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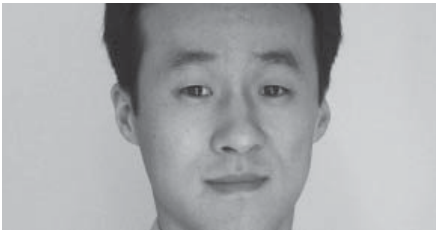
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Paul Noritaka Tange, Tange Associates

Paul Noritaka Tange began his architectural career upon receiving his Master in Architecture from Harvard University, Graduate School of Design in 1985. That same year he joined Kenzo Tange Associates, the architectural firm headed by his father, well known international architect, Kenzo Tange. Paul became President of Kenzo Tange Associates in 1997 and founded Tange Associates in 2003. Tange Associates, headquartered in Tokyo, Japan, has worked worldwide and offers a full range of architectural and urban design and planning services. At this time, Tange Associates has close to 40 on-going projects in ten countries. The firm's extensive international experience enables it to work effectively worldwide, in all cultures.

Masato Minami, Arup Japan

Masato Minami is a senior structural engineer in the Tokyo office of Arup, a global multidisciplinary firm. Since receiving his Bachelor and Master of Engineering degree from the University of Tokyo, he has been working with Arup for more than 10 years including three years in London. He worked on Mode Gakuen Cocoon Tower for more than four years as the leading structural engineer in all stages from the scheme design stage through to its completion in October 2008. His previous works include a number of award-winning buildings such as Sony City, Tomihiro Museum and Forestry Hall Tomochi.

"The elliptic shape permits more ground space to be dedicated to landscaping at the building's narrow base, while the narrow top portion of the tower allows unobstructed views of the sky."

Mode Gakuen Cocoon Tower is an innovative educational facility located in Tokyo's distinctive Nishi-Shinjuku high-rise district. Completed in October 2008, the 204-meter (669 ft) 50-story tower is the second-tallest educational building in the world*. The building's elliptic shape, wrapped in a criss-cross web of diagonal lines, embodies the "cocoon" concept developed by Tange Associates. Student occupants are inspired to create, grow and transform while embraced within this cocoon-like, incubating form. In essence, the creative design successfully nurtures students to communicate and think creatively.

Architectural overview

In designing Mode Gakuen Cocoon Tower, Tange Associates offers a new solution for school architecture in Tokyo's tightly meshed urban environment (see Figure 1). A new typology for educational architecture, the tower and accompanying auditoriums successfully encompass environmental concerns and community needs with an unparalleled inspirational design.

Literally a vertical campus, the high-rise tower can accommodate approximately 10,000 students at the three vocational schools sharing the building. These include: the fashion school Tokyo Mode Gakuen; HAL Tokyo, an information and technology school; and Shuto Iko, a medical welfare school. Mode Gakuen operates all three.

The low rise building, an intriguing egg-shaped structure adjacent to the high rise tower, houses two major auditoriums (see Figure 2) – Hall A and Hall B. The halls are used for school as well as public functions. With approximately one thousand seats, the auditoriums will bring to the area a wide and exciting mix of cultural events. The high-rise tower floor plan is simple; three rectangular classroom areas rotate 120 degrees around the inner core (see Figure 3)

* Note: The tallest educational building in the world is MV Lomonosov State University, Moscow, Russia (239m / 784feet).



Figure 1. Mode Gakuen Cocoon Tower

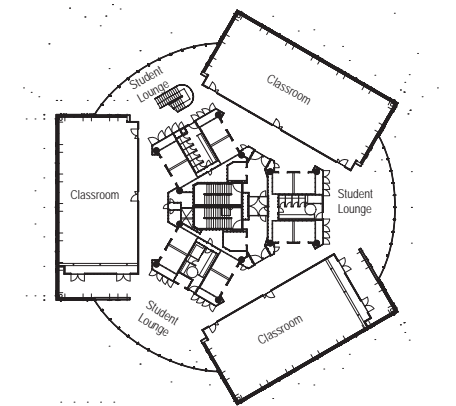


Figure 3. 21st floor plan

...soaring skyscrapers

“We have the capital, technology and a demand for skyscrapers but we have not moved forward because of regulations and public opposition that few people will really benefit.”

Kim Jong-su, who heads the Korea Super Tall Forum, which comprises academics and people in the building industry who support the construction of tall buildings, discusses the government's reluctance to push ahead with a tall buildings program in South Korea. From 'Soaring skyscrapers in dark economic times,' JoongAng Daily, February 10th, 2009

From the 1st to the 50th floor, these rectangular classroom areas are arranged in a curvilinear form. The inner core consists of elevators, staircases and shafts. To ease the potential congestion that might be caused by vertical movement, the three schools are laid out in 3 parts of the building; lower tier, middle tier and upper tier.

Unlike the typical horizontally laid out school campus, the limited size of the site challenged Tange Associates to develop a new typology for educational architecture. Student lounges are located between the classrooms, facing three directions; east, southwest and northwest. Each atrium lounge is three-stories high and offers sweeping views of the surrounding cityscape (see Figure 4). As new

types of schoolyards, these innovative lounges offer students a comfortable place to relax and communicate.

The tower is designed specifically with the environment in mind. This includes a cogeneration system, installed within the building, that produces about 40% of the structure's power and thermal energy. This greatly increases the building's operational efficiency and decreases energy costs. It also reduces potential greenhouse gas emissions that contribute to global warming. The elliptic shape allows for even distribution of sunlight, thereby limiting heat radiation to the surrounding area. The shape also ensures that it aerodynamically disperses strong wind streams; an important issue in this high-rise

district that attracts large and damaging gusts of wind.

Enhancing the community is a major goal. Positioned like a gateway between Shinjuku Station, Tokyo's busiest train terminal, and the Shinjuku CBD (Central Business District), the building is revitalizing the area. A "3D Pedestrian Network" of inviting passageways below and above ground, open to the public, allows a free flow of pedestrian traffic. Along with the addition of thousands of young students, the building is a magnet for businesses that will bring vitality to the area along with needed commerce. ㄸ



Figure 2. The low rise building adjacent to the high rise tower, houses two major auditoriums.



Figure 4. Three-story high student lounges in between the classrooms facing east, southwest and northwest offering stunning views of Tokyo's skyline.

The elliptic shape permits more ground space to be dedicated to landscaping at the building's narrow base, while the narrow top portion of the tower allows unobstructed views of the sky. The nurturing forces of nature are close at hand to the student; an inspiring environment in which to study, learn and grow. For the community, the fascinating design of Mode Gakuen Cocoon Tower is a welcome contribution to the urban landscape and an example of how such design innovation benefits and impacts its immediate surroundings.

Structural overview

Both superstructures are steel construction with CFT (concrete filled tube) columns. The basement structure is a composite construction of steel and reinforced concrete with RC shear walls. The foundation is a combination of a raft and cast-in-situ concrete piles. The pile positions could not be identical with the column positions due to the complexity of the column arrangement so a 3.8m thick raft slab above the piles was used to transfer the vertical forces from the columns to the piles.

The main structure consists of three elliptical diagrid (DG) frames and an inner core frame. The building has relatively large storey shear deformations in the middle storeys due to the bending of each of the DG frames. Because the three diagrid frames are connected rigidly with each other at the base and the top only, the structure can be viewed as a portal frame with large rotations in the middle and smaller rotations at the top and bottom. The storey drift of the perimeter frame is largely through bending while the storey drift of the inner core is by shear. Viscous oil dampers have been utilized to exploit the shear deformation of the core and to dissipate the associated seismic energy. The inner core has six viscous dampers on each floor from the 15th to the 39th floor. The dampers reduce the seismic force that needs to be resisted by the structure.

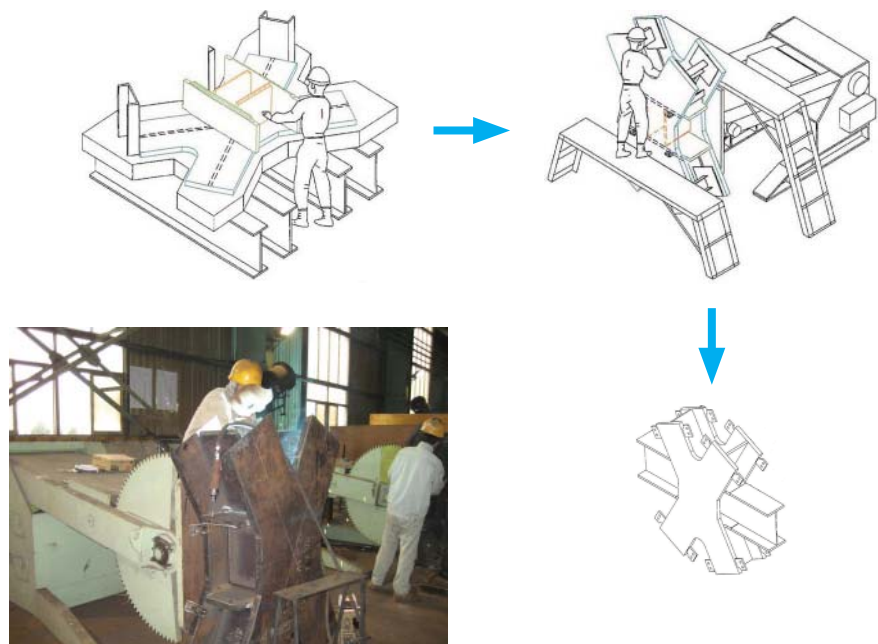


Figure 5. Fabrication sequence of intersection node

The DG frames are located at the perimeter, giving the structure a wide stance. It then is able to efficiently transfer lateral force and overturning moment due to earthquake or wind to the basement. The DG frames are 24m wide with intersections every 4 meters on each floor level, and they curve in a vertical ellipse. Storey heights are such that the distance on the elliptical line is uniformly 3.7m, so that the DG members intersect at the same angle on each floor. This produces smooth external patterns and significantly simplifies the fabrication of steel and exterior cladding units. Diagrid members are mainly I-sections 400mm wide and 400mm deep, which is relatively small for such a slender high-rise building and serves to maximize the internal space.

The floor beams of classrooms support the floor loads and connect the diagrid frames and the inner core horizontally preventing out-of-plane buckling of the diagrid frames. Most of the classrooms are architecturally designed for exposed floor beams and service ducts in the ceiling while other areas are finished by ceiling boards. Parallel floor beams

are rigidly connected to the intersection of the diagrid frames and cranked at the beam above the partition, between classroom and corridor, towards the columns of the inner core. The floor beams are rigidly connected at both ends. As a result, the exposed beams in the classrooms look well-ordered. Furthermore, the diagrid frames are robustly stiffened against out-of-plane buckling.

At intermittent levels there are 3-storey atriums, for use by the students, as places to take breaks. The external glazing of the atriums is three storeys high and the maximum width is nearly 20m. Double-arched vierendeel truss beams are provided at each floor level to carry the weight of glazing panels and resist wind pressure. The vierendeel beams are hung from the beams above so that no structural member obstructs the view on any storey.

Connection design is one of the challenges of a diagrid structure because many members (seven in this case) from various angles are concentrated at one point. There were many

meetings between the engineers and fabricators to find a solution that was reasonable to fabricate and structurally robust. In the adopted solution the intersection node is fabricated from a number of rolled plates (see Figure 5) and butt-welded with the DG and floor members on site.

Roof facilities

Unlike many other high-rise buildings, this building does not have a flat surface on top giving a priority to the architectural shape. However, an exterior cleaning system and the provision of a hovering space for helicopters are essential for a high-rise building in Japan.

To provide a hovering space of 10m square, a retractable roof was designed (see Figure 6). Half of the floor is attached to the retractable roof. At the request of the Tokyo Fire Department the roof can be opened within 8 minutes by a pair of hydraulic jacks, forming the hovering space.

The maximum wind speed that allows hovering is 15m/sec. Although the shape of the retractable roof suggests the possibility of aerodynamic, unstable vibration during the opening, it has been confirmed that it should not occur even in a 30m/sec wind speed as, per the Japanese loading standard.

A gondola hanger is installed below the hovering space and moves around on the rails arranged in a Y-shape with a turntable at the centre. The hanger is able to deliver the gondola to all external surfaces of the building by extending and revolving the arm at each end of the Y-shaped rails (see Figure 6).

To enable the hanger to revolve the arm, the floor for hovering and the top roof are supported by three pairs of crossing columns only. The perimeter steelwork is on the same level as the hanger's arm and made of sliding doors.

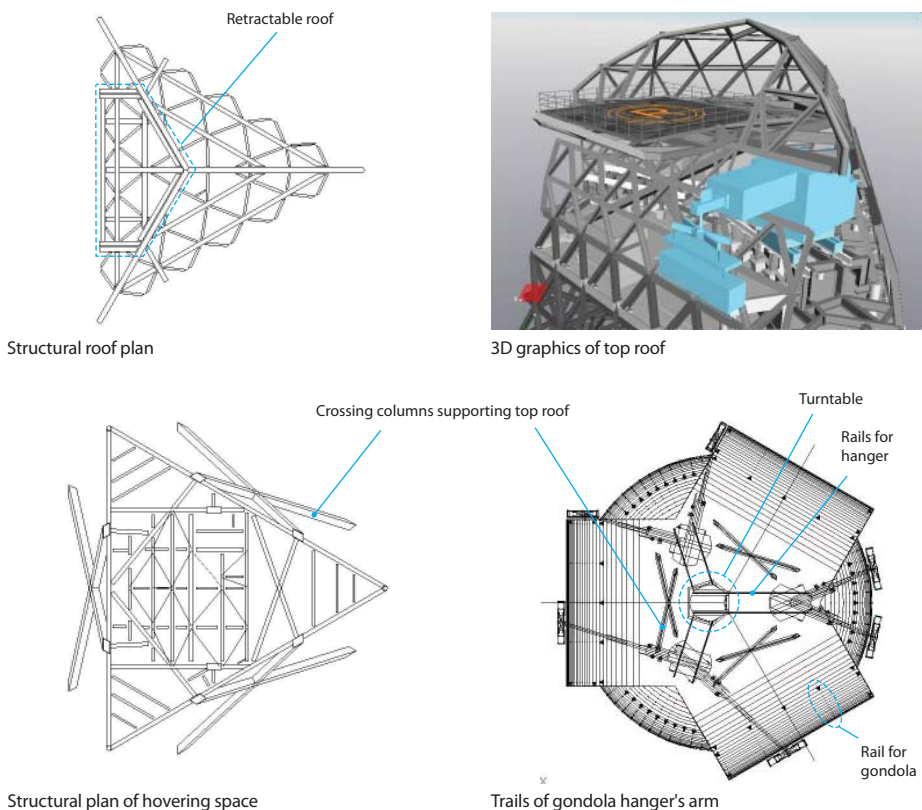


Figure 6. Roof facilities

Site erection

Steel erection on site has been carried out in a cycle of three storeys by the following sequence.

1. The inner core frame is erected with sufficient accuracy and welded.
2. Each intersection node and two DG members are assembled into an inverted V-shape with temporary bolt connections and erected.
3. Floor beams are erected and aligned.
4. Bolt tightening and welding.

External glazing panels were also assembled on site into 6.0m wide by 3.7m high units and this installation followed three storeys below the steel erection.

Conclusion

Many high-rise buildings have been built in highly seismic countries, like Japan, in recent decades. However, most of them are box-shaped with vertical columns. The shape of the building proposed by the architect was strongly favored by the client. Thus, those engaging in the design and construction have made every effort to achieve this shape.

The completion of this uniquely shaped skyscraper could be regarded as a significant achievement in Japan's history of high-rise buildings. ■