MODE GAKUEN
Cocoon Tower

Introduction
Mode Gakuen is a vocational school for students in the fields of fashion and interior and graphic design, with bases in Tokyo, Osaka, Nagoya, and Paris. In 2004 Mode Gakuen instituted an architectural competition for its new Tokyo location, and this was won by Tange Associates. Located in Nishi-Shinjuku in the heart of Tokyo, this 203.65m-high, 50-storey skyscraper was commissioned in February 2005 and completed in October 2008. It is the second-tallest educational building in the world and the 17th-tallest building in Tokyo.

79. Architectural section.

The tower’s curved outline and distinctive cocoon shape (Figs 79, 80) are intended by the architect to symbolise a nurturing of the students that it accommodates, and form a boldly different presence amid a dense cluster of conventionally box-like skyscrapers. The building actually contains three educational bodies catering for around 10 000 students. As well as the Tokyo Mode Gakuen fashion school, it also accommodates HAL Tokyo and Shuto Iko, which are respectively information technology and medical schools.

80. External view.
The typical tower floor plan is circular with the three rectangular classroom plans imposed on top (Fig 81). Each classroom is 24m wide. The depths of the classrooms vary as the perimeter surface draws an elliptical curve vertically. Spaces between the classrooms are used as small atria where students can refresh themselves between classes.

Next to the tower on the same site is a 30m high elliptical annex, containing two large lecture theatres and some retail outlets, including a bookshop. Both the high-rise building and annex share the same four-storey basement structure which is used for car parking and retail space.

The main structure comprises three elliptical diagrid frames and an inner core frame (Fig 82). Because the three diagrid frames are connected rigidly with each other at the base and the top only, the building has relatively large shear deformations in the middle storeys due to the bending of each diagrid frame. The structure can be viewed as a portal frame with large rotations in the middle and smaller rotations at the top and bottom. The inter-storey displacement of the perimeter frame is largely through bending, while that of the inner core is by shear. Viscous dampers are utilised to exploit the shear deformation of the inner core and to dissipate the associated seismic energy. On each floor from the 15th to the 39th, the inner core has six viscous dampers, which reduce the seismic force that needs to be resisted by the structure.

**Structural outline**

Both superstructures are of steel with concrete-filled tubular columns in the inner core. The basement is a composite construction of steel and reinforced concrete with concrete shear walls, while the foundations combine a 3.8m thick raft slab and cast in situ concrete piles. The pile positions could not coincide with the column positions due to the complexity of the column arrangement, so the raft above the piles was used to transfer the vertical forces from the columns to the piles.
The diagrid frames at the perimeter are 24m wide with intersections every 4m on each floor level, curving in a vertical ellipse and giving to the structure a wide stance so that it can efficiently transfer lateral force and overturning moment from earthquake or wind to the basement. Storey heights are such that the distance on the elliptical line is uniformly 3.7m, allowing the diagrid members to intersect at the same angle on each floor. This shows the external patterns smoothly, and significantly simplified the fabrication of steel and exterior cladding units. Diagrid members are mainly I-sections 400mm wide and 400mm deep – relatively small for such a slender, high-rise building and helping to maximise 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 to expose floor beams and service ducts in the ceiling (Fig 83) while other areas are finished by ceiling panels. 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 intermediate levels there are three-storey atriums for the students to refresh themselves. Their external glazing is three storeys high and the maximum width is nearly 20m. Double-arched vierendeel truss beams at each floor level 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 (Figs 85-86).

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 numerous 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 several rolled plates (Fig 88) and butt-welded with the diagrid and floor members on site.
Roof facilities
The priority given to the architectural profile means that, unlike most high-rise buildings, it does not have a flat surface on top. However, an exterior cleaning system and provision of a hovering space for helicopters are essential for a high-rise building in Japan, so to provide such a hovering space of 10m square, a retractable roof was designed (Fig 90). Half of the floor is attached to the retractable roof. At the request of Tokyo Fire Department the roof can be opened within eight minutes by a pair of hydraulic jacks to form 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 opening, it has been confirmed that this should not occur even in a 30m/sec wind speed, as per the Japanese loading standard.

A gondola hanger for exterior cleaning is installed below the hovering space and moves around on 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 (Fig 91).

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

The annex
As already noted, the annex next to the tower contains shops and large lecture theatres (Figs 79, 92). Its roof structure is a reinforced concrete shell varying between 150mm and 200mm thick, and spanning 30m x 45m. A special permanent formwork spaceframe system called Trusswall was used to support the shell, eliminating the need for conventional formwork.

Conclusion
Many high-rise buildings have been built in highly seismic countries like Japan in recent decades, but most of them are box-shaped with vertical columns. The very different shape of this building, as proposed by the architect, was strongly favoured by the client, and so those involved in its structural design and construction made every effort to achieve the shape. The completion, therefore of this uniquely shaped skyscraper may be regarded as a significant achievement in Japan’s history of high-rise buildings.