Trade Center, designed by Skidmore, Owings & Merrill.

This page: Jennifer Krichels; cover: © David Sundberg/Esto

EDITOR'S NOTE
Opening new vistas

This issue celebrates the completion of a process that began with a news conference ten years ago. It was then that the city's two major transportation authorities each announced plans to undertake the extraordinary architectural and engineering challenges posed by projects highlighted in these pages. One involved burrowing deep below city streets to tie a tangled labyrinth of subway lines into a single, coherent transit center. The other entailed building to a height of 1,776 feet to redefine Lower Manhattan's skyline as an ever-present symbol of hope and renewal. Despite their contrasts in elevation, each represents a pinnacle of modern construction accomplishment. Conceived by Metropolitan Transportation Authority planners to link four century-old stations on the A, C, J, M, Z, 2, 3, 4 and 5 subway lines, **Fulton Center** opens new vistas for the 300,000 daily commuters streaming through what had been a subterranean warren of platforms and connecting passageways. Through the successful collaboration of Grimshaw Architects, Arup, and James Carpenter Design Associates, it has become an important landmark in the incredible and often overlooked feat of engineering that is the New York City subway system. Crowning this landmark is its conical, 110-foot-tall steel-and-glass dome gathering daylight and funneling it far underground. In **One World Trade Center**, the tallest skyscraper in the United States, the Port Authority of New York and New Jersey shouldered the responsibility of taking a site where so many perished and making it a reverential sign of the city's resilience and vitality. Designed by David Childs of Skidmore, Owings & Merrill to be the safest office building in the world, its redundant steel frame makes for a robust structure whose column-free spans open the interiors to new views of Lower Manhattan's rapidly changing fabric. When admiring its simple clarity in both form and cladding, it can be easy to forget the tumultuous journey that brought the tower to completion. But in remembering the process, we acknowledge the extraordinary teamwork and collaboration that went into the tower and will continue through the completion and operation of the World Trade Center campus.

Gary Higbee, AIA, Editor
higbee@siny.org/
higbee@ominy.org

Fulton Center Sky-Reflector Net

Lower Manhattan's bustling transit hub is crowned with an ambitious tensile structure that required rigorous collaboration between designer, fabricator, and installer.

NAVIGATING AMONG NINE SUBWAY lines and the streets of Lower Manhattan, 300,000 people converge daily to walk through Fulton Center, which opened to the public on November 10, 2014. Just as stunning as the number of users is their initial reaction to the new transit hub's atrium pavilion. Spotting the artwork *Sky Reflector-Net* that crowns the eight-story hall, they turn from hardened commuters into tourists: Travelers pause under, photograph, and orient themselves by the skylit cable-net structure cradling 952 Alanod-coated perforated anodized-aluminum panels, each measuring 0.145 inches thick.

The varied responses bear out the installation's multiple functions. As Arup's Zak Kostura, structural engineer for the project, explains, "The artist came to the table wanting to create an experiential effect; the architect wanted people to use it as a wayfinding device; and the engineer wanted to make sure, quantitatively, that daylight could penetrate Fulton Center's lower levels."

Kostura adds, "In a normal project, you can almost get away with dividing up the systems that support the interests of different stakeholders. Here, achieving our goals required intensive collaboration."

Sky Reflector-Net was conceived by James Carpenter Design Associates (JCDA) in response to Arup and Grimshaw Architects' initial 2003 design of the Fulton Center pavilion. While that scheme would go through multiple iterations for value engineering, the three-story structure consistently featured a dome whose south-facing, 53-foot-diameter oculus would top out at 108 feet tall. JCDA namesake James Carpenter imagined suspending a skewed hyperbolic paraboloid—or hypar—armature from the dome's sloped oculus, and tracing its double curvature in panels that brighten and, evoking the New York subway system's historical reliance on sunshine, reflect natural light into subterranean circulation zones.

Carpenter's vision was compelling enough to win the public-art commission for *Sky Reflector-Net*. Developing it beyond concept required interdisciplinary support. "That hypar shape didn't

Above Three teams of contractors performed the panel installation, connecting each panel to nearby cruciform at its four corners.

Below A skylight at the top of Fulton Center sends light into the atrium below, much like the subway-illuminating sidewalk skylights that used to punctuate New York City streets.

This page top and opening spread: Zak Kostura; this page bottom, facing top and center and following page: MTA/Patrick Cashin; facing page bottom: Jennifer Krichels; concluding page: James Ewing

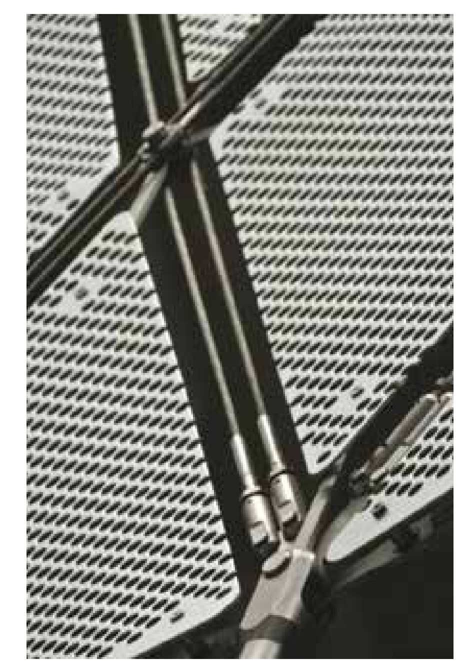
Right Tightly choreographed fieldwork required two boom lifts and a swing stage operating simultaneously.
Below center A form-found structure, the net adopted its final geometry once 56 tie rods at its base were tensioned on-site.
Below Cruciforms connect panels. Rod segments have serial numbers to ensure proper placement.

assume the weight of the panels, the connections, or the position of the boundary form, which would all dictate the final design," Kostura explains of the myriad factors that would have to be calculated to realize the complex geometry. JCDA subsequently worked with Grimshaw as well as Arup, which was tapped as prime consultant to the MTA in 2003, to bring the idea to life.

While Carpenter did not originally picture it as such, budgeting dictated approaching the hypar as a purely tensile structure. Arup reverse-engineered tensile forces and node positions according to Carpenter's preferred geometry by executing more than 113 iterations of a computational model. Next, modeling yielded the unstressed length of each cable segment, along with 1,056 x, y, and z coordinates that would ultimately position the 952 infill panels into 17 rows.

All but the top and bottom rows comprise rhomboid panels, and Kostura notes that a traditional hypar-shaped net would have included horizontal banding to panelize it into stiffer triangles. "Jamie [Carpenter] and Grimshaw made an adamant assertion that the panels should be diamond-shaped and not triangulated. That posed an immense structural challenge of creating a soft net from rigid, delicate panels, which would waft in the intense amounts of sun and airflow in the atrium."

The panels are bolted to one another via paddle connectors, held between 112 quarter-inch-diameter steel cables that crisscross to form the 17 rows. The integrated team had to treat a seemingly minute detail of *Sky Reflector-Net*—the left, right, and bottom holes where each panel would receive the paddle connector—with the same scrutiny as its cable lengths. Indeed, if attached with less tolerance than the maximum billowing of the net, then extreme movement could rip the aluminum piece from its source.



Using computational fluid dynamics to model the cable net under 815 different conditions, the team arrived at peak width and height values for the holes of 0.23 inches and 0.08 inches, respectively. Hole dimensions were set with construction tolerances. A similar parametric design process also generated the cruciform-shaped paddle (see diagram), which swages the crisscrossing cables with a through-bolt; the paddle's horizontal and vertical pieces measure 0.25 inches thick at their ends, and taper to 0.125 inches at that bolted midpoint. All elements freely rotate around the bolt axis to account for panel movement. Bolts at the tips of the horizontal and vertical pieces connect paddle to panel.

The meticulous engineering of *Sky Reflector–Net* might suggest a direct file-to-fabrication approach to execution. But this project's delivery required overlapping digital efforts. "We engage in modeling before we even sell a project," says Jeff Vaglio, a Los Angeles–based associate director of Enclos' Advanced Technology Studio, which assumed oversight of fabricating and erecting the artwork in summer 2010. He continues, "On many projects, it is not until after contracts are awarded that we're able to exchange model information."

Enclos and Arup used the same software platforms in modeling the cable net and its panels. They did not necessarily incorporate the same criteria. Namely, "We set up our tools to anticipate field conditions that are not absolutely precise, but are within construction tolerances of adjacent trades," Vaglio says.

Strength of panel-to-paddle bolts was one inconsistency that arose from the different perspectives. In turn, Arup and Enclos discussed the movement tolerances associated with a more robust bolt, forecast the network-wide ramifications of individual adjustments, and then identified the exact locations to increase bolt size. All of the cable net's bolts are stainless steel ASTM Grade F593 316, and nuts are stainless steel ASTM Grade F594 316. Eighth- and sixteenth-inch-thick Neoprene and Teflon-coated washers separate the panel and paddle materials to avert galvanic reaction.

The enlarged design team relished further opportunities to ensure accuracy. Enclos and Schopfheim, Germany–based panel manufacturer Durlum conducted parallel engineering to validate production of the 8,524 square feet of anodized aluminum. Similar quality control was performed during the mockup of 13 panels at the Westford, Massachusetts, workshop of contractor TriPyramid, with one engineering team manually deriving the panel geometry and a second team automatically generating it from the parametric model.

Finally, Enclos deferred fabrication of tensioned AESS stainless-steel tie-back rods until site surveys confirmed as-built data: Each 0.375-inch-diameter rod addresses construction tolerances via adjustability. At the oculus, for example, rod segments were connected by couplers set within a hole at the base of each kingpost—the vertical member that connects the tension rods to the oculus's upper lattice of tube sections. "The rods had to be free to slide through the kingpost holes so the contractor could tension the rods evenly, but to resist skylight deflections we needed to be able to lock each kingpost to the rods once tensioning was finished," Kostura explains. "So we came up with a novel detail involving cylindrical nuts that could be torqued against external threads on the coupler until they bear on a flange within the pocket of the kingpost. Those nuts were left loose on the rod assembly until tensioning was complete. The result was a stable system with compact, almost invisible connections between the kingpost and rod."

"It makes me feel very safe that, as a group, we're taking the precautionary steps to ensure a prudent structure," Vaglio says of the redundancy. And while that diligence clearly paid off—the *Sky Reflector-Net* cable net was installed in one piece during a single morning for minimal disruption to adjacent work, for example—Vaglio adds, "We learned that no matter how precise our modeling, there's always a point when the reality—the construction site—decouples from the model and craftsmanship is paramount." Double- and triple-checked in the abstract and perfected in the field, *Sky Reflector-Net* spins its transformative effect on commuters, and elevates Fulton Center from public transit node to a jewel for the people. ☐

This spread Work on the surrounding pavilion building continued throughout cable net installation. Work was performed carefully to ensure the relatively delicate cable net system was not compromised by construction activities nearby.

FULTON CENTER SKY-REFLECTOR NET

Location: **Fulton at Broadway and Cortland Street, New York, NY**
Owner: **MTA Arts for Transit and Urban Design and the MTA Capital Construction Company (MTACC)**, *New York, NY*
Sky-Reflector Net Artist: **James Carpenter Design Associates (JCDA)**, *New York, NY*
Architect: **Grimshaw Architects**, *New York, NY*
Structural and Mechanical Engineer, Facade Consultant: **Arup**, *New York, NY*
Construction Manager: **Lend Lease**, part of a joint venture with **PB Americas**, *New York, NY*
Structural Steel Erector: **Imperial Iron Works**, *Bronx, NY*
Architectural Metal Erector: **Jordan Panel Systems Corp.** (exterior/interior metal panels), *East Northport, NY*
Ornamental Metal Erector: **Capco Steel Erection Co.**, *Providence, RI*
Curtain Wall Fabricator and Erector: **Enclos**, *New York, NY*

Fulton Center Structure

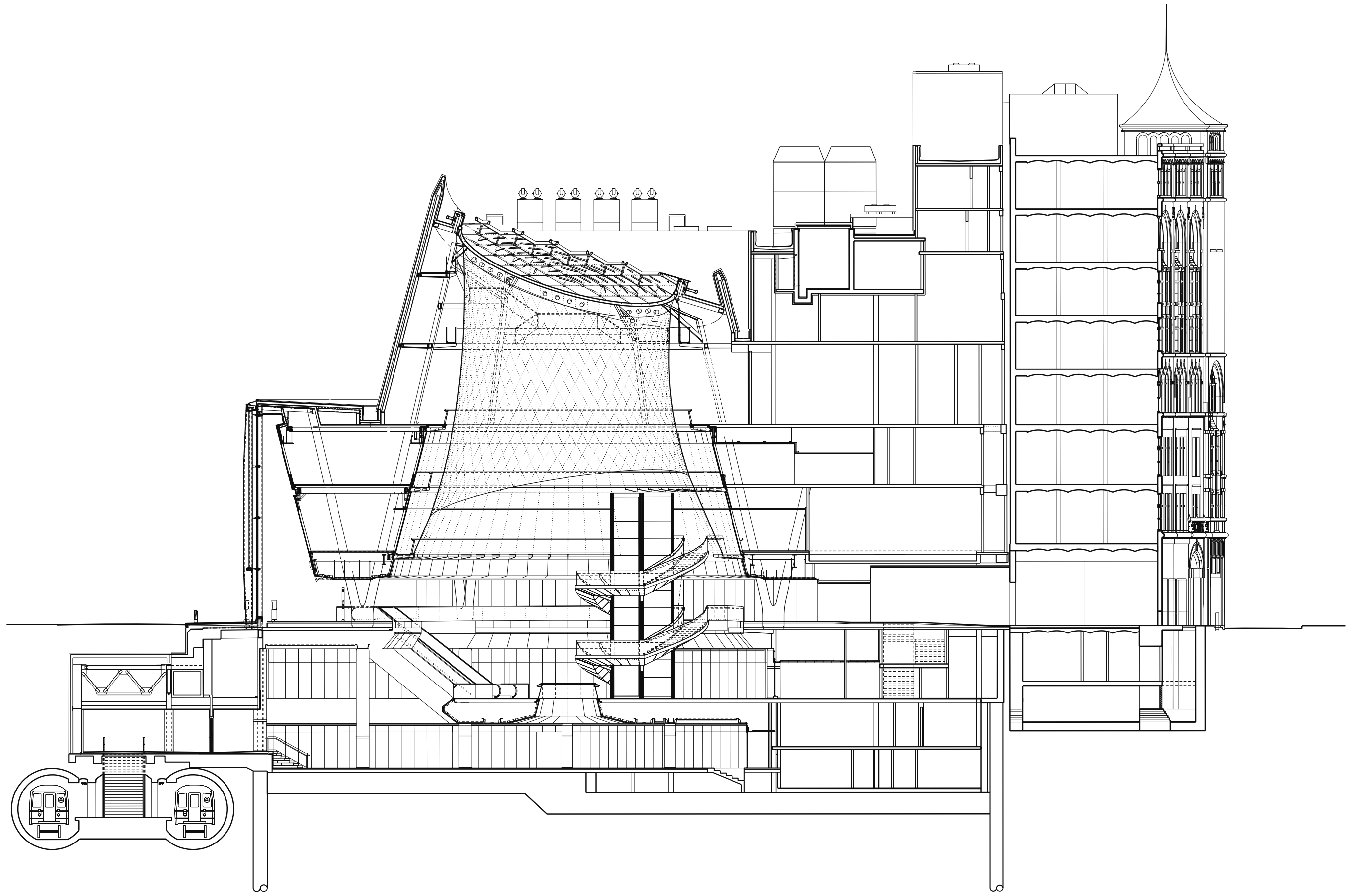
New York City's subway system is a wonder of the world—which most riders take for granted. At the new Fulton Center in Lower Manhattan, a single escalator ride can remind even the most jaded urbanites of the marvel at their service.

FROM JOHN STREET, VISITORS CAN enter the Fulton Center pavilion via the Romanesque Revival–style Corbin Building. There, they reach a concourse underneath Broadway via a 30-degree wellway that cuts a section through the basement and sub-basement of the 125-year-old building, revealing inverted masonry arches that distribute superstructure loads more evenly. Commenting recently in *The Guardian*, Jimmy Stamp wrote that the escalator journey makes available to the public a "beauty of construction that can be found nowhere else. This short descent makes you feel the weight of the building and realize the incredible feat of engineering that is the New York City subway."

Adapted as an extension of the Fulton Center pavilion, the Corbin Building contributes multiple meanings to the wider project. The eight-story landmark is an aesthetic foil to the Grimshaw design next door. Once widely known as the "father of the skyscraper," the building also preserves Lower Manhattan's complex urban fabric. And, designed by Francis Hatch Kimball for Long Island Rail Road president Austin Corbin, the building helps the Fulton Center capture the full spectrum of New York's transportation history.

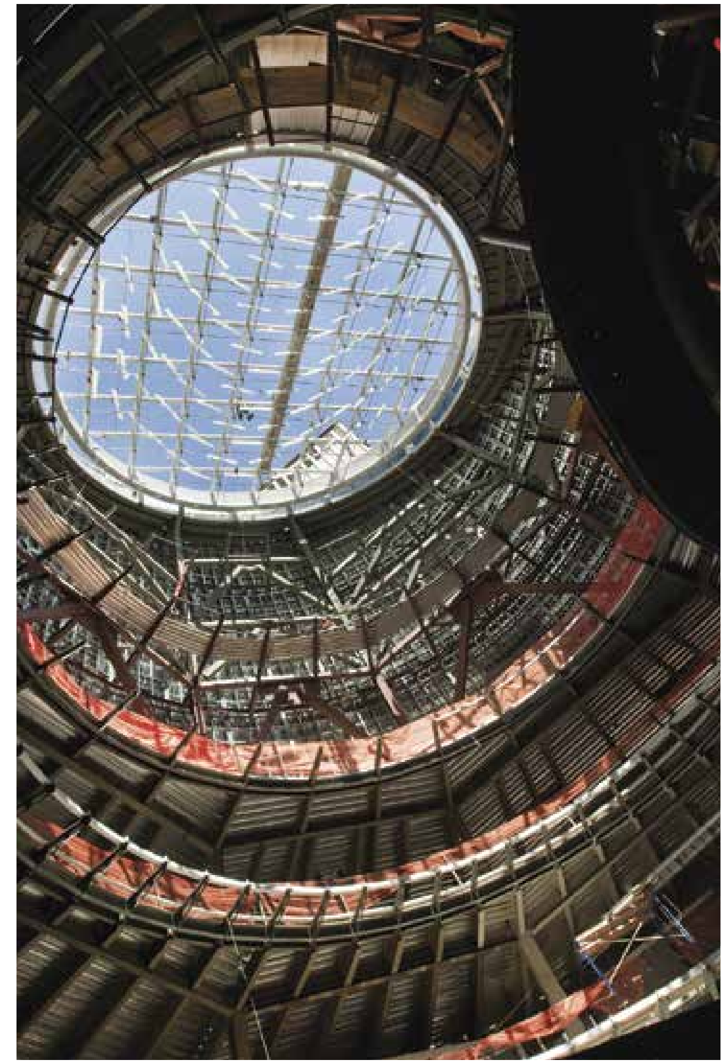
Yet initial plans for the Fulton Center had targeted the Corbin Building for teardown.

In 2003 MTA Capital Construction appointed Arup as prime consultant for the Fulton Center, and the multidisciplinary engineering firm hired Page Ayres Cowley Architects to document the Corbin Building prior to demolition. This research disinterred rich memory from underneath years of neglect, which contributed to the proto-skyscraper's addition to the National Register of Historic Places later that year.



Above A section of the Fulton Center and the adjacent Corbin Building.
Left An interstitial building ties the Fulton Center to the historic Corbin structure.

This spread photographs: MTA/Patrick Cashin; diagram: Arup; opening spread: James Ewing



Above left Within the pavilion, the outer branches of V columns support the pavilion roof, while the inner branches support the oculus and frame the center's dome.
Above right A circulating stair connects the center's shopping and dining venues.

Grimshaw and Arup's scheme for the overall Fulton Center was revised, to save the high-rise. In order to fully integrate into the transit node, the Corbin Building would perform as the southern entrance to the Fulton Center and include the plunging escalator, among other functions. Allocating those roles to the structure meant first updating it to current codes and standards, says Arup principal Craig Covil, noting, "When the Corbin Building was designed 125 years ago, the New York building code did not have chapters concerning seismic nor wind loading."

The Corbin Building forms a 152-foot-long narrow wedge shape whose major axis runs north to south, and which measures 40 feet at its widest point. Structurally, it comprises a gravity frame of cast-iron columns and wrought-iron beams supporting Guastavino tile-arch floors. While columns are embedded within the building envelope, the facade is self-supporting masonry, with self-supporting cast-iron bay windows on the south and west elevations.

Unreinforced masonry is the source of lateral stability in a historical building like the Corbin tower, and due to the 20-foot width of the west elevation, as well as its abundant fenestration, Arup identified this side of the building as a particular weak spot for lateral load. It also found that the new functions required of the Corbin Building's adaptive reuse could compromise the structure further. In a 3-dimensional ETABS model, for example, Arup demonstrated that penetrating the north elevation to link to Fulton Center new construction overstressed the masonry. The escalator wellway—the realization of which would require removal of parts of the street and two basement levels, all within liquefiable soils—also posed adverse effects to the south masonry retaining wall.

To resist north–south loading, the Arup team decided to link the Corbin Building's destiny to the new construction. Instead of creating lateral load structure within a small historic footprint, it ties levels 2 and 3 of the Corbin Building to the Fulton Center via an interstitial building. Set back slightly from the Broadway street wall, the interstitial building features a structural steel grid of wide-flange steel sections consistent with ASTM A992 standards rising the full height of the Corbin Building. Covil refers to the seemingly separate volume as a "splint."

During construction, steel integrity ties consisting of 8-by-4-inch double angles were installed in a north-south direction between opposing piers. These angles were required to resolve the lateral thrust of the inverted arch foundations during ex-

cavation of the adjacent lot. In preparation for the transit center's construction, engineers underpinned the western end of the building. These portions are supported on reinforced concrete walls cast beneath the existing shallow foundation.

For additional support, Arup applied a seismic upgrade technique to the north-elevation masonry between datum and level 2. Crews encased the wall in 4 inches of reinforced shotcrete and attached it to the existing masonry via L-shaped reinforcing bars in a 2-by-2-foot grid. To stiffen the Corbin Building above level 3, a concrete moment frame distributes lateral loads to the Fulton Center ties below, and connects to the interstitial building directly in accordance with system modeled after springs.

Arup produced these solutions in tandem with its development of the escalator void. To realize it, the project team followed a similar principle of transferring the southern retaining wall's loads to the newly constructed floor diaphragms to the north. Now, steel and concrete act as a horizontal beam over the wellway, connecting the Corbin and interstitial building to one another at street level.

At the basement and sub-basement levels, moreover, a massive ring beam was placed within the escalator insertion, and aligned to the Fulton Center structure. A new concrete retaining wall moves load from the south retaining wall into the ring. Crews undertook the process of creating this wall over the course of more than a year, first by underpinning the new element with concrete needle beams and excavating the so-called Bull's Liver soil, then creating the retaining wall and the profiled concrete wellway itself.

When the Corbin Building earned historic status, and project stakeholders signed a memorandum of understanding to integrate the landmark into the overall Fulton Center, the design team had already developed a full-block new-construction scheme for the project. Even though the sudden change of course scrapped three months of work, Covil recalls being pleased with the decision "because preserving the Corbin Building is the right thing to do," he says. "It added significantly to our work, because we had to revisit a lot of assumptions, but that process helped our thinking."

Indeed, the interstitial building performs many other tasks, chief among them buttressing the Fulton Center pavilion in addition to the Corbin Building. The pavilion's structural grid is tied to the more robust middle structure so that, as Covil says, "Those three components are all effectively one building." (Unlike the multivalent interventions found beneath the Corbin Building, the interstitial and pavilion buildings are rooted to structural columns on 25-foot centers, which rise from a concrete raft.) In what Covil calls "a mixture of compromise and optimization," the interstitial building also shoulders egress, ConEd transformers, freight elevators, and a conduit for main electrical equipment, all of which benefit the entire headhouse facility.

The most visible of all of the maneuvers required to bring Fulton Center to life is within the pavilion, where V columns comprised of wide flange column sections rise to support the second and third floors of the "donut" surrounding the central atrium. The outer branch of each V column terminates at the pavilion roof, while the inner branch rises to support the oculus, and frame the dome beneath. Moment connections between gravity columns and primary girders provide additional lateral stability and general redundancy.

As passengers stream through the transit hub, they may be unaware of the feat of engineering that has brought them here. ☐

Above Arup demonstrated the construction's feasibility with a 3-dimensional ETABS model.
Facing The interstitial building under construction at the northeast corner of John Street and Broadway. When the Corbin earned historic status, the design team revisited initial plans for full-block development.

This page: MTA/Patrick Cashin; Facing page: James Ewing

FULTON CENTER STRUCTURE

Location: **Fulton at Broadway and Cortland Street, New York, NY**
Owner: **MTA Arts for Transit and Urban Design and the MTA Capital Construction Company (MTACC)**, *New York, NY*
Sky-Reflector Net Artist: **James Carpenter Design Associates (JCDA)**, *New York, NY*
Architect: **Grimshaw Architects**, *New York, NY*
Structural and Mechanical Engineer, Facade Consultant: **Arup**, *New York, NY*
Construction Manager: **Lend Lease**, part of a joint venture with **PB Americas**, *New York, NY*
Structural Steel Erector: **Imperial Iron Works**, *Bronx, NY*
Architectural Metal Erector: **Jordan Panel Systems Corp.** (exterior/interior metal panels), *East Northport, NY*
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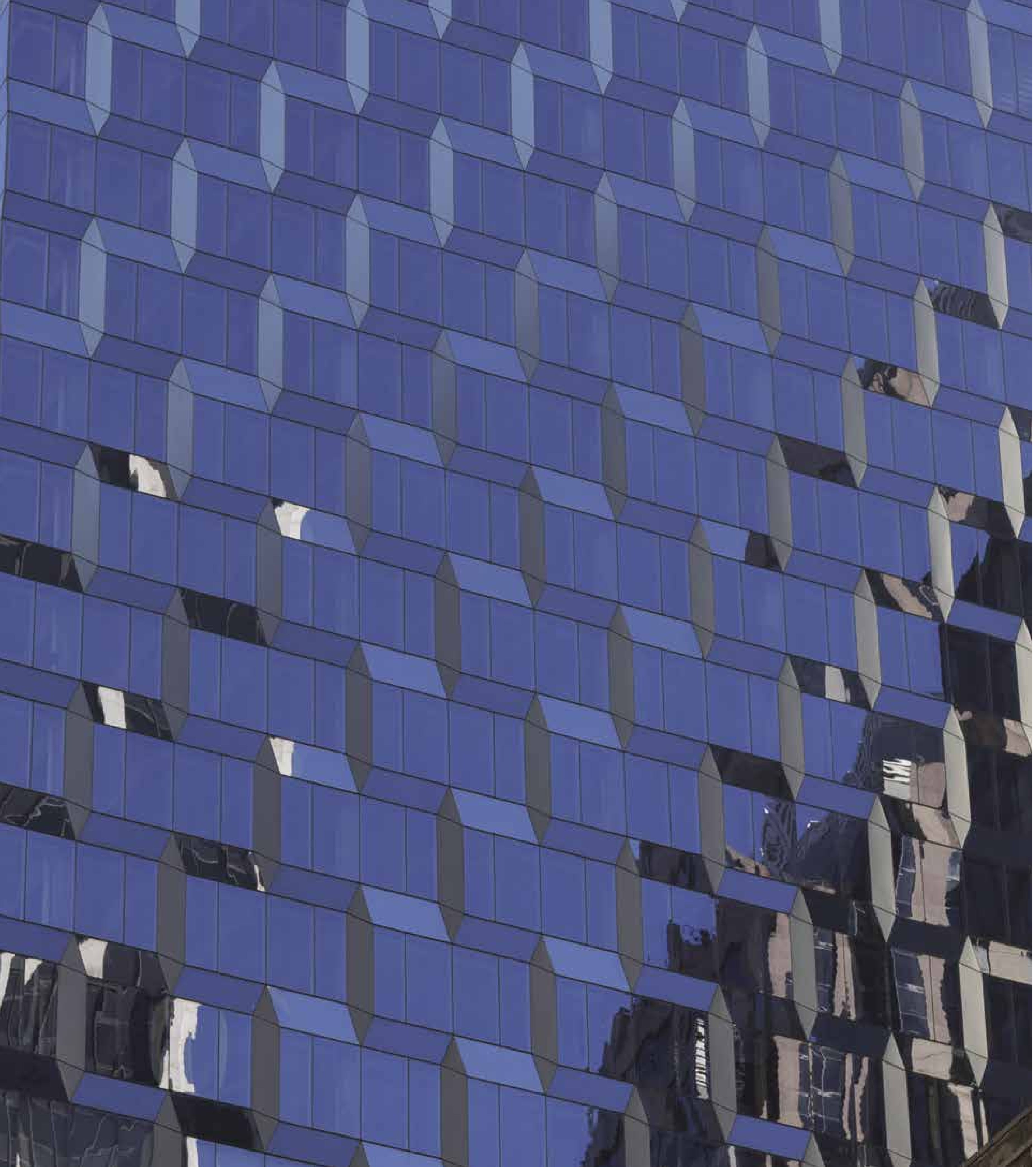


International Gem Tower

A faceted curtain wall defines a shimmering architectural icon for North America's Diamond and Gem District in Midtown Manhattan.

Editor's note: To learn about the structural steel design of the Gem Tower, read The Gem of the Big Apple *reposted with permission from the December 2014 issue of* Modern Steel Construction *at www.siny.org/project/GemTower.*

FORTY-SEVENTH STREET BETWEEN MANHATTAN'S Fifth and Sixth Avenues is renowned worldwide for its prominence in the gem industry. When a midblock site provided the opportunity to erect a symbol of this distinction, developer Extell commissioned architect Skidmore, Owings & Merrill (SOM) to design the International Gem Tower, a 34-story steel and glass office building whose signature feature is its dazzling curtain wall.

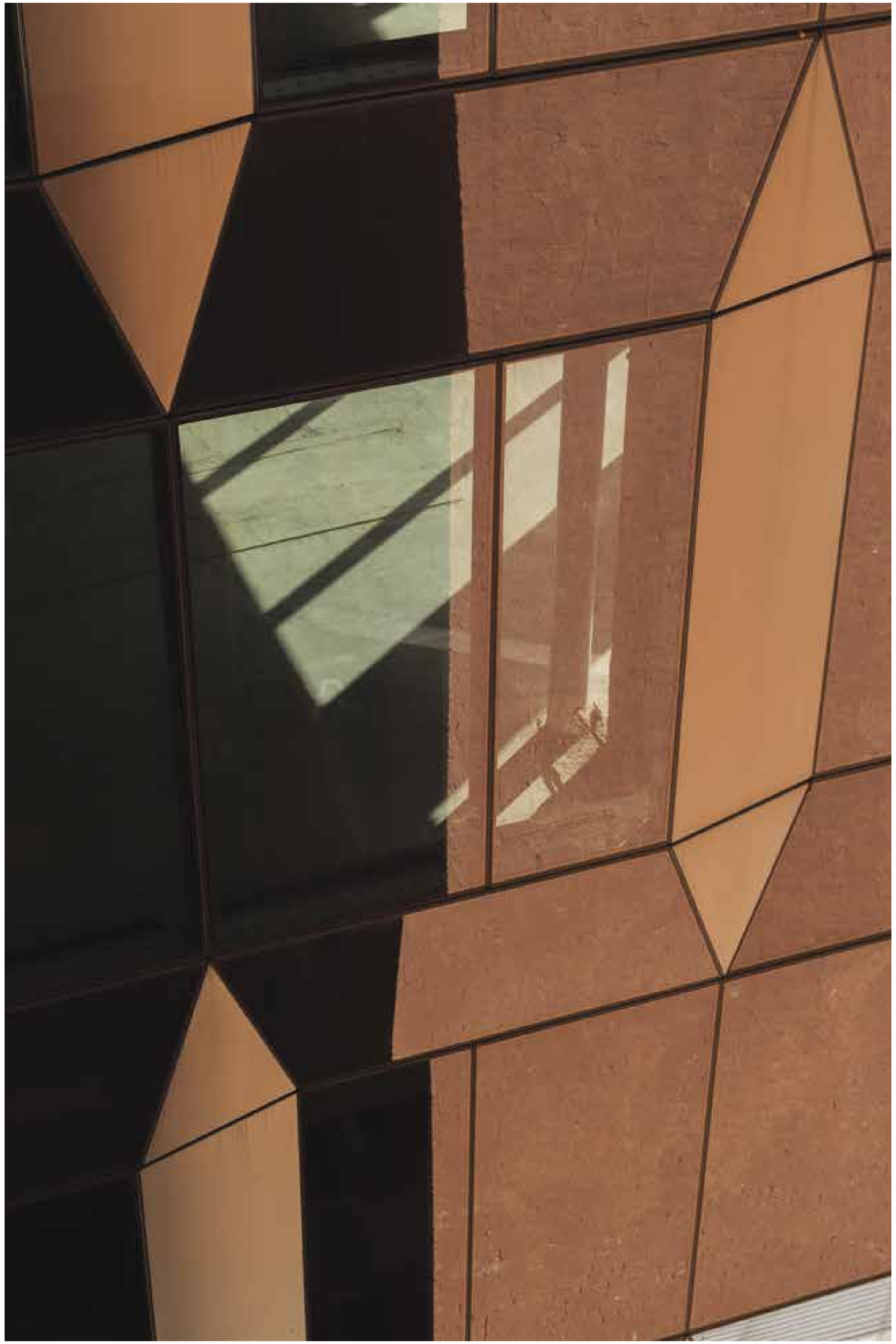
Extell, whose President, Gary Barnett, worked in the diamond industry in a previous life and brought significant market knowledge to the project, "wanted an iconic building that they could be proud of, with enhanced visibility and recognition, especially since there's no avenue frontage," says Kim Van Holsbeke, senior design architect at SOM. High-rises are typically located along the avenues in New York City, but because the Gem Tower is sited mid-block, the upper floors boast unobstructed views north to Rockefeller Center, and south to the Empire State Building.

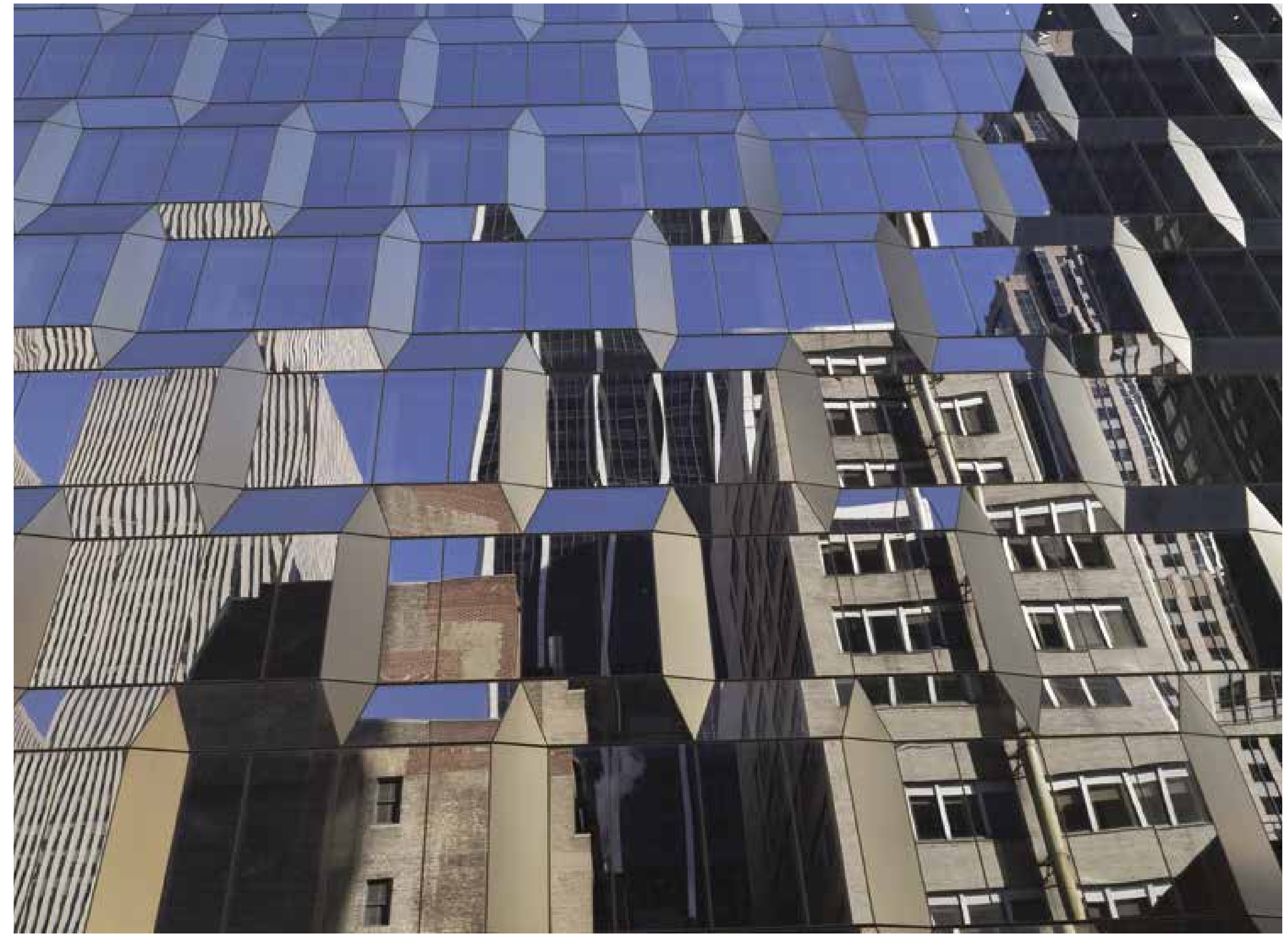
Although planning began nearly a decade ago, the project progressed slowly during the recession of the late aughts and picked up again as the economy began to regain momentum. The delay provided an opportunity to refine the ratio of rental units and gem suites and define a building plan that would be sustainable within New York's real estate market. "Feasibility studies began in 2005, and by early 2006 we had determined the building configuration and started the intensive design process," says Van Holsbeke. Construction drawings were finalized in 2007 and excavation moved slowly for the next two years. In 2010, when economic growth rates started to rise, so did the tower.

The building is divided into three zones: A three-story podium is programmed for retail through the second floor; an office rental component that comprises the middle section of the tower and fronts 46th Street (13 stories) and long-term tenants in the diamond industry occupy an elevated series of condominium suites that face 47th street (17 stories). The corporate rental units and the gem suites presented very different business typologies, so each has its own entrance on its corresponding street with private elevator banks.

For the latter, many tenants of the gem industry require highly secured space with loading requirements that support reinforced safes and security systems. A reinforced steel band in the floor slabs was added to the base building structure to minimize additional reinforcements post occupancy. The full-time tenants—including the Gemological Institute of America, which has purchased three floors at 50 West 47th Street—occupy the higher floors to maximize views.

The client challenged SOM to go beyond a detailed curtain wall and design an icon for the gem industry. "The story of the diamond industry didn't inspire the geometry directly, but it's very fitting for its location," says Van Holsbeke. The design was conceived as a subtly folded glass plane realized





This spread A non-directional finish for the curtain wall's stainless steel components requires little maintenance and gives a multifaceted appearance.

This spread and opening page: Tex Jernigan

through a repetitive system that achieves a 14-inch depth through a pleated geometry. Seven variations of insulated glass units form 232,447 square feet of the curtain wall facade. Each IGU, or medallion, measures 15 feet in height and 3 feet in width. Depth is achieved through fritted glass spandrels that pitch 8 inches out from the vertical vision panels and a 9-foot rectangle, punctuated vertically with 3-foot triangles of stainless steel with a starlight 7J finish. The result is an elongated hexagonal shape that bookends each panel with great effect on the visual geometry but not leasable square footage. The panels appear to angle outward but are, in fact, perpendicular to the floor plates to maximize interior real estate.

Low iron, insulated glass manufactured by Viracon forms the 27-square-foot surface area of the vision lites—the majority of the surface area on each panel. At the base of the panel, ceramic fritted spandrel glass features a full-flood coat to conceal the floor slabs behind it, says Larry Platman, senior project manager at Permasteelisa. The curtain wall is bolted to the floor plates with proprietary, extruded aluminum P-anchors via hooks connected to the back of the curtain wall. "The proprietary fastening system is cleaner and provides adjustability in various applications, including laterally, vertically, and after the curtain wall has been installed," Platman explains.

The panels of Starlight 7J stainless steel were manufactured in Japan by Tsukiboshi Art Company. The finish is non-directional and uniformly textured without any coatings, so it requires very little maintenance. "We selected the steel early on because of the quality," Van Holsbeke says. "The Starlight 7J stainless has a beaded speckle quality that reduces directionality and produces a particular liveliness when the suns hits it."

Thanks to carefully specified materials, the facade has an ever-changing appearance, dependent upon the weather conditions. "The reflective character of the sun would embellish a semi-diagonal pattern, or sometimes they'd disappear into the shimmering building, which we thought very fitting since diamonds and gems do the same by polishing and faceting the stone's surface," Van Holsbeke explains. "We created an analogy for how we treated the facade to create a vibrant and dynamic presence."

Different elements of the facade are emphasized depending on light levels and the time of day, an effect the architects modeled in Rhino and Maxwell.
Facing The 232,447-square-foot facade is comprised of seven types of insulated glass units.

This page: Tex Jernigan; Facing page: Extell

"We created an analogy for how we treated the facade to create a vibrant and dynamic presence."

Kim Van Holsbeke, Skidmore, Owings & Merrill

The ideas were first tested in Rhino and Maxwell to mimic the effects of environmental conditions, from sun angles to cloud densities. Computer-aided analysis also helped derive cost efficiencies and communicate the geometry to the client and curtain wall manufacturer, Permasteelisa. It even identified the maintenance challenge posed by marrying the steel against glass: Window-washing rollers roll over the outer point of the glass, so the sharp edge of the steel frame rolls over the glass edge for greater resistance against natural wear and tear.

Since completion, the International Gem Tower has been leased to near its maximum capacity. The retail portion of the building has been purchased by the Gulayar Group, which fitted out the building's 80 feet of frontage with marble and mirrored finishes that beckon visitors to enter the International Gem Tower's street-level Jewelry Shopping Mall. ☐

INTERNATIONAL GEM TOWER

Location: **50 West 47th Street, New York, NY**
Owner/Developer: **Extell Development Company**, *New York, NY*
Architect: **Skidmore, Owings & Merrill LLP**, *New York, NY*
Structural Engineer: **DeSimone Consulting Engineers**, *New York, NY*
Mechanical Engineer: **Edwards & Zuck**, *New York, NY*
Construction Manager: **Tishman Construction**, *New York, NY*
Curtain Wall Consultant: **IBA Consultants**, *New York, NY*
Structural Steel Erector: **DCM Erectors, Inc.**, *New York, NY*
Curtain Wall Fabricator: **Permasteelisa North America Corp.**, *New York, NY*
Curtain Wall Erector: **Tower Installation, LLC**, *Windsor, CT*
Metal Deck Erector: **DCM Erectors, Inc.**, *New York, NY*

One World Trade Center
Facade

The tower's base as seen from the grounds of the National September 11 Memorial and Museum, pictured in the foreground.
Facing The tower under construction in 2011.

This page: Tex Jernigan; facing page and opening spread: James Ewing/OTTO

An icon before it was ever built, the tower in Lower Manhattan is known throughout the world by a shimmering facade that protects those within even as it enhances the city around it.

THE COMPLETION OF ONE WORLD Trade Center marks a milestone in New York's post-9/11 recovery. The emblematic nature of the building, located just north of the massive pools set within the footprints of the fallen Twin Towers it is meant to replace, brought continual challenges to a design team that briefly included World Trade Center site master planner Daniel Libeskind. All that remains of his original concept for the building, once referred to as the Freedom Tower, is the iconic 1,776-foot height, coinciding with the year the Declaration of Independence was signed, and making One WTC the tallest building in the Western Hemisphere, surpassing Chicago's Willis Tower.

What emerged instead—after a decade of endless dialogue, design, re-design, and construction—is a gleaming tower whose monolithic appearance masks a heavily reinforced structure. (The building's structural design is detailed in a feature on page 26). "Our most convincing attribute is that you look at the building and it looks like an office building, and you have no idea how robust it is," says Kenneth Lewis, managing partner at Skidmore, Owings & Merrill (SOM). According to Lewis, the architects at the New York office of SOM, led by chief designer David Childs, wanted to make the façade as uniform as possible to create the image of a building that was aspirational rather than defensive.

To achieve that seamless look, SOM worked with Viracon to specify glass panels that were extremely large, building a special production line for that purpose. While most glass panels at the time of fabrication a few years ago were configured to be about 10 feet tall with an additional spandrel piece, the glass panels at One WTC are 13 feet, 4 inches and span the entire floor-to-floor height without intermediary mullions. "What we did that was unique with this project back then is that we chose to run the glass fully by the slab edge so the horizontal mullion at the bottom doesn't break through the glass," explains Nicole Dosso, a director at SOM. The design also maximizes the vision area for building occupants and facilitated the installation process of the unitized curtain wall during construction. Reinforced mullions, some as heavy as 60 pounds each, are clipped at the edge of the slab and attach the curtain wall to the building.

The glass itself is a single, low-iron insulated glazing unit (IGU). Its outer lite is thicker than what normally would be required for wind or hurricane force winds, a minimum of ⅜ inches when standard thickness is ¼ inch. The inner lite—laminated for the safety of occupants—varies in thickness depending on location. The end result is a crisp, clear panel that produces pure reflection rather than the oil-canning effect that can create an impressionistic appearance. "That makes the form of the building read as a whole instead of as an articulated surface," says Lewis.

Though the shimmering glass façade stands as a kaleidoscopic display of refracted light as the sun and clouds move through the sky, the prismatic structure nevertheless is articulated with stainless steel panels spanning the full height of each floor at its

> “You look at the building and it looks like an office building, and you have no idea how robust it is.”
>
> Kenneth Lewis, Skidmore, Owings & Merrill

corners as the square plan at the bottom of the building shifts and tapers to a smaller square at the top. Measuring 200 feet by 200 feet at its base—the same size as the footprints of the original Twin Towers and the memorial pools—One WTC is capped by a 150-foot by 150-foot square, which is rotated 45 degrees so that the midpoints of the square at the bottom are the corners of the square at the top. The imposing shaft that gives form to this transition—producing eight isosceles triangles that run the length of the shaft and a series of octagonal floor plates at its center—comprises over 70 floors of office space rising above the 186-foot-tall concrete podium at the base and culminating in three levels of observation decks spanning the 100th to 102nd floors. The 6-foot-tall steel band at its roof has an upper elevation of 1,368 feet and a lower one of 1,362 feet—the two heights of the original Twin Towers. A series of communication platform rings and a 441-foot-tall mast crown the observatory.

Just below and above the observation decks are mechanical areas. In order to eliminate any louvers exposed on the exterior wall, the designers created a plenum behind it, housing an interior walkway. Set back approximately 5 feet from the curtain wall is a continuous louver that conceals all mechanical distribution. The empty vertical slots over these areas that are visible from the exterior are a result of smaller curtain wall panels there. Rather than the typical 5-foot-wide panel, the glass stops short by just over a foot, allowing intake and exhaust to occur through those open slots.

A third major mechanical level is located in the podium. The podium wall base consists of vertical laminated glass fins and horizontal stainless steel slats. The more than 4,000 glass fins, each measuring 13 feet, 4 inches by 2 feet, are positioned at varying angles in a regular pattern over the height of the podium. This pattern accommodates ventilation for the mechanical levels behind the podium wall. A reflective coating refracts and transmits light to create a dynamic glass surface in an attempt to assuage the fortress-like appearance of the podium’s 28-inch-thick concrete walls. Glass over the lobby entrances feature a dichroic coating that reflects and absorbs different portions of the color spectrum, resulting in a range of red, purple, and green casts, depending on the angle of vision.

Perhaps the greatest achievement of the curtain wall however, is not what is visible from the outside, but what is experienced from the inside. The extra large, unobstructed glass panels flood the narrow floor areas around the building’s core with daylight, creating bright, sunny office space that requires very little artificial lighting. And of course, there’s always the view. □

Above More than 4,000 laminated glass fins and stainless steel slats form the face of the podium, accommodating mechanical ventilation and breaking down the mass of the building’s base.

This spread: James Ewing

ONE WORLD TRADE CENTER FACADE

Location: **1 World Trade Center, New York, NY**
Architect: **Skidmore, Owings & Merrill LLP**, *New York, NY*
Developer: **1 World Trade Center LLC** (a wholly owned corporation by the Port Authority of New York and New Jersey and the Durst Organization), *New York, NY*
Structural Engineer: **WSP Cantor Seinuk**, *New York, NY*
Mechanical Engineer: **Jaros Baum & Bolles**, *New York, NY*
Spire, Communications Rings, Cable Net Wall Engineer: **Schlaich, Bergermann und Partner Gmbh**, *New York, NY*
Protective Design Engineer: **Weidlinger Associates**, *New York, NY*
Construction Manager: **Tishman Construction Corporation** (An AECOM Company), *New York, NY*
Curtain Wall Commissioning Consultant: **Israel Berger and Associates**, *New York, NY*
Structural Steel Erector: **DCM Erectors Inc.**, *New York, NY*
Architectural and Ornamental Metal Erector: **Tower Installation**, *New York, NY*
Curtain Wall Fabricator and Erector: **Benson Industries, Inc.**, *New York, NY*
Metal Deck Erector: **DCM Erectors Inc.**, *New York, NY*

One World Trade Center
Structure

A product of both historic loss and future goals for Lower Manhattan, the building's structural steel frame maximizes safety, construction efficiency, and tenant experience.

Editor's note: Because of security requirements for One World Trade Center and surrounding properties, certain information on the grade, size, and type of structural steel has been omitted.

SIMPLY PUT, ONE WORLD TRADE Center's structure consists of a concrete core and a steel perimeter moment frame. But there is nothing simple about the design of this 1,776-foot tall crystalline icon—the most significant of the new construction at the 16-acre World Trade Center site both from a symbolic point of view, and in terms of sheer size.

At its base, the structure's massive 110-by-110-foot concrete core, whose walls are as much as 4 feet thick, is bigger than most towers being built today. By comparison, Rafael Viñoly's recently topped-out 432 Park Avenue, also in Manhattan—which, at 1,396 feet, surpasses One WTC's 1,368-foot-high roofline—can fit inside of it.

Notably, the "tube" design of the original Twin Towers took much of the structural duty away from the buildings' center and placed it with the exterior walls. In One WTC's hybrid structure, both are equally important. "Having a robust core has a lot of value," says Ahmad Rahimian, Director of Building Structures at WSP Group, who worked with the architects at SOM on both One WTC and the previously completed Seven WTC, in addition to several other structures at Ground Zero. "The core brings stiffness and strength, and securely houses all the mechanical distribution, and especially all means of egress—the inadequacies of the Twin Towers' stairs were a problem."

The building's perimeter features a framing system that uses approximately 45,000 tons of high-strength structural steel, used along with the prequalified ductile beam-column connections. At the lower levels, multi-floor "super diagonals" encircle the building like a belt. At the uppermost floors by the mechanical levels, outriggers connect the perimeter columns to the core. The structural system at the perimeter allows for load shedding, or the transfer of loads to other locations. "On a theoretical level, the moment frame creates a rope out of all of the perimeter beams so that if the thing that is supporting that rope goes away—two columns, for example—that rope goes into tension and pulls the forces back to the core, which is where they want to go," explains SOM's Kenneth Lewis.

At One WTC, life safety is paramount. "The engineering of the original Twin Towers was brilliant," Lewis says. "It created robust buildings against forces of wind and earthquake that were incredibly light. However, it did not anticipate what happened to them—I don't think anyone could have." To provide optimum egress and firefighting capacity, the new building features extra-wide pressurized stairs, concrete protection for all sprinklers and emergency

Taken together, the perimeter and core systems make One World Trade Center safer than either system could make it on its own.

Left The tower under construction in 2011 amid massive infrastructure improvements adjacent to the site.
Facing top An aerial view of One WTC and the National September 11 Memorial site.
Facing bottom From left: typical low-, mid-, and high-rise floor plans illustrate the tower's tapering form.

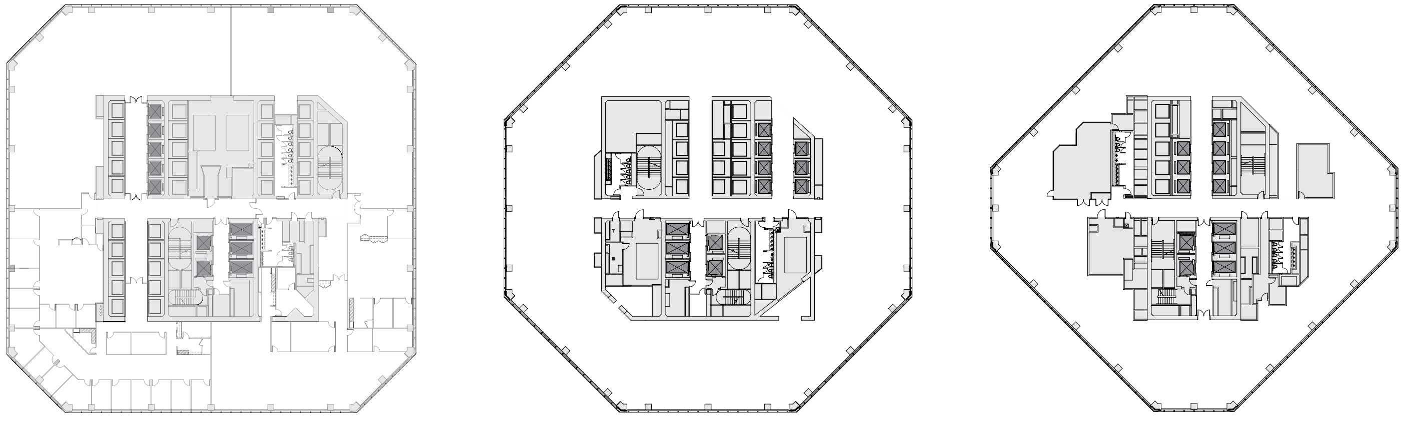
risers, interconnected redundant exits, additional stair exit locations at all adjacent streets, and direct exits to the street from tower stairs. To safeguard the building against the threat of vehicle-delivered explosives, the lower portion of the fortified base features 28-inch-thick concrete walls that shelter the area of the 60-foot-high lobby, though this is an added feature and does not contribute to the tower's structural integrity.

"We really pushed the concrete system to produce a 14,000 psi concrete—that was the first time it was done in New York City," says Rahimian. "One thing we had with this project that was nice is that the Port Authority has its own material testing lab. We worked for months to streamline the mixes."

As the over three million-square-foot building tapers, some of the cells within the core drop off, and its walls decrease in thickness to a minimum of two feet. The narrowing of the building geometry not only accommodates the project's gross area requirement, but also creates an aerodynamic shape that reduces the wind effect on the tower. "There's a practical reason why the top of the building is smaller than the bottom, not just the usual notions of load," explains Lewis. "In the old World Trade Center, you'd get to the higher floors and there were these 70- to 90-foot spans from the core, which was relatively small, to the perimeter, leaving large areas with no daylight. You want the floor area to be smaller so people are closer to the glass."

The floor system within the concrete core is a formed cast-in-place concrete beam and flat slab system, while the floor area outside the core is concrete on composite metal deck supported on steel beams and connected via shear connectors. That column-free floor system spans

This page and opening page: James Ewing/OTTO; facing page top: Iwan Baan; facing page bottom: One World Trade Center



Left Concrete walls more than 2 feet thick shelter the lobby; slots allow daylight into the space.
Above Most members of the tower's design and construction team also worked together on 7 World Trade center, a project that allowed them to test many of the safety strategies they would later use on One WTC.

This spread: James Ewing

between the core and the perimeter—with a maximum span of 47 feet—for construction efficiency and flexibility of tenant use.

At the building's apex, a 441-foot-tall spire—comprising three circular communication platform rings and a needle-like mast—is mounted atop a reinforced concrete mat that is directly supported by the tower's concrete core. According to Rahimian, that mat is strong enough to be the foundation for a 40-story building.

The tower structure extends 70 feet below grade passing through four subterranean levels where some of its structural components required repositioning to clear the PATH commuter train tracks that cross the building at the lowest basement level. The foundation and below-grade structure are founded on Manhattan bedrock using spread and strip footings with bearing capacities of 60 tons per square foot or better. Space constraints due to the proximity of existing train lines—which remained operational throughout construction—required excavating deeper into the rock at select locations in order to achieve a higher bearing capacity of up to 114 tons per square foot. Rock anchors/tie downs extending 80 feet into the rock were installed to resist the overturning effect from extreme wind events.

The symbolic significance of One WTC, rising to a record-breaking height from the ashes of the worst attack on American soil, forced designers to create a heavily reinforced tower with structural and life safety redundancies that exceed existing codes to withstand a potential similar attack while preserving life and the building itself. Taken together, the perimeter and core systems make One WTC safer than either system could make it on its own. □

ONE WORLD TRADE CENTER STRUCTURE

Location: **1 World Trade Center, New York, NY**
Architect: **Skidmore, Owings & Merrill LLP**, *New York, NY*
Developer: **1 World Trade Center LLC** (a wholly owned corporation by the Port Authority of New York and New Jersey and the Durst Organization), *New York, NY*
Structural Engineer: **WSP Cantor Seinuk**, *New York, NY*
Mechanical Engineer: **Jaros Baum & Bolles**, *New York, NY*
Spire, Communications Rings, Cable Net Wall Engineer: **Schlaich, Bergermann und Partner Gmbh**, *New York, NY*
Protective Design Engineer: **Weidlinger Associates**, *New York, NY*
Construction Manager: **Tishman Construction Corporation** (An AECOM Company), *New York, NY*
Curtain Wall Commissioning Consultant: **Israel Berger and Associates**, *New York, NY*
Structural Steel Erector: **DCM Erectors Inc.**, *New York, NY*
Architectural and Ornamental Metal Fabricator: **Airflex Corp., Inc.**, *Farmingdale, NY*
Architectural and Ornamental Metal Erector: **Tower Installation**, *New York, NY*
Curtain Wall Fabricator and Erector: **Benson Industries, Inc.**, *New York, NY*
Metal Deck Erector: **DCM Erectors Inc.**, *New York, NY*

Promise Academy I

Promise Academy I, a new project by nonprofit organization Harlem Children's Zone, relies on a steel structure to meet the building's multiple educational programming needs and solve challenges posed by its tight construction site.

RECENTLY COMPLETED WITHIN THE ST. Nicholas Houses complex, a public housing development in central Harlem, Promise Academy I aims to offer the community's children a bright future by providing them with school facilities that best fit K-12 students' educational needs. With a facade colored in light, neutral shades accented by glazing framed in bold red, this five-story, 135,000-square-foot school building with rooftop play areas stands out from the surrounding institutional red brick housing.

Given a very restrictive site within the residential development, architect John Ciardullo Associates, PC, chose a structural steel frame to solve challenges encountered during the design process and ensure the building functions as a school that accommodates more than 1,300 students of various ages.

Given its location within a housing development, Promise Academy I occupies a very constrained site where the face of the building falls on the property line. Since the perimeter footings could not extend beyond the property line, strap beams were used to tie back these footings to the interior footings. The lightweight steel frame was advantageous in reducing the eccentric loads on the perimeter footings.

"All the schools that we build in the city are steel-framed buildings," says Chuck Heaphy, a senior architect who led the project for Ciardullo. "We find that steel is well suited for schools for various reasons." One of the most important of these is the structure's ability to adapt to the wide variety of spaces required in modern educational environments: classrooms, libraries, cafeterias, gymnasium, and auditoriums. "Using steel allowed us freedom in our design to configure the spaces as we needed for this wide range of spaces in a tight site for a K-12 building," says Heaphy.

In the Promise Academy I building, the use of steel enabled not only different bay sizes needed for classrooms but also long spans for large public assembly spaces. A 67-by-97-foot area on the first floor is used as a combination gymnasium–auditorium where long span steel beams create the necessary column-free space. Cellular LB60 x 215, 52-inch-deep proprietary Smartbeam beams were selected for the gymnasium in order for them to span across the width of the gymnasium. In addition to supporting the gymnasium roof, a set of double cellular beams were used to support a three-story classroom section directly over gymnasium. The circular openings allowed the architects to run the mechanical, plumbing, and sprinkler systems through

This spread and opening spread: John Ciardullo Associates

Facing A curtain wall marked with red trim creates a visual connection with the surrounding residential complex, revealing a library. The school's steel structure allowed architects to stack a recreational area on the roof, maximizing use of the small building site.
Right The school is the largest school built for Geoffrey Canada, who is featured in the acclaimed documentary "Waiting for Superman," and his Harlem Children's Zone initiative.
Below A unitized metal wall system of aluminum-faced composite panels encloses most of the building's exterior.

the beams, ensuring the gymnasium maintained the 24-foot clearance required for basketball and volleyball. The exposed steel frame at the gymnasium served to organize the MEP systems and resulted in an aesthetically pleasing structure.

Steel was also used on top of the gymnasium to create a rooftop play area. A rarely used steel shape, 8-inch hollow steel sections (HSS) with a 24-foot height, was used around the play yard's perimeter to support a network of steel cables. A netting system was connected to the cables in order to enclose the play yard.

"The most important priority for the project was scheduling," says Heaphy. "The Harlem Children's Zone wanted this school to be up and running as soon as possible because there was an urgent need for educational space." A unitized metal wall system composed of aluminum faced composite panels encloses the majority of the building's exterior. The unitized system allowed 12-by-30-foot panels for the wall system to be fabricated offsite in Long Island while the steel frame was being erected. Using this wall system helped them to save at least three to four months of erection time. The concurrent process of offsite panel fabrication and onsite steel frame erection worked well for a project started during severe wintertime weather conditions. "Six weeks after the steel frame was erected, we had an enclosed building ready for the interior work," says Heaphy.

Contrasting materials on the lower and upper levels of the building achieved aesthetic and functional goals—brick on the lower floor allowed the architects to tie the building into its surrounding context and also provided durability for the lower floor. Above the first floor, the four-story metal panel system puts less weight on the lower part of the building.

Above A typical classroom. The steel structure accommodates the range of spaces required for a K-12 school, including classrooms, cafeterias, and auditoriums.

Below left Cellular beams span across the width of the gymnasium, creating a column-free space and supporting three stories of classrooms overhead.
Below right The school's main entrance.

This spread: John Ciardullo Associates

A structural glazed curtain wall occupies only a small portion of the building enclosure, but serves an important purpose. On the southwest corner, two libraries stack together on the third and fourth floors where the curtain wall creates a welcoming transparency, enforcing a strong visual connection between the school and its surrounding community. In addition to the libraries, the aluminum curtain wall was used to accentuate the corners of three major circulating stairs flooding them with natural light.

Since its founding in the 1990s as a "one-block pilot", Harlem Children's Zone has provided comprehensive help and critical support to children and their families in underserved communities continually expanding the reach of its programs in the past several years. It serves more than 12,300 youth and 12,400 adults today. Open since May 2013, Promise Academy I will continue serving the community and bringing positive changes to the neighborhood for its current and future generations. □

PROMISE ACADEMY I

Location: **245 West 129th Street, New York, NY**
Owner/Developer: **HCZ-Promise LLC**, a partnership between Harlem Children's Zone and Civic Builders, *New York, NY*
Architect: **John Ciardullo Associates, P.C.**, *New York, NY*
Structural Engineer: **John Ciardullo Associates, P.C.**, *New York, NY*
Mechanical Engineer: **DVL Consulting Engineers, Inc.**, *Hackensack, NJ*
Construction Manager: **Tishman Construction, an AECOM Company**, *New York, NY*
Structural Steel Fabricator and Erector: **Glasmar Steel Erectors, Inc.**, *Rockville Centre, NY*
Miscellaneous Iron Erector: **FMB, Inc.**, *Harrison, NJ*
Architectural Metal Fabricator and Erector: **W&W Glass, LLC**, *Nanuet, NY*
Ornamental Metal Erector: **JEM Architecturals Inc.**, *Bronx, NY*
Curtain Wall Fabricator and Erector: **W&W Glass, LLC**, *Nanuet, NY*
Metal Deck Erector: **Glasmar Steel Erectors, Inc.**, *Rockville Centre, NY*

121st Police Precinct Station House

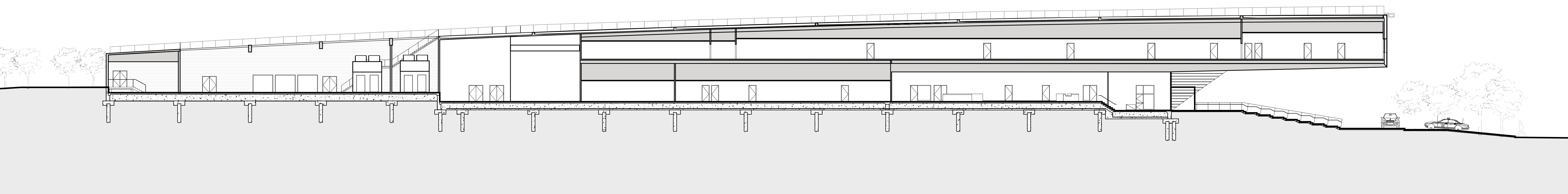
A cantilevered structural steel design allows Staten Island's new police station to sit on a challenging site—and become a new model for civic buildings in the city.

Completed in 2013, NYPD's 121st Police Precinct Station House on Staten Island is the first new stationhouse constructed in the borough in 50 years, accommodating the nearly 400 officers that serve in this rapidly growing borough. It is also the first police station in the city to be certified LEED Silver under former Mayor Michael Bloomberg's PlaNYC 2030.

Designed by Rafael Viñoly Architects (RVA), the 47,000-square-foot station's massing and design are boldly forward thinking for such a specific program. Sited on a long, narrow lot that was formerly a millings yard for the New York City Department of Transportation, the new building had to adapt to several challenging constraints: a block-long, sloping site that is smaller in the front of the building (facing east) than the back, a residential neighborhood to the north and a cemetery to the south. In response, RVA composed a 500-feet-long, gently arcing, two-story bar volume. The building's shape conforms to the narrow, irregular site, with smaller frontage (140 feet) at the bottom of the hill to the east, and the longest elevation facing north.

Bands of glazing accentuate the horizontality of the building's form and provide glimpses of the muscular trusses that support a massive second-story cantilever. Because of the slope of the site, the station is only one story on its western end, at the highest point of the hill. The cantilever makes a second story possible, and pushes the public face of the building close to busy Richmond Avenue: it gives the illusion that the lobby is closer to the street than it is, projecting a welcoming presence, but also maintaining security.

The impressive 95-foot overhang shelters broad concrete steps, creating a protected public entrance.

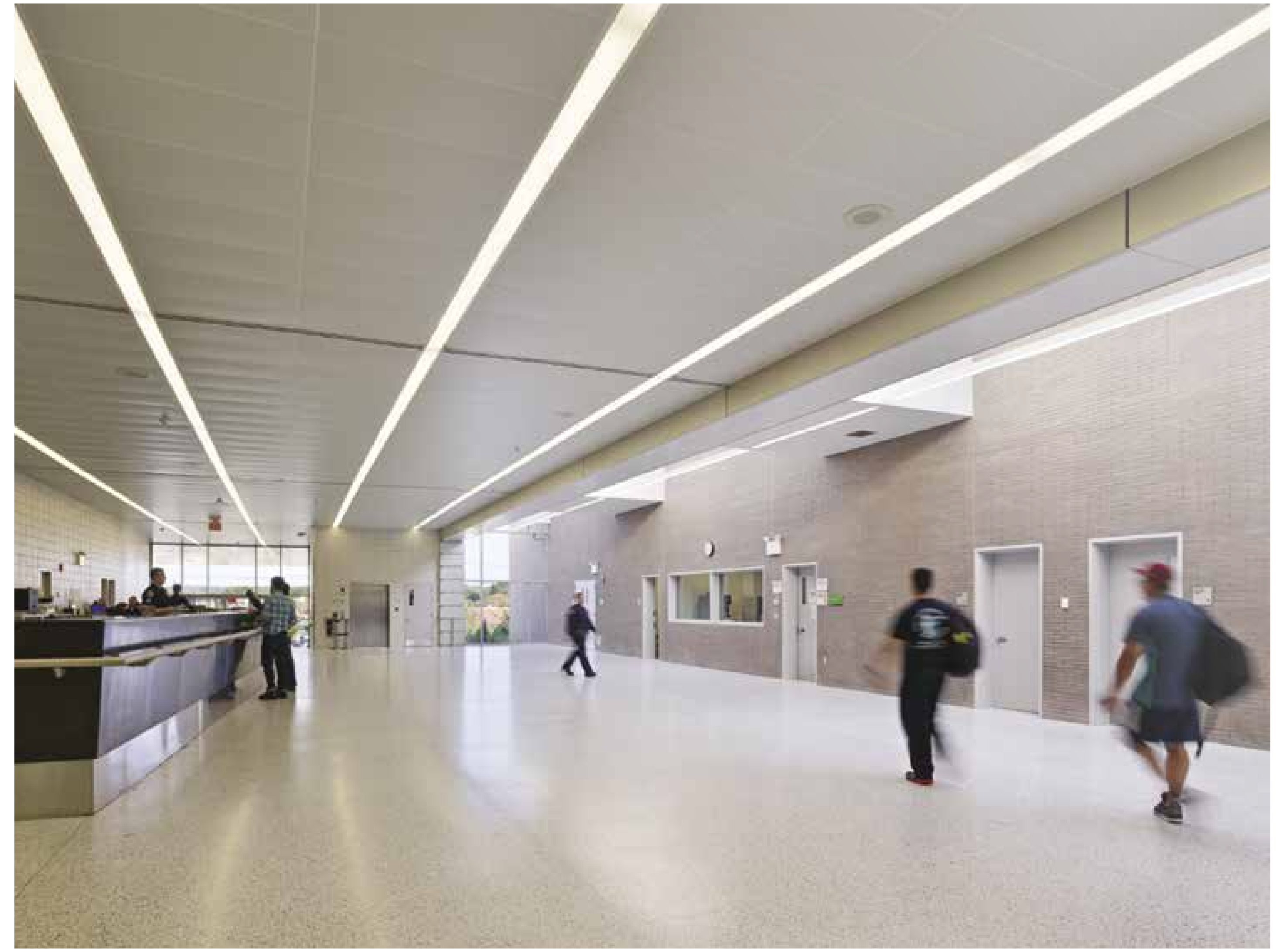


This page top: Rafael Viñoly Architects; bottom and facing: United Structural Works; opening page photo: © Bruce Damonte; diagram: Rafael Viñoly Architects

This spread Massive steel trusses allow the building's 95-foot cantilever, which creates a protective overhang above the main entrance and maximizes the long, narrow site.

The station's cantilever isn't just a grand civic gesture—it also allows for a column-free lobby and front desk area, preserving sightlines for safety and an open, airy atmosphere. Offices and storage areas line the perimeter of the ground floor behind the lobby. More offices and staff locker rooms on the second floor receive ample daylight from the bands of windows and have views out (the building's narrow footprint means that 80 percent of the spaces receive daylight and 95 percent have views). A single-story grey brick wing extends from the south houses a muster room for community meetings. It also holds a detainee processing area and the detective unit; their proximity to each other makes officers more efficient—as does a building that is only two stories. The rear third of the station, to the west, contains the building's mechanical systems and covered parking for smaller police vehicles.

As Wilmers explained, officers didn't want mechanicals located in a hard-to-reach basement, but it turned out a lower level would have nearly been impossible to construct. The architects and engineers discovered extensive amounts of granite running through the site, much of which needed to be drilled and removed. In order to create the required rock sockets, 108 caissons of 32- and 18-inches were drilled into the granite. Additional granite removal was required for the installation of grade beams,



This spread The station's cantilever creates a column-free lobby and front desk area and supports second-floor offices and staff locker rooms.

pile caps, underground utilities, and a storm detention vault.

The building's cantilever was the other big construction challenge. The design required the installation of two 95-foot-long transfer trusses featuring 120-foot back spans to counter the deflection forces of the extreme cantilever. In total four 18-foot-high steel trusses needed to be fabricated off site, disassembled, then shipped to Staten Island and reassembled laid on their sides. After reassembly, a crane operator delicately raised the truss upright, lifted and rotated them 180 degrees to land them onto previously installed steel braced frames and temporary steel shoring. Due to their composite structure, the trusses were not complete until all infill beams, metal decking, shear studs, and concrete slabs had been fully installed. The curve of the building, with a 3,800-foot radius of the building plan and a 40-foot curved increase in roof height, required careful fabrication and installation of intricate steel frame connections. The bottom courses have sections as large as W30x235, with W14x398 diagonal supports at the base of the cantilever.

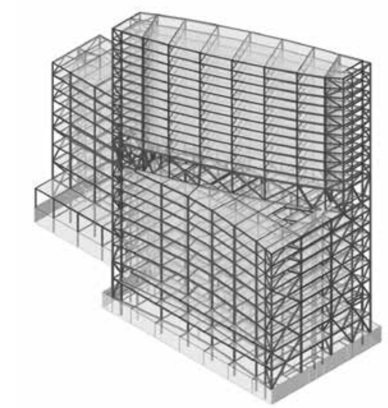
In order to achieve a LEED Silver rating, "we were able to break out of some of [the client's] standards," said Wilmers, including an energy-efficient building envelope, low-E glazing on all exterior windows and the skylight above the lobby, brownfield reclamation of the site, stormwater management, bio-retention areas, and drought-resistant landscaping. "The building orientation is also advantageous for heat gain, with the short sides facing east and west," said Wilmers. The 121st Police Precinct Station House should also set a precedent for the City's station houses of the future—both in the way it solves the quandary of a challenging site with sophisticated steel construction, and with its sleek, modern design. It serves its users efficiently and is a gracious presence in a borough poised for change. □

Above left and facing: © Bruce Damonte; Above: Brad Feinknopf

The cantilever makes a second story possible, and pushes the public face of the building close to busy Richmond Avenue, projecting a welcoming presence, but also maintaining security.

121st POLICE PRECINCT STATION HOUSE

Location: **970 Richmond Avenue, Staten Island, NY**
Owner: **New York City Police Department**, *New York, NY*
Architect: **Rafael Viñoly Architects**, *New York, NY*
Structural Engineer: **Ysrael A. Seinuk, PC**, *New York, NY*
Mechanical Engineer: **Joseph R. Loring and Associates, Inc.**, *New York NY*
Construction Manager: **The LiRo Group**, *New York, NY*
Structural Steel and Miscellaneous Iron Fabricator and Erector: **United Structural Works**, *Congers, NY*
Architectural Metal Fabricator and Erector: **RISA Management Corp.**, *Westbury, NY*
Ornamental Metal Fabricator and Erector: **RISA Management Corp.**, *Westbury, NY*



Fordham University Law School and Residence Hall

The new face of the school's Lincoln Center campus uses two curved structural steel trusses to accommodate a tight budget and the need for column-free spaces within the new mixed-use building.

IN 1954, FORDHAM UNIVERSITY PRESIDENT Father Laurence J. McGinley asked New York City master planner Robert Moses if Fordham—founded in 1841—could create a satellite of its Bronx campus by renting space in a new office building at Columbus Circle. Moses turned him down, but what he offered instead nearly made the cleric fall off his chair. According to Fordham history, Moses proposed the school use almost 10 acres of what would become Lincoln Center for the Performing Arts' 16.3-acre campus. So, before there was an Alice Tully Hall, Avery Fisher Hall, Metropolitan Opera House, or even an iconic fountain at Lincoln Center, Fordham's law school building opened there in 1962.

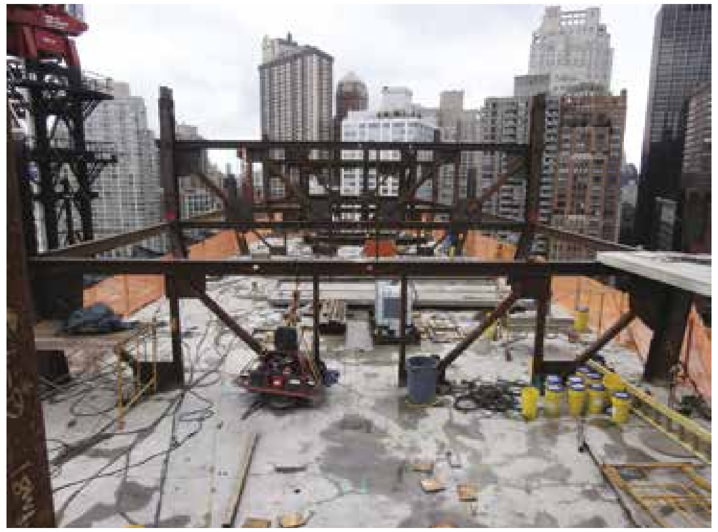
Today, Fordham's Manhattan campus has expanded to become home to portions of its undergraduate college and its graduate schools of arts and sciences, business, education, and social service. In 2014, as part of the first phase of a 15-year master plan for the Lincoln Center campus, Fordham opened the doors of a new law school and residence hall by Pei Cobb Freed & Partners, led by partners Henry Cobb and Yvonne Szeto. The nine-story law school (with a tenth floor below grade), roughly L-shaped in plan, has gently curving facades clad in a checkerboard pattern of glazing and precast concrete panels. The, 478,305-square-foot lower building more than doubles school's event and office space, while the residence hall on levels eleven through twenty-two provides much needed housing for 130 undergraduates.

The law school also creates a new northern enclosure for Fordham's Robert Moses Plaza, a lush green square, protecting it from busy West 62nd Street. Szeto and Cobb stepped the building's northern elevation back at the second floor, creating an outdoor terrace that looks across 62nd Street to Lincoln Center's plaza. Combined with this *piano nobile*, as Szeto calls it, the law school's concave curves are an inviting gesture to its grand cultural neighbor across the street, its buff-colored panels visually connecting to Lincoln Center's swaths of travertine. "From the first visit Yvonne and I made here, we were aware that this was a very privileged site," says Henry Cobb, founding partner. "We are creating, with this building, a new face for the Lincoln Center campus."

The most unusual part of Fordham's brief for the building was the inclusion of an undergraduate residence hall with the law school. Using a type of framing system developed in 1966 by prominent American structural engineer William LeMessurier, the architects deftly added a 12-story tower on top of the school in order to accommodate the dorm.

In plan, the glass and steel tower diagonally bisects the easternmost volume of the law school, with its convex curves complementing the school's concave ones. "We decided not to just place the [dormitory] east-west, so it would separate 62nd Street and the plaza, but instead to angle it so it opens out more gently to the north and south," says Szeto, gesturing to Columbus Avenue.

Such a complex mix of programs and spaces—many of them column-free, such as the law school's library, a large multi-purpose room on the second floor, and classrooms on the third and fourth—required extensive coordination with the project's structural engineers, WSP Cantor Seinuk (WSPCS).



This page, clockwise from top left Staggered truss construction. An exterior view of the mega truss. Beam openings for telecom and HVAC requirements. The school under construction in 2012. Mega truss load transfer from tower to podium. The dormitory's staggered truss.

Facing page The law school's triple-height lobby (top) and column-free moot courtroom (bottom).

This page: Christina Nambiar/Pei Cobb Freid & Partners; opening page photo: © Paul Warchol

This page and following spread: © Paul Warchol

Programmatically, Szeto and Cobb placed the law school's most public programs, such as mock courtrooms, event spaces, and the dining room, on the first two floors. Floors three and four contain instructional spaces; five and six hold the 90,000-volume law library; seven and eight are for faculty and administration offices; and the ninth floor provides an elegant and private space for the work of the law clinic, a law firm within the school that has 14 practice areas and takes court-appointed cases. "Within every package of two floors, we have multistory atriums where we connect the students," says Szeto; providing a sense of community in the "vertical campus" was another of the firm's missions.

Whereas conventional steel framing with composite concrete on metal deck flooring was selected for law school floors, LeMessurier's staggered truss system was chosen for the framing of the dormitory floors. It consists of a staggered truss steel framing system spaced up to 30 feet, with 30-foot-long, 8-inch-thick precast, pre-stressed concrete planks spanning between the trusses, with floors alternately supported on the top and bottom chords. The top and bottom chords and perimeter columns are W sections, and the interior vertical and diagonal members of the truss are HSS (square/rectangular sections). "This system results in a considerable saving in both building height and cost," explains Rodica Kestenband, Vice President and WSPCS Project Manager. The trusses are in line with the partition walls, so that the steel is concealed by a soffit on top of the wall. The diagonal members are eliminated at corridors, replaced by a Vierendeel truss system to allow for corridor openings to go through the truss.

To maximize the open spaces at the law school below, WSPCS developed two curved trusses, matching the profile of the dormitory tower and extending its entire length within the mechanical floor and supported on six mega-columns. Column free spaces were also created by hanging large floor areas from Vierendeel trusses between the top levels of the law school.

The building's design and program require the transfer of upper level columns supporting the staggered truss system once they reach the 10th floor (the first floor of the dormitory). Story-deep trusses between the 10th and 11th floors, and located within the exterior wall of the residential tower, allow this transfer to happen. This economical truss system can be used because the 10th floor is dedicated to mechanical equipment (as is the 23rd).

The lateral-load resisting system consists of a combination of resistance provided by the stiffness of the story-deep staggered truss system and braced frames inside the elevator walls in the residential tower. The lower level framing utilizes a combination of braced frames in the elevator cores, combined with moment frames strategically located within the column lines. The frames, column, and diagonal members are typically A992 Grade 50 W14 sections; however some members require built-up plate sections or W14 sections with ASTM A572 Grade 50 plates.

This unusual combination of a law school and an undergraduate dormitory—not to mention Fordham's home within the context of Lincoln Center—reflects the current and future face of cities, says Cobb. "The future of cities is going to involve more and more mixed use," he says. "Even though these are both Fordham buildings, they serve totally different constituencies. Most people don't notice the dorm when they are close up to the law school, yet it's a very important gesture. I think in a strange way the dormitory adds something to law school." ☐

Top The law school's double-height library.
Above A curving steel staircase connects the third and fourth-floor student lounges and is a focal point in the tall interior space. Curved HSS stringers provide an efficient continuous path for load transfer and are connected by radial HSS cords that support metal pans seats for precast terrazzo treads and risers. The guardrail is made of curved glass panels slipped into a steel shoe at the base that is anchored to the top of the HSS stringer.

FORDHAM UNIVERSITY LAW SCHOOL AND RESIDENCE HALL

Location: **150 West 62nd Street, New York, NY**
Owner: **Fordham University, New York, NY**
Architect: **Pei Cobb Freed & Partners**, *New York, NY*
Structural Engineer: **WSP Cantor Seinuk**, *New York, NY*
Mechanical Engineer: **Cosentini Associates**, *New York, NY*
Structural Steel Erector: **Falcon Steel Co., Inc.**, *Wilmington, DE*
Miscellaneous Iron Fabricator and Erector: **Ment Brothers Iron Works Co.**, *New York, NY*
Architectural Metal Fabricator and Erector: **Benson Industries**, *New York, NY*
Ornamental Metal Fabricator and Erector: **Airflex Industrial Inc.**, *Farmingdale, NY*
Curtain Wall Fabricator and Erector: **Benson Industries**, *New York, NY*

CONTINUING EDUCATION WITH *ARCHITECTURAL RECORD* AND *ARCHITECT*

The Steel and Ornamental Metal institutes of New York continues its series of AIA Continuing Education articles with *Architectural Record* and *Architect* in 2015, with topics ranging from designing residential towers with structural steel to the highly coordinated construction of the Pavilion at Brookfield Place in Lower Manhattan. More topics are available online at continuingeducation.construction.com and www.architectmagazine.com via the Continuing Ed tab. Read the current course introductions and find complete text and tests via the URLs below:

Re-Thinking Steel: A Logical Choice For High-Rise Residential Design

Optimizing The Structure To Maximize Usable Space


CONTINUING EDUCATION

RE-THINKING STEEL—A LOGICAL CHOICE FOR HIGH-RISE RESIDENTIAL DESIGN

OPTIMIZING THE STRUCTURE TO MAXIMIZE USABLE SPACE

Presented by: Steel Institute of New York

LEARNING OBJECTIVES

CONTINUING EDUCATION

SPECIAL ADVERTISING SECTION

More than half of the world's population (54 percent) currently lives in urban areas. By the year 2050, that number is projected to grow to two thirds (66 percent). According to John Wilmoth, of the UN's Population Division, the source for the above figures, "Managing urban areas has become one of the most important development challenges of the 21st century. Our success or failure in building sustainable cities will be a major factor in the success of the post-2015 UN development agenda"

This assessment may sound like a dire challenge or a great opportunity depending on your point of view. Either way, one thing is clear: As more people come to live in urban areas, large or small, more housing must be designed and constructed to accommodate them. In New York City alone, projections call for one million more residents by the year 2040. As population increases, density usually increases—meaning that buildings necessarily get taller. In this scenario, high-rise multi-family buildings can become the preferred housing choice for many either due to affordability, proximity to transportation systems, or because of upscale, tenant-oriented design. This trend is already playing out in cities across the United States and Canada where high-rise condominiums and apartments have been built and occupied at a healthy, sustained rate over the past decade.

Originally published in the December 2014 issue of *Architect* magazine. Go to http://go.hw.net/AR1214Course1 for complete text and to take the test for free.

Structural Innovation: Weaving Successful Outcomes

Architects, owners, contractors, fabricators, and installers can change the way they work together to achieve more integrated project delivery.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Sponsored by the Steel Institute of New York | By Peter J. Arsenault, FAIA, NCARB, LEED AP

COLLABORATION THROUGH INTEGRATED PROJECT DELIVERY

Around the country, architects are perfecting the art of effective collaboration to produce highly successful projects. Building design and construction are influenced by increasingly complex demands and user requirements, particularly in dense, urban settings. One such example is a highly visible and significant project in the area around the site of New York City's former Twin Towers at the World Trade Center in Lower Manhattan.

The project involved design and construction of an entry pavilion to the Winter Garden and World Financial Center, located across the street from the World Trade Center, which was heavily impacted by the attacks of 9/11. Perhaps no other project in the country illustrates more clearly the challenges and benefits of an architect-led, collaborative, project-delivery process, or integrated project delivery (IPD).

Originally published in the November 2014 issue of *Architectural Record*. Go to course number ARdec2014.1 at ce.architecturalrecord.com for complete text and to take the test for free.

UNIVERSITY LECTURE SERIES

The Institutes sponsor free lectures for students and building industry professionals at institutions including Columbia GSAPP, Cooper Union, and Pratt Institute. For more information on upcoming lectures, visit the Events tabs at www.siny.org and www.ominy.org.

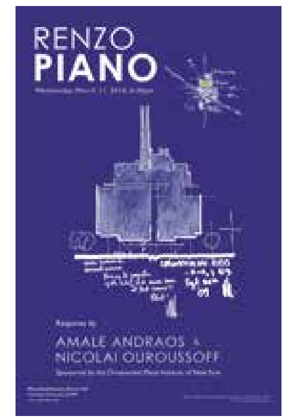
RECENT

Grimshaw Sheds Light onto Design Inspired by Nature for Columbia Students

In front of a packed Wood Auditorium at Columbia's GSAPP on October 29, 2014, Andrew Whalley explored themes of biomimicry, biophilia, and other natural phenomena within Grimshaw Architects' vast body of work. The event was sponsored by the Steel Institute of New York. The talk began with a surprise video appearance by Sir Nicholas Grimshaw (unable to travel due to a recent accident) who introduced his colleague and encouraged young architects-to-be in the audience to find inspiration in the world around them. The lecture provided documentation of Grimshaw's nature-inspired projects, and a comprehensive representation of the unique presentation of the practice's current work. After the talk, Whalley joined Columbia GSAPP Dean Amale Andraos, along with Lise Anne Couture and Laurie Hawkinson, to discuss these themes with the audience whose notable attendees included BuroHappold Engineering's visionary leader Craig Schwitter.

To watch a video of the talk, visit the News tab at www.siny.org

Renzo Piano Discusses Manhattanville Campus at Columbia



On March 11, 2015, celebrated architect Renzo Piano presented a lecture on Columbia University's new 17-acre Manhattanville campus. The event was sponsored by the Ornamental Metal Institute of New York. Now under construction, the 6.8 million-square-foot project will retain the existing street grid, improve pedestrian access, enhance waterfront views, introduce open space to the public, and provide new homes for the Jerome L. Greene Science Center, the School of the Arts, Columbia Business School, the School of International Public Affairs, an academic conference center, and more. Dean Amale Andraos and Nicolai Ouroussoff gave their responses following Piano's forward-thinking talk.

UPCOMING

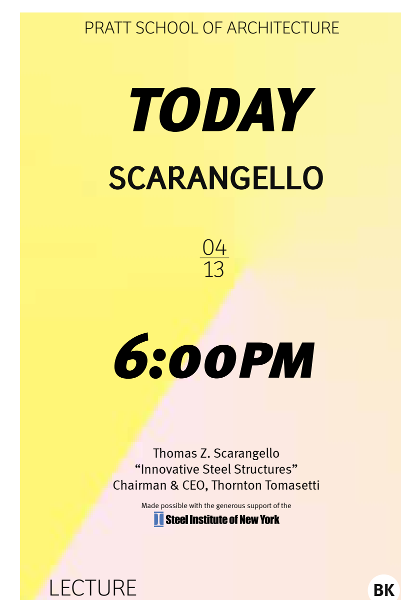
Collaborative Futures: Emergent Trends in Facade Design & Delivery at Facades+ April 16

On April 16, 2015, the Ornamental Metal Institute of New York will sponsor a panel discussion at New York's Facades+ symposium exploring emergent geometries and materials that have given birth to a new alliance between facade designers and fabricators.

Relationships developed through the design-assist contracting method have enabled built projects previously considered too challenging or high-risk. In "Collaborative Futures: Emergent Trends in Facade Design & Delivery," panelists will discuss the intense teamwork happening between the concept and execution of today's complex facade programs, and where the industry is subsequently headed. The discussion will be moderated by Peter Arbour (Vidaris); panelists include Mike Haber (W&W Glass); Alberto de Gobbi (Permasteelisa); Mic Patterson (Enclos); and Jeffrey C Heymann (Benson Industries Inc).

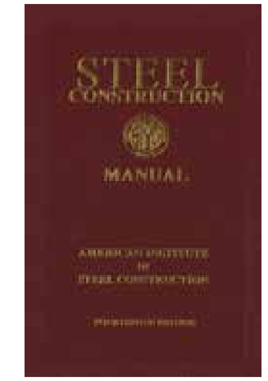
With the theme of "Resilience," this year's New York Facades+ symposium will focus on innovation in facade design for changing environmental conditions. Registered architects can earn 8 AIA LU/HSW credits for the day-long event, which includes keynote addresses by Thorsten Helbig (Knippers Helbig Advanced Engineering) and Greg Pasquarelli (SHoP Architects). Location: CUNY Graduate Center, Proshansky Auditorium, 365 Fifth Avenue at 34th Street, New York, NY 10016. Visit www.facadesplus.com for more information and to register.

Thomas Z. Scarangello / Chairman & CEO, Thornton Tomasetti "Innovative Steel Structures" April 13



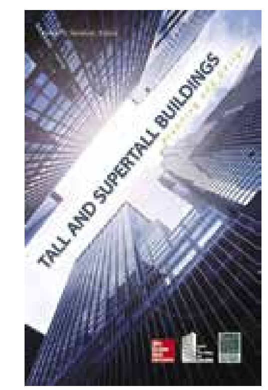
PROFESSIONAL RESOURCES

Donating steel manuals to engineering programs



For the past two decades the Steel Institute of New York has contributed complementary copies of the Steel Construction Manual to engineering programs at colleges and universities in the five boroughs. Contact the Institute at (212) 697-5553 for more information.

Tall and Supertall Buildings: Planning and Design



CTBUH has released a new book featuring contributions from 30 global experts from the CTBUH member network—many of them CTBUH Leaders—who were involved in the planning and design of the some of the world's most significant skyscrapers. Edited by Akbar Tamboli, P.E., F.ASCE, *Tall and Supertall Buildings: Planning and Design* describes the special design features and engineering techniques used for landmark buildings including Sears Tower, Taipei 101, Burj Khalifa, Petronas Towers, Shanghai Tower, and Kingdom Tower.

This authoritative resource addresses HVAC systems, sustainability, geotechnical and foundation engineering, wind engineering, and more. Construction photographs and detailed diagrams are included throughout. This is the definitive guide for engineers, architects, project managers, building inspectors, and anyone involved in the planning and design of tall and supertall buildings. For more information, visit store.ctbuh.org.

For more information about upcoming Institute-sponsored events, visit www.siny.org and www.ominy.org.

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LOCAL UNION NO. 40
International Association of Bridge, Structural Ironworkers & Riggers
451 Park Avenue South
New York, NY 10016
(212) 889-1320

Robert Walsh
Business Manager and
Financial Secretary-Treasurer

Kevin O'Rourke
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LOCAL UNION NO. 361
International Association of Bridge, Structural Ironworkers & Riggers
89-19 97th Avenue
Ozone Park, NY 11416
(718) 322-1016

Matthew Chartrand
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LOCAL UNION NO. 14
International Union of Operating Engineers
141-57 Northern Boulevard
Flushing, NY 11354
(718) 939-0600

Edwin Christian
President and Business Manager

LOCAL UNION NO. 15 & 15-D
International Union of Operating Engineers
44-40 11th Street
Long Island City, NY 11101
(212) 929-5327

Thomas Callahan
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Windsor, CT

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(212) 594-1662

Peter Myers
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Ornamental Metal Institute of New York

The Steel and Ornamental Metal institutes of New York are not-for-profit associations created in 1972 to advance the interests of the structural steel and the architectural, ornamental, and miscellaneous metal construction industries. They serve a geographical area encompassing New York City and the adjacent counties of Nassau, Suffolk, and Westchester. Each sponsors programs to aid architects, engineers, construction managers, and developers in selecting structural systems and architectural metals for optimum building performance. Programs in which the institute is engaged include:

- Consultations extending to the preparation of preliminary design and construction cost analyses for alternative structural systems
- Consultations on design and finishes for bronze, stainless steel, and aluminum for architectural and ornamental ironwork, curtain wall systems, window walls, and metal windows and panels
- Seminars covering structural systems, economy of steel design, curtain wall systems, design, and use of alloys and surface treatments for miscellaneous iron work, and issues important to the construction industry addressed to developers, architects, engineers, construction managers, detailers, and fabricators
- Representation before government bodies and agencies in matters of laws, codes, and regulations affecting the industry and the support of programs that will expand the volume of building construction in the area
- Granting of subsidies to architecture and engineering schools and funding of research programs related to the advancement and growth of the industry
- Publication of Metals in Construction, a magazine dedicated to showcasing building projects in the New York area that feature innovative use of steel

Institute staff are available with information regarding the use of structural steel and architectural metals for your project by contacting institute offices at

211 East 43rd Street, Suite 804
New York, NY 10017
T 212-697-5553/5554 F 212-818-0976

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THE STEEL INSTITUTE OF NEW YORK
THE ORNAMENTAL METAL INSTITUTE OF NEW YORK
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