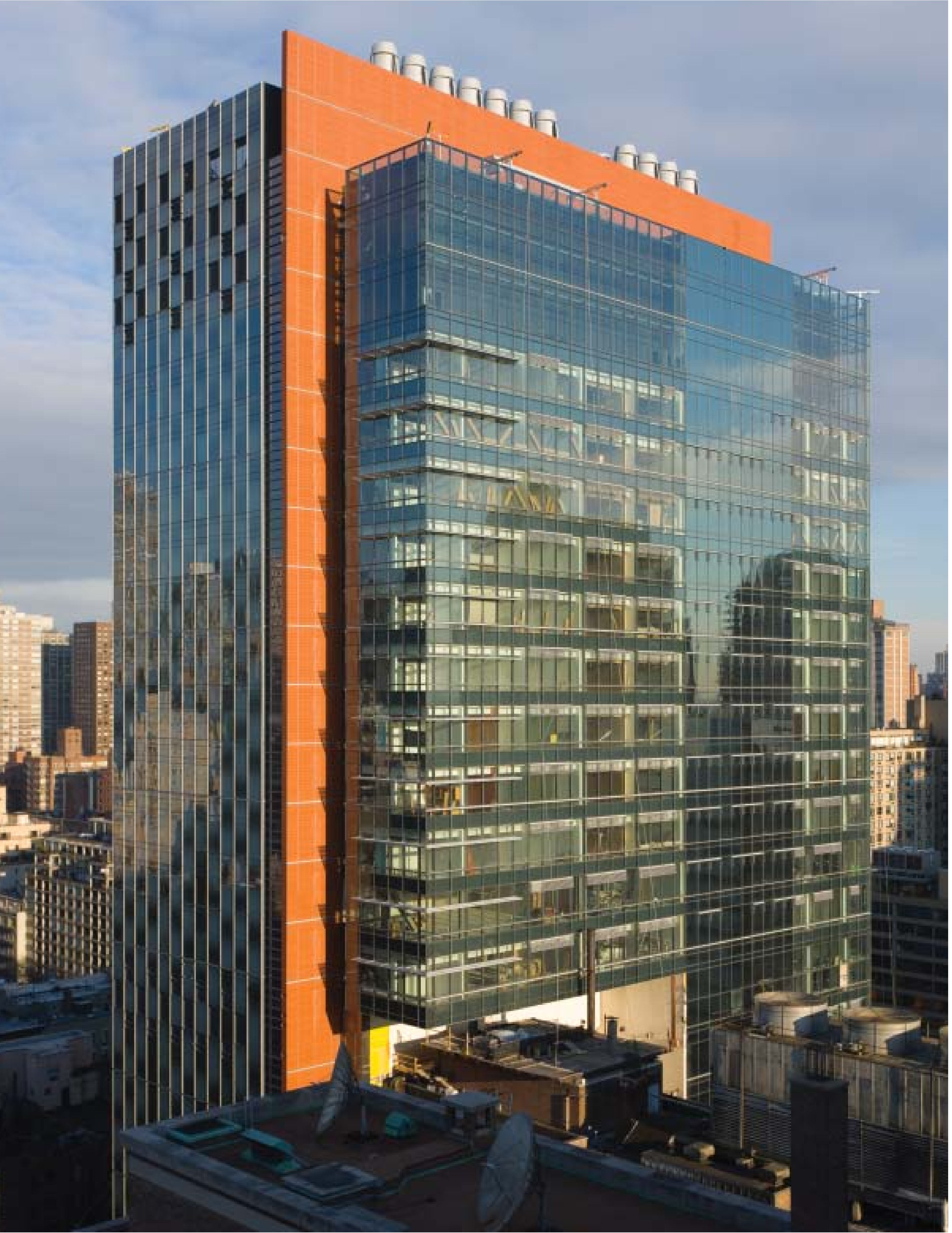

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MEMORIAL SLOAN-KETTERING CANCER RESEARCH CENTER

Steel Structure Eliminates Sway

As a building type, research laboratories carry strict programmatic and structural specifications—not only is heavy mechanical equipment required to support the facilities, but any vibration or building motion can disrupt controlled testing. While designing labs in a densely packed and vertical city like New York has proved to be challenging, the unique steel structure of the recently completed Memorial Sloan-Kettering Cancer Research Center proves that flexibility and stability can coexist when using the right materials.

The 692,000-square-foot research center, designed by the New York and Chicago offices of Skidmore, Owings & Merrill (SOM) and Portland, Oregon-based Zimmer Gunsul Frasca (ZGF), is part of a two-phase development in Manhattan's Upper East Side. In the recently completed first phase, a 24-story lab and office building was erected on a narrow, 70-foot-wide site between 68th and 69th Streets. The challenge of the design was to create a structure that would not only meet the rigorous requirements of the laboratories but also cantilever 13 levels over an existing building, which in phase two of the process will be demolished and replaced.

The site's space constraints also presented challenges: not only did the designers have to build up to the maximum allowable height, but they were forced to excavate 70 feet of bedrock to allow for several sub-basement levels. "Steel was really a godsend because of the amount of rock we had to go through," says Charles Besjak, associate partner and structural engineer at SOM. "We needed to pick up the schedule after losing time in the dig, and steel was by far the quickest means."

Two adjoining wall systems make up the majority of the building's structure. Load-bearing, six-story X braces run up the north and south faces and are connected by stacked moment frames on the east and west faces. The largest members were employed for the gravity loading columns—14W665, 21-by-21 inch square columns with 2 1/2- to 3-inch flanges. For the X-braced frames, the engineers chose W14 series columns and W24 beams, all 65 ksi steel, the largest members being 14W311, 17-by-16 inch column shapes with 2 1/4-inch flanges. These diagonals resist the majority of the lateral loads imposed on the building, along with reducing the gravity drift produced by the cantilevered volume. For the nodes where the diagonals meet the beams, the engineers designed dense connecting members from A572, 50 ksi plates, minimizing the loss of structural capacity in the transference of loads. The X brace system transfers the lateral and gravity loads to concrete footings beneath the building, designed to withstand up to 40 tons per square foot.

Bolted W30 columns and beams form the moment-frames of the east and west faces, which, in turn, connect to the X braces at the north and south, forming a full tube structure. Belt trusses around the circumference of the building between the tenth and eleventh floors, and just below the roof, lend additional support, holding the upper levels tightly in form. These belt trusses surround mechanical floors, which support the laboratories underneath. "Most lab buildings are horizontal," explains SOM partner Mustafa Abadan. "When you build them vertically, you have to break the building up into smaller volumes."

At the two mechanical floors, outrigger trusses connect the belt trusses to the building's core-braced frame, all of which use the same

OPPOSITE The architects cantilevered thirteen stories off the side of the main volume.

TOP Ironworkers maneuver the mega braces into place.

BOTTOM Prefabricated connection nodes on the gravity loading columns made for an easy erection.

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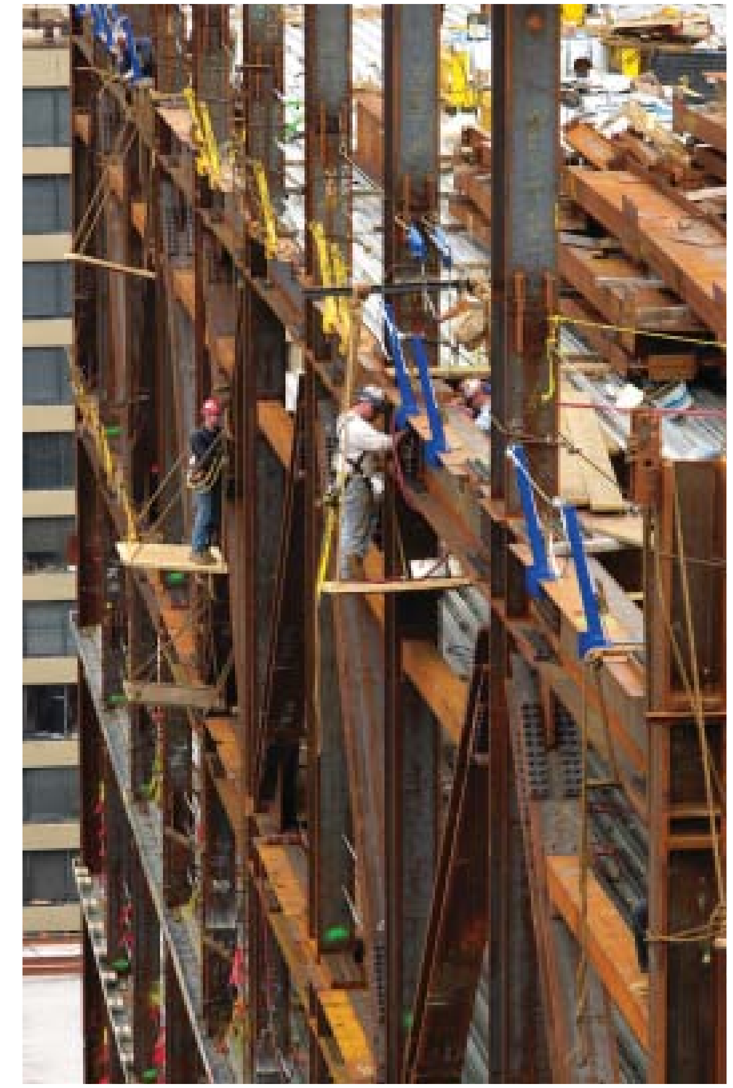
size beams and columns as the east and west face moment frames. This connects the core to the exterior bracing system, and, according to Besjak, provides control over the deflections for the slender structure, which at 416 feet has the same aspect ratio as the Sears Tower. The core-braced frame supports the elevator shaft, which is located on the eastern side of the building and separates the main part of the building from the cantilevered volume, which begins eleven stories up.

The volume of the main building and the cantilever are expressed in the curtain wall. Fritted glass clads the laboratories off the main core, varying in opacity depending on the interior program, while a transparent curtain wall encases the offices of the cantilever. The two volumes are separated by a terra-cotta dividing wall, which responds to the brick buildings of the surrounding campus.

The cantilevered volume adds additional space while preserving an adjacent building. "It was a real jigsaw puzzle given the footprint, allowable height, and space needed," says Abadan. "Given the surrounds, we needed to overlap the existing building to locate a new space." The cantilever, which projects 32 feet out, contains an integrated double-height strut system along the north and south corners of the building's east face. This arrangement creates two columns of six, two-story struts placed at every other story along the 13 cantilevered floors. These struts, which measure 14W109 at 65 ksi, are moment connected to the building's framing system and to beams that project 30 feet into the suspended volume.

The weight of the cantilever is transferred to the north and south by the metal deck and concrete slab flooring. "It was important to take those loads to the mega braces to limit global building movement and provide structural rigidity," said Besjak. These concerns were paramount in the design process and determined much of the building's planning and engineering. In order to ensure optimal connections, many of the members were welded off-site, including the columns and flanges, to which the beams were later bolted. For the bracing members as well, all nodes and joints were pre-welded, and the members between were later bolted. Throughout the building, engineers opted for one inch, A490 slip-critical high-strength bolts, which were strong enough for the members and allowed the contractors to order economically in bulk.

The off-site welding and prefabrication made steel an ideal choice for the project because it allowed for a quick and easy erection. Steel's inherent flexibility also made the material desirable; while the laboratories are modular, changing technologies require easily reconfigurable space. "Concrete just doesn't provide enough of that flexibility, in terms of allowing for change," says Abadan. Even the belt trusses on the mechanical floors contribute to the building's flexibility, as they accommodate the machinery in a way that it can be easily accessed and replaced. But perhaps the greatest triumph of this building is that through clever engineering the steel structure minimized vibrations and lateral sway, creating one of the tallest research facilities in the world.



ABOVE Work on belt truss at the mechanical level

TOP Steel members on the metal decking await erection.

BOTTOM An integrated double-height strut system supports the 32-foot cantilever.

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The steel structure minimized vibrations and lateral sway, creating one of the tallest research facilities in the world.

ABOVE The different treatments of the curtain wall correspond to programmatic elements within the building.

MEMORIAL SLOAN-KETTERING CANCER RESEARCH CENTER

Owner **Memorial Sloan-Kettering Cancer Center;**
Division of Facilities Management *New York, NY*
Project Manager **Granary Associates** *New York, NY*
Architects **Skidmore, Owings & Merrill LLC** *New York, NY*
Zimmer Gunsul Frasca Partnership *Portland, OR*
Structural Engineer **Skidmore, Owings & Merrill LLC** *Chicago, IL*
General Contractor **Turner Construction** *New York, NY*
Structural Steel Fabricators **Kline Iron and Steel, Inc.** *Columbia, SC*
Cives Steel Company *Gouvernor, NY*
Structural Steel Erector **Cornell and Company** *Woodbury, NJ*
Miscellaneous Steel Fabricators **Cornell and Company** *Woodbury, NJ*
Cives Steel Company *Gouvernor, NY*
Miscellaneous Steel Erectors **Cornell and Company** *Woodbury, NJ*;
Post Road Iron Works *Greenwich, CT*; **FMB, Inc.** *Harrison, NJ*
Superior Erectors *Plainfield, NJ*
Architectural Metal Fabricators and Erectors **Champion Metal & Glass** *Deer Park, NY*
Ornamental Erectors *West Hempstead, NY*
Ornamental Metal Fabricators **Coordinated Metals, Inc.** *Carlstadt, NJ*
All State Erectors Centereach, NY
Ornamental Metal Erectors **Coordinated Metals, Inc.** *Carlstadt, NJ*
Ornamental Erectors *West Hempstead, NY*
McFarlane Contracting LLC *Hackensack, NJ*
Curtain Wall Fabricators **Permasteelisa Cladding Technologies** *Windsor, CT*
Allied Bronze LLC *Long Island City, NY*
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