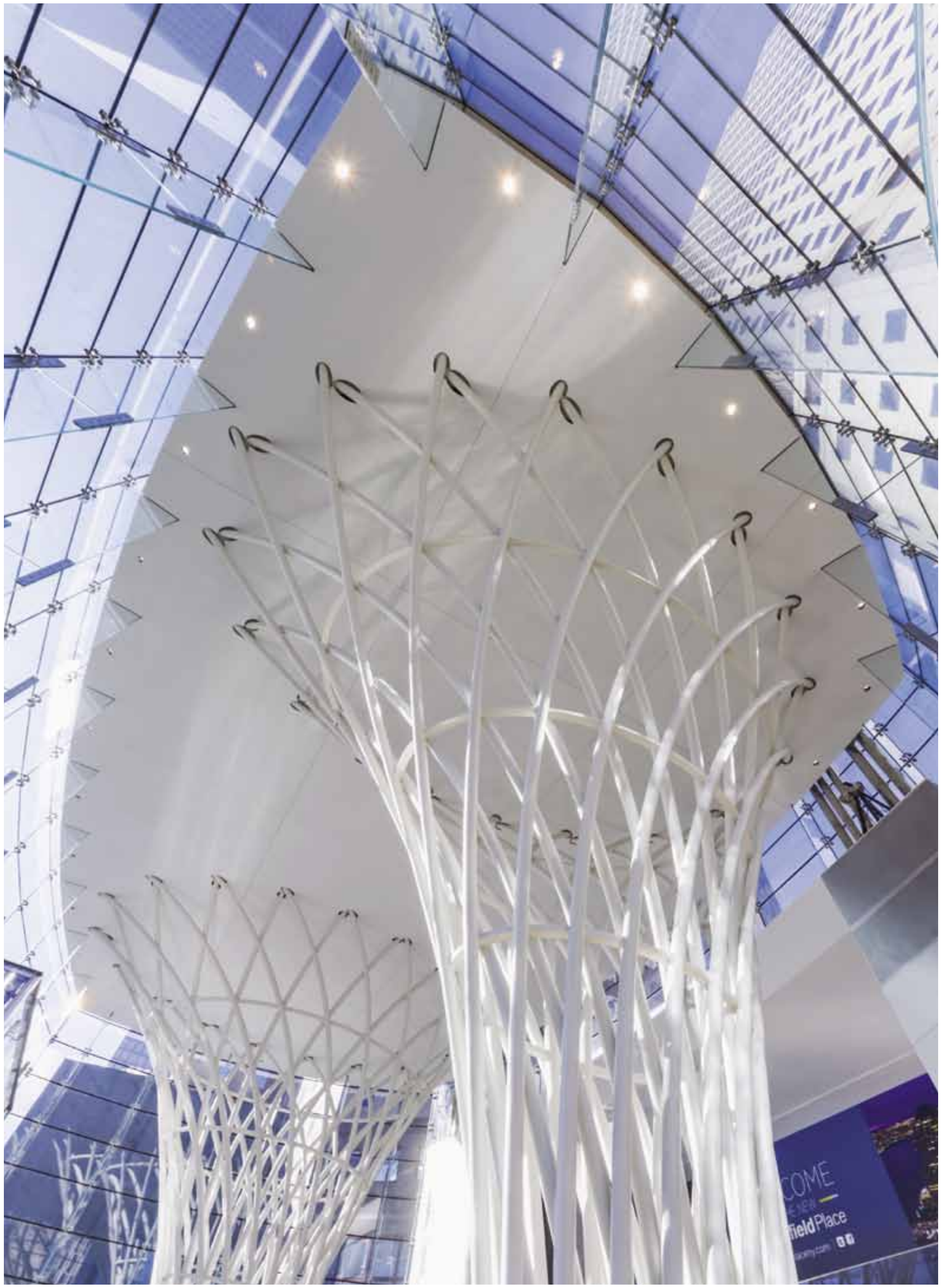

The design of 54-foot-tall expressive columns at the center of the pavilion began as a solution mandated by structural conditions created by transit tunnels below.

The Pavilion at Brookfield Place

A pair of 54-foot-tall expressive columns supports the roof of a new front door to Lower Manhattan's transit hubs, bearing the structure's loads with a woven basket of lightweight twisting steel tubing that spirals down to plaza level.

REBUILDING LOWER MANHATTAN IN THE decade since 9/11 has resulted in one of the densest constellations of new architectural ideas—and challenges—in the city's history. These have created a stronger infrastructure, and the opportunity to meet the needs of a changing city, which is seeing the influx of a diverse workforce beyond financial services, including media, technology, and other fields that will allow New York to compete in the rapidly changing global economy.

A key piece of the undertaking is the Pelli Clarke Pelli Architects-designed Pavilion at Brookfield Place, formerly known as the World Financial Center, a public space that serves as a front door to the Fulton Street and World Trade Center transit hubs used by more than 100,000 commuters and visitors daily. The pavilion will be the western terminus of the highly anticipated east–west underground pedestrian passageway, a half-mile corridor that allows workers and tourists to access subways, office buildings, and the World Trade Center complex without having to contend with inclement weather. Visitors enter from ground level entries or from six high-speed escalators that travel 50 feet below grade to the World Trade Center Concourse, Port Authority Transportation Hub, and September 11 Memorial sites.

Softly curving glass curtain walls define the pavilion's exterior, allowing its 8,000-square-foot volume to glow like a lantern at night. But the transparency of this enclosure was paramount. "Our goal was to build upon our 2002 renovation by extending a glassy pavilion outward from the existing Winter Garden, a contrast to the more massive existing stone base frontage on West Street," says Craig Copeland, associate partner and Design Team Leader of the project for Pelli Clarke Pelli Architects (PCPA). Inspired by the way that the glassy Winter Garden faces the Hudson River, PCPA wanted to give an optimistic, transparent face to the center of Lower Manhattan. "The design intent was to create a secured entrance that would still be open and inviting, as opposed to closed and fortress-like," says Copeland.

To achieve the striking transparency of the glass-and-steel pavilion, PCPA worked with structural engineer Thornton Tomasetti (TT) to examine how the structure could be built. (TT and PCPA were part of the team that designed the original, 1980s Winter Garden, from which the new pavilion extends. TT also performed repairs to significant portions of the structure after the 9/11 attacks.) Because of the underground passageway and transit system beneath, the team discovered the

Clockwise from top The columns' first two tiers were fabricated and assembled at Walters's Canadian facility, while the larger third, fourth, and fifth tiers arrived at the site in sections. Metropolitan Walters devised a temporary mechanical connection to ensure precise alignment of the steel tubes before erection in the field. A built-up grillage at the base of the columns consists of an upper and lower plate with cross- and circumferential-stiffener plates. Once column sections were erected on site, the temporary connections were removed to give the basketlike form its continuous appearance.

This page: Pelli Clarke Pelli Architects; opening page and facing page: © Jeff Goldberg/Esto

Above The twin columns mirror each other, with outer tubes spiraling in opposite directions. At each of five vertical tiers, a continuous elliptical steel ring plate holds tubes together.

soaring roof and hanging glass curtain wall could only be supported at two points of contact at the center of the space.

"What emerged was the concept to treat the structure like a pair of trees joining to support a singular canopy," says Copeland. PCPA did not want the columns to feel solid, so working with TT they developed a diagrid steel structure that allowed an expressive, basket-like form to emerge. This design for the 54-foot-high sculptural columns could support the entire pavilion, providing its main lateral resistance system while amplifying the openness of the space.

The contract for fabrication and installation of the column superstructures was awarded to Metropolitan Walters, a Canada-based firm with an installation and erection arm in New York City. Seamless in appearance, the twin columns required meticulous machining, erection, and finishing because each is composed of five separate steel sections with exposed connections that had to be welded in the field. After developing an initial Rhino model of the columns and testing it through 3-D printing and simple physical models, PCPA shared the design files with TT, who translated them to a Tekla model to study and tune to meet critical structural dynamics, and further to enable sharing the model with Metropolitan Walters.

"As Metropolitan Walters was figuring out not only the final structure but the process of how to build it, they proposed an innovative approach to phasing the fabrication and installation," remembers Copeland. "We conceived each of the columns in five tiers, and our impression was those would be the fabrication demising lines. Metropolitan Walters cleverly reconceived the connection points." In typical diagrid structures, members are in a common plane and intersect at joints. But Metropolitan Walters realized a problem—because tubes for the sculptural columns were arranged in two separate layers, locating connections at each seam would make intersections that were too tight for installation by hand in the field. To solve the challenge, they moved connection points slightly above the columns' tension/compression rings. This allowed them to avoid any complicated welds at intersection points. At each of the five vertical tiers, the tubes are held together by a continuous elliptical steel ring plate, and at intersections between

Above Each one unique, the columns' 6-inch curving steel tubes are arranged in two separate layers, creating an intricate basketlike form.
Facing top At 55 feet high and 113 feet wide, the pavilion's curving curtain wall is designed for maximum transparency, allowing the basket superstructures within to be the emphasis.
Facing bottom A half-mile corridor connects pedestrians to subways, office buildings, and the World Trade Center complex.

each tier a hidden solid steel pin connects the 8-inch O.D., 6-inch I.D. tubes.

With the limiting factor the size of a flatbed truck, the columns' first two tiers were fabricated in Hamilton; the third, fourth, and fifth tiers arrived at the site in two, three, and four sections, respectively. The seams between these joints had to align precisely—any irregularity would show up in high relief in the sunlit pavilion space. Metropolitan-Walters set up a system allowing their installation team to mechanically fasten bolts on temporary plates installed to make sure the tubes would align. Once alignment was confirmed in the shop, the temporary bolts were removed. The erection team then reassembled these mechanical connections, performed field welds, and then ground them off for a perfectly smooth finish.

"Like any great solution, once the fabrication phasing was revealed it seemed very simple and obvious, but we really struggled as a team to figure it out," says Copeland. He likens the solution to the story of Brunelleschi, who—according to the Renaissance biographer, Vasari—proposed and then achieved the seemingly impossible challenge of balancing an egg upright on a piece of marble. "As Vasari recollects, maybe with extra poetry, once somebody sees the trick—which is simply cracking the egg—they understand it, and anybody could do it. This is not completely true in the case of the pavilion baskets—because their fabrication and installation still required extreme care and coordination in carrying it out—but of course conceiving of the process was the big step forward."

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 facade, 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.

For Copeland, who joined PCPA in 1988, the opportunity to work on updating a project that was so often discussed year after year by the more senior staff around the office was an unforgettable one. "I'd always heard about the World Financial Center and there was this mystery and allure to it," he says. For the firm, designing the new pavilion has been an opportunity to appreciate designs from more than 30 years ago, when the first phases of the World Financial Center were finished. "What I'm very excited about is we've taken the existing building and helped bring it up to date, functionally and aesthetically, working off of the substance of so much that was already there to begin with." ☐

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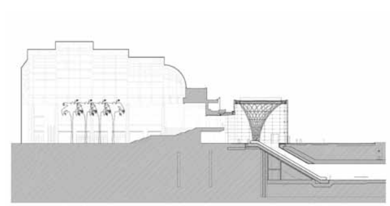

THE PAVILION AT BROOKFIELD PLACE

Location: **100 West Street, New York, NY**
Owner and Developer: **Brookfield Office Properties Inc.**, *New York, NY*
Architect: **Pelli Clarke Pelli Architects**, *New York, NY*
Architect of Record: **Spector Group**, *New York, NY*
Structural Engineer: **Thornton Tomasetti**, *New York, NY*
Mechanical Engineer: **Flack + Kurtz**, *New York, NY*
Construction Manager: **Plaza Construction**, *New York, NY*
Structural Steel Fabricator and Erector: **Metropolitan Walters, LLC**, *Hamilton, ON*
Curtain Wall Fabricator: **Permasteelisa North America Corp.**, *New York, NY*
Curtain Wall Erector: **Tower Installation**, *Windsor, CT*
Miscellaneous Iron Erector: **Hallen Welding Service Inc.**, *Long Island City, NY*
Ornamental Metal Fabricator and Erector: **A-Val Architectural Metal**, *Mount Vernon, NY*