

Tall Buildings Push Limits by Stepping Up, Not Back

A number of structurally innovative towers defy convention, and gravity, by getting bigger as they get taller

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Since the dawn of the skyscraper, architects have been preoccupied with going higher. In the mid-to-late 19th century, advances in steel construction and elevator technology allowed buildings to soar into the air—usually going straight up, or sometimes tapering back a bit at the top. While some recently completed and still-under-construction buildings are currently vying for the title of “World’s Tallest,” these days—with less emphasis on achieving great heights—architects are exploring new directions.

One such architect, not surprisingly, is Rem Koolhaas. His Office for Metropolitan Architecture (OMA) has designed a striking—some might say audacious—residential tower for Manhattan’s Flatiron district. When completed (current plans have the project moving forward), it will be OMA’s first building in New York City, the setting for Koolhaas’s 1978 classic book, *Delirious New York*. In it, Koolhaas celebrates the early-20th-century drawings of Hugh Ferriss, which illustrate the possibilities for skyscrapers following the landmark 1916 Zoning Law that created New York’s pervasive setback buildings.

Koolhaas’s building at 23 East 22nd Street also refers to Ferriss’s work, though in an unexpected way. “This is a typical New York building, but turned on its head,” says Jason Long, the project architect based in OMA’s New York office. Growing out of a narrow lot, the building rises straight up for several stories, then swells at its midsection, tapering back again at the top. “The shape of the building derived from two acts of kindness,” Long explains. The stepped condition of the cantilevering midsection allows sunlight to continue to reach the roof garden of the neighboring building. By tapering at the top, the building does not impede downtown views from inside One Madison Park, a much taller tower by the same developer, Slazer Enterprises, currently under construction on 23rd Street. (The two buildings will share an entrance lobby and amenities.)



Continuing Education

Use the following learning objectives to focus your study while reading this month’s Continuing Education article.

Learning Objectives - After reading this article, you will be able to:

1. Describe current trends in the design of tall buildings.
2. Identify the various forces that act on buildings.
3. Describe various structural strategies used for cantilevers.
4. Describe the advantages of steel and concrete in structural design and their various applications.



23 East 22nd Street grows out of its 33-foot-wide lot to cantilever more than 30 feet over its neighbors. One Madison Park, a glass tower by the same developer, is located just north of it.

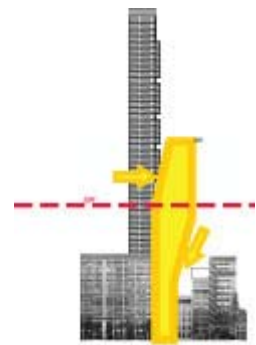
The 355-foot-tall OMA building would tower over its neighbors on 22nd Street, a mostly residential block lined with a mix of 10- to 12-story structures and smaller town houses in the shadow of the Flatiron Building. The original motivation for the growth spurt in the OMA building's midsection was to provide a good mix of apartment units—a total of 18 luxury units, including several duplexes and terraces—with varying floor plans and ceiling heights. OMA's initial design included a much more dramatic cantilever. Working from the earliest stages of design development with structural engineers at WSP Cantor Seinuk, however, OMA modified that element so that the cantilever became more gradual. The first cantilever, on the seventh floor, where the building sets back slightly, is the greatest, at 10 feet 5 inches, with successive ones above it stepping out at every other floor for a total overhang of 30 feet 8 inches above the adjacent five-story town house to the east. (The developer purchased air rights from a number of nearby properties.)



OMA's project puts a modern twist on New York's historic setback buildings.

Spanning 10 floors of the 24-story building, the cantilever resembles an inverted staircase. At such a scale, the daring design is impressive, but the concept is an ancient one. In a corbel, which predates vaults, a block or brick is partially embedded in a wall, with one end projecting out from the face. The weight of added masonry above stabilizes the cantilever and keeps the block from falling out of the wall. The same theory holds true for this building, though steel plates are added at each of the cantilevered floors to counter overturning due to lateral, or wind, forces. In the absence of such forces, the building would be completely stable without additional support because of plans to use post-tensioning cables to anchor it into the bedrock.

The primary structure of the building, however, is not steel but concrete. The facades are composed of 12-inch-thick, high-strength structural concrete and act as sheer walls (thinning out to 10 inches above the 21st floor). The structural strategy can alternately be described as a tube with punched-out window openings or a series of stacked Vierendeel trusses that form a tube. "The structure fits nicely with the architecture," explains Silvian Marcus, C.E.O. of WSP Cantor Seinuk. "Because the floor area is so small, putting the structure in the perimeter keeps the interiors free of columns. It also suits the architects' desire for varied fenestration."



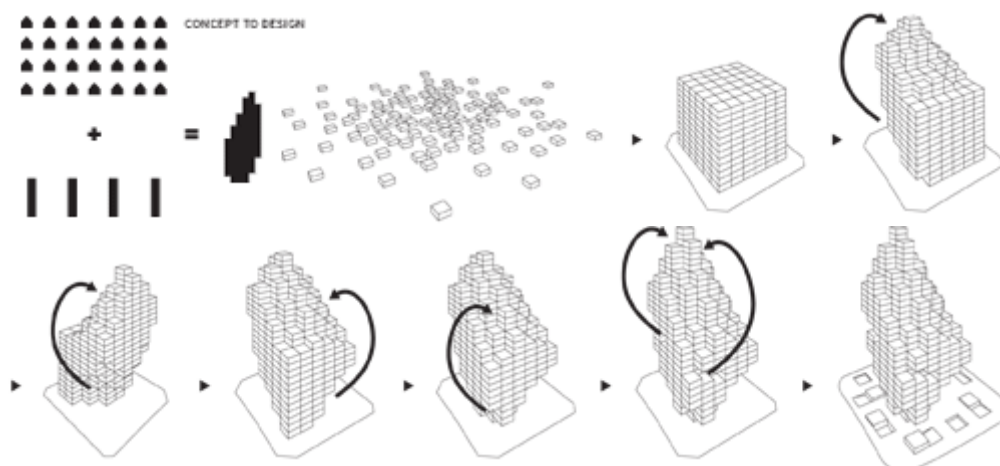
It shifts to maintain light and views for neighbors.



23 East 22nd Street's facade acts as a structural corset, with compression forces greatest at the middle (left). At the building's base is a 46-foot-tall, column free screening room (right).

In fact, the vertical window openings, which mimic those of nearby buildings, play a significant structural role. The size of the openings correlates to moments of stress. In areas under greatest stress, the window spacing is modified to provide increased structural area and rigidity, supporting the building like a structural corset. In the tower's midsection, where the forces generated by the cantilevers are greatest, openings are smallest. There, ceiling heights are also at their lowest at 11 feet. Where forces are minimal, as at the top of the building, ceiling heights increase to 15 feet, and openings get bigger, creating loftlike interiors. All of the forces from the upper part of the building travel down the east and west side walls to the building's base, where a 46-foot-tall, column-free screening room for the Creative Artists Agency is located. The box-in-box construction at the base acoustically isolates the screening room from the apartments. Adds Long, "In some ways, the base is more complicated structurally than the cantilever above."

A similarly stepped building is planned—and was recently approved for construction by the local municipality—for Rødovre, a suburb of Copenhagen. Facing fewer site restrictions in terms of lot size and adjacent buildings than OMA's tower, Sky Village—as the mixed-use building is being called—steps out in more than one direction. Designed by Rotterdam-based MVRDV and its Danish codesigners, ADEPT, the 380-foot-tall "stacked neighborhood" features a combination of apartments, offices, retail, and parking.



The basic design starts with a square grid of 36 units, or pixels, each two stories tall and measuring 25 1/2 feet wide by 25 1/2 feet

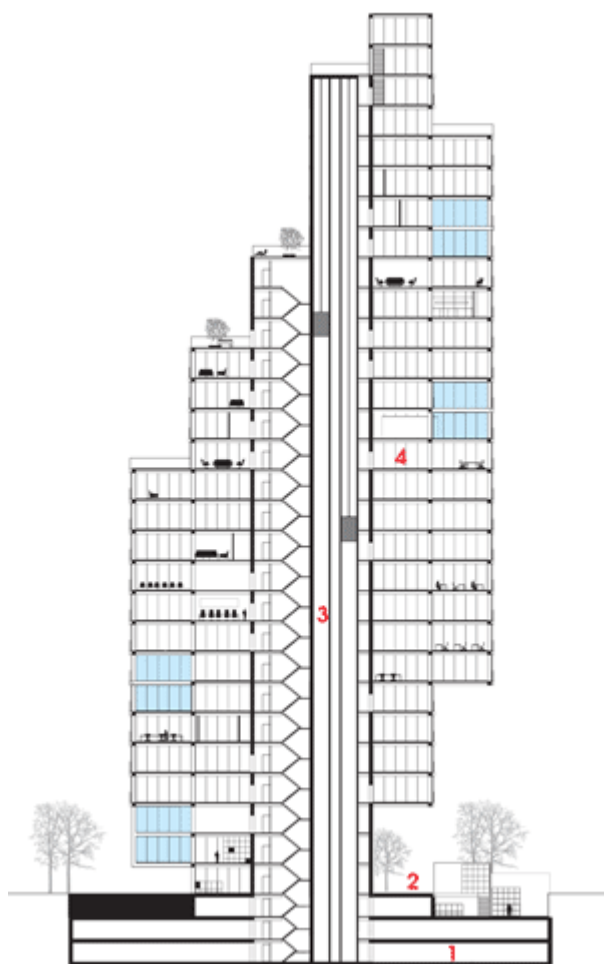
long, a dimension arrived at for its flexibility for use as a suitable parking grid, housing unit, and office type. The four central pixels make up the core. Surrounding pixels are removed and stacked on top of each other in various configurations, though no single floor comprises all 36 pixels. The building gets “fattest” about a third of the way up, where floors contain up to 26 pixels. “We’re very fond of Legos and use them in the office for conceptual designs,” says Anders Peter Galsgaard, one of the Copenhagen-based engineers. “We try to build the same way.”



Galsgaard also likens the structure to a Christmas tree, with a very stiff base, in this case consisting of two levels of underground parking, and a main trunk, the cast-in-place concrete core made up of elevators, stairs, and shafts. The pixels, which have a column at each of the corners and diagonal bracing on two sides, will hang from the core from steel trusses rather than cantilever in the traditional sense. According to Galsgaard, “Hanging the pixels this way creates a lot of compression in the core, so even under very high wind loads there is very little tension, which allows us to use steel more efficiently.”



The shape of the 380-foot-tall volume—described by the engineers as “not exactly optimal in terms of aerodynamics, but not bad either”—was derived from a variety of considerations. Wind forces in Denmark are mainly from the west, and are also much stronger than those from the east. By hanging more units facing west, they are essentially leaning into the wind, thus optimizing the structural design.



SECTION

1. Underground parking
2. Plaza
3. Core
4. Pixel units



While the designers took into account the impact of wind loads, programmatic considerations heavily influenced the final form. By varying the infill, a mix of offices and apartments are created. Stacking more units toward the north, a taller building emerges with sunnier, south-facing terraces and views to Copenhagen. The designers wanted to minimize the impact of shadows on the surrounding low-rise houses without blocking views on the street level. By pulling away most of the pixels on the ground floor, an open outdoor plaza is created, with some space kept for lobbies and shops. Using identical pixel-unit sizes for cutouts in the ground, the plaza achieves the same qualities and character as the rest of the tower, as if the tower were emerging from the ground.

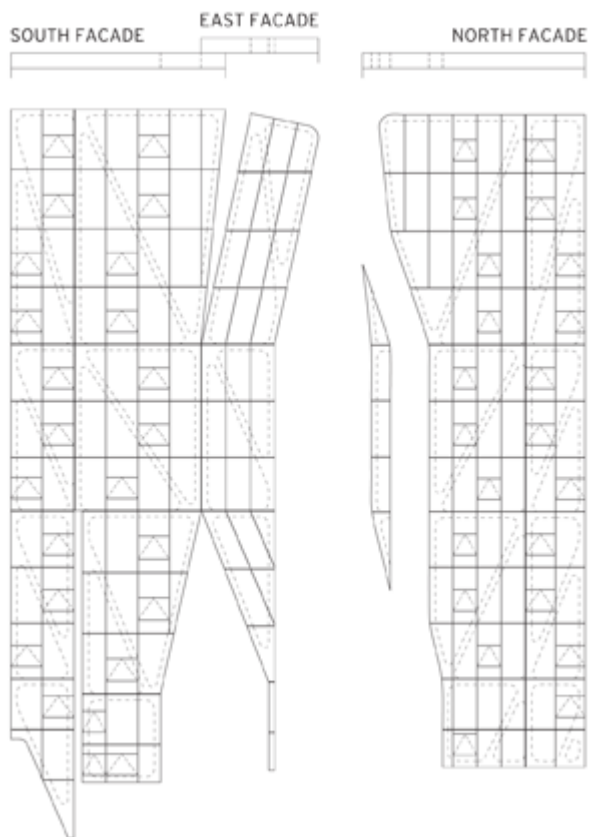
For another New York building, now under construction and moving forward, Los Angeles-based Neil M. Denari Architects used a different approach. Rather than stepping up, the reverse-tapering form of HL23—a 14-story residential building on New York City's West Side—gradually slopes out. “We didn’t want a Cartesian stepping like a wedding cake,” says Denari, whose design was inspired instead by a prism.

Denari, like OMA, was faced with a narrow Manhattan lot, which was further constrained by the presence of the High Line—a 22-block-long former railway that rises almost 20 feet above grade—immediately adjacent to it. But unlike OMA’s tower a few blocks east, which is completely (and surprisingly) as-of-right, Denari’s building—his first ground-up design—required a number of waivers. “There were a lot of restrictions for this site, but the developer was not interested in conforming to the building code,” Denari admits. “He really wanted to push boundaries.” Fortunately for both the architect and the developer, the city was behind the project, particularly because of its relation to the High Line, which is currently being transformed by Diller Scofidio + Renfro and Field Operations from its disused state into a nearly 7-acre, elevated urban park.

Denari’s project also takes a much different structural approach than 23 East 22nd Street. “Because the building is wider at the top than at the bottom, there is a natural instability,” explains Stephen DeSimone, president of DeSimone Consulting Engineers, who is working with Denari. “By using steel—which is a much lighter building material—you automatically reduce the effect of the building wanting to topple over.” So, unlike 23 East 22nd Street, which can be described as a brute-force solution with its thick concrete walls, HL23 is made up of slender structural members, including canted steel columns (at a maximum 24-degree angle and located mostly along the long, steel-clad eastern facade) and diagonal bracing (composed of 8-inch pipes and forming a tripartite composition on the glazed north and south elevations).



HL23 rises out from under Manhattan's High Line, a former elevated railway currently being transformed into an urban park.



The large glass panels lay flat along the north curtain wall, but fold over the sloping east and south facades.

The building reaches overall stability only upon completion of construction. Throughout the construction process, guy-wires provide supplemental bracing. They will stay in place until the concrete slabs are poured. Because of the small building footprint, concrete is not used in the elevator core. Instead, a steel plate acts as a shear wall to take horizontal and twisting loads—the first time such an assembly has been used in a residential building in New York City, according to the engineers.

The structure is also integral to the envelope, and was designed at the same time, with facade consultant Front, to avoid any “reverse engineering,” as Denari puts it. The sloping east facade, which cantilevers a total of 14 feet 6 inches over the High Line (it is set back 8 feet from the High Line platform at the second floor), features custom-designed stainless-steel panels with small window openings. The north and south facades feature extra-large glass panels measuring up to 11½ feet tall.

As construction progresses, an independent contractor lasers the structure to produce surveys on an ongoing basis. “This building is closer to a Swiss watch than most buildings,” says Denari. “Ambitions are higher and tolerances are smaller. None of the steel can be even slightly out of place.”

Though the forms of each of these buildings are new, the technology that makes them possible is not. And while they seem to push the limits of structural engineering, they have only just begun to scratch the surface of what's possible for 21st-century buildings.



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