High-Rise Reinforced Concrete Building Using 150 MPa High Strength Concrete — Park City Musashi Kosugi —

150MPa 高強度コンクリートを用いた超高層 RC 造建物 — パークシティ　武蔵小杉 —




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Synopsis

This project consists of two towers of 59 and 47 stories with 1437 apartments which are, at the time being, the Japan's tallest super high-rise reinforced concrete (RC) building with 203.45m height. To ensure an environment-friendly living and construct a sustainable building with an effective use of its components, 100-year lasting building systems are suitably selected, taking adequately into consideration all aspects of seismic and fire protection.
Combination of a super high-strength concrete of 150 MPa and high strength steel, which is used for the first time in Japan, vibration control devices and the newest developed construction methods in such super high-rise buildings let designers plan the apartment spaces without beams and columns, resulting in wide windows that allow the inhabitants enjoy wide view of the outside and feel unrestrictive living spaces.
Construction is progressively achieved by assembling precast elements. Precast construction contributed largely to ensure high quality, increase safety and shorten time of various tasks. The application of new materials and techniques are supported by structural tests and construction experiments.

Structural Data

Building name: Park City Musashi-Kosugi
Owner: Mitsui Fudosan Residential Co./Shin-Nisseki Fudosan Co.
Design and supervision: Takenaka Corporation

Fig.1 Park City Musashi Kosugi

Schematic design and exterior design: Jun Mitsui & Associates Inc. Architects
Construction: Takenaka Corporation
Building use: Corporative housing, public utilities, commercial facilities, day care center
Number of stories: 59 floors on the ground, 3 basement floors and 2 story penthouse
Maximum height: 203.45m
Total floor area: 103,295.03m^2
Structural type: Reinforced concrete and partly steel
Structural system: Moment resisting frame
Construction period: Oct. 2005~Apr. 2009

1. Background and Design Concept

This condominium project is a part of the wide developed area, in which many high rise buildings are intended to be built within a natural environment around Musashi-kosugi Station, which is located within Kawasaki City, Kanagawa Prefecture in Japan.
The design planning is inspired by the natural landscape revival of Musashino and its living birds. The two towers are set close to each other and their faces, which are shaped as feathers, are direct in a way to reflect a couple-bird on a tree. This illustrates an environment where people are drawn closer and which designers of the towers called “twin-bird concept”.
Furthermore, to ensure an environment-friendly living and construct a sustainable building with an effective use of its components, 100-year lasting building systems (skeleton/infill, plumbing, electric system, shaft) are suitably selected, taking adequately into consideration all aspects of seismic and fire protection. Because the commercial value of the apartments is of extremely importance, such large-scale housing complex is provided with various apartment units with highly attractive living spaces.

Fig.2 View from towers’ base

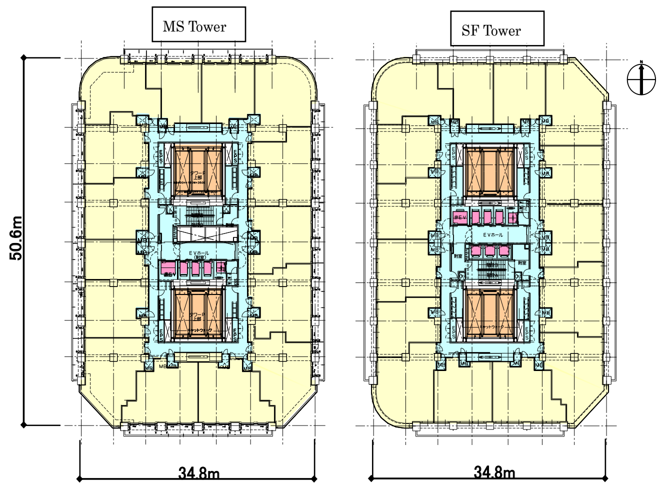

Fig.3 Typical floor plan

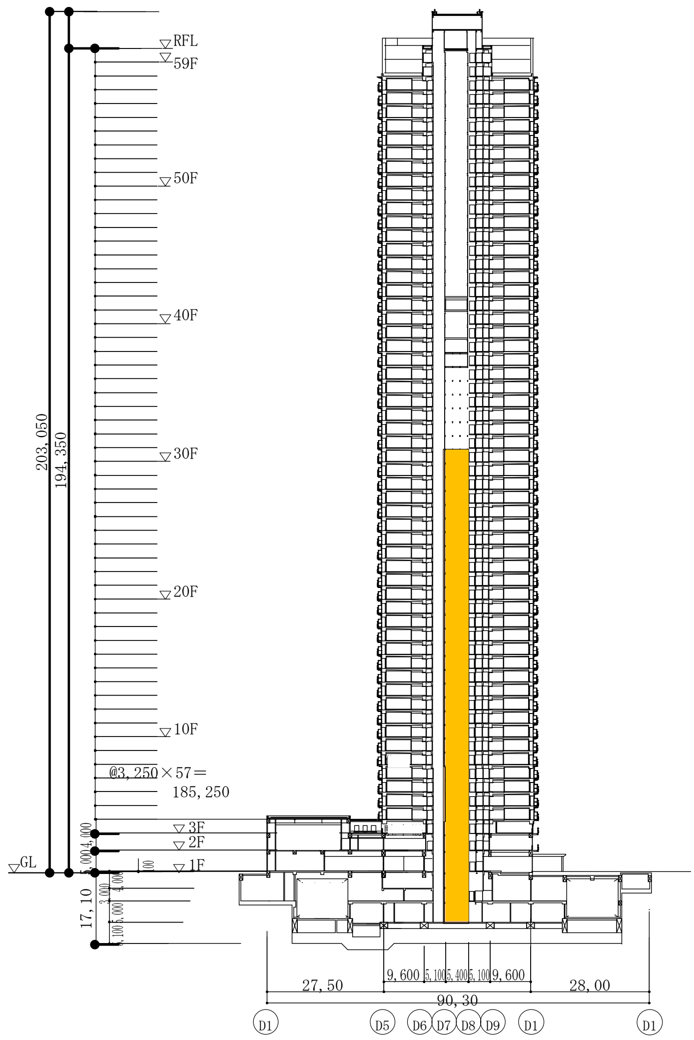

Fig.4 Section (MS Tower)

2. Outline of the Structure

Because both towers are similar, except for the number of stories, only the Mid Sky tower is described herein.
The floor shape of this building is rectangular, measuring 35m in width and 50m in length and contains an opening at its center. The main structure consists of moment resisting frames in both orthogonal directions. The peripheral frames and core frames are connected with girders only in the short direction as shown in **Fig.5**. The aspect ratio in the short direction is 5.44, which gives the building slender proportions.
The seismic control system of the building includes

visco-elastic damper walls at each story from the 3rd to the 38th story and other aseismic devices, named column-type dampers and made of relatively low yield-strength steel panels, at each story from the 3rd to the 10th floor.

The story height is 5m for the first story, 4m for the second story and 3.25 for all other stories. The main materials used in the reinforced concrete columns are summarized in **Fig.6**. The compressive strength of concrete varies from 150 to 30 MPa. The main reinforcement of columns are of very high strength with a specified yield level of 685 MPa at maximum.

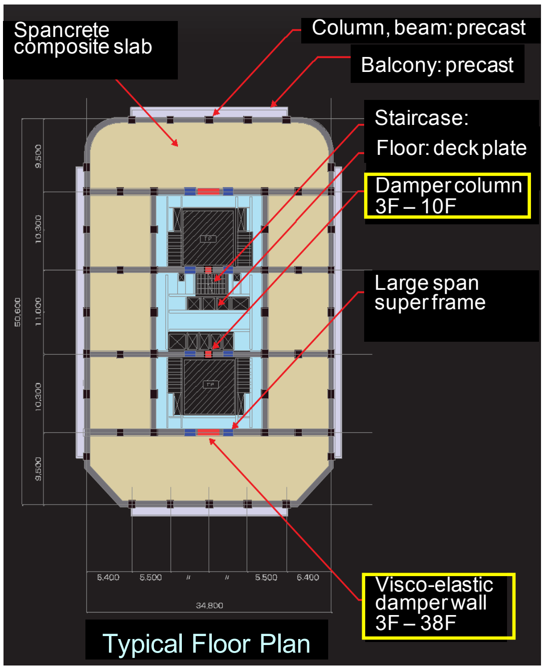

Fig.5 Outline of structure (MS Tower)

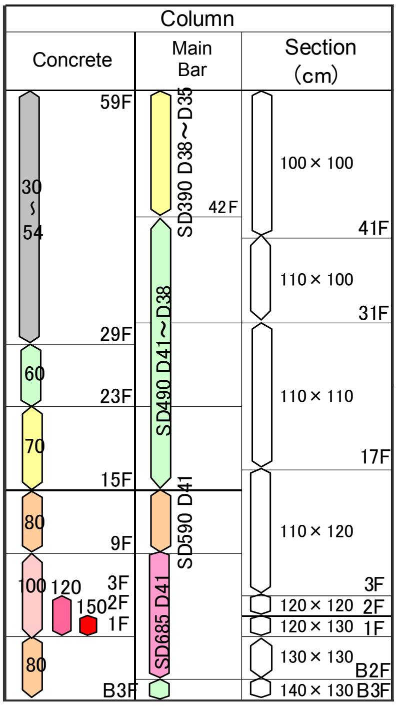

Fig.6 Characteristics of main materials of columns along building height

3. High-strength Concrete

The 150MPa concrete contains a certain amount of Silica-fume powder as well as a high-range water reducer (fluidifier) in order to balance the low water/cement ratio and increase the workability.

As it is well known, high strength concrete engenders explosions during fire due to the enclosed amount of water. When the planned concrete strength is beyond 80 MPa, organic fibers, like Poly-propylene, are added to the concrete. During fire, the fire-resisting performance is significantly improved. The mechanism is based on the creation of voids due to melting of the organic fibers during fire, allowing the encased water to stream out without inducing any inside pressure as shown in **Fig.7**. The 150MPa concrete of Mid Sky Tower also contained such organic fibers as well as steel fibers. The use of steel fibers improves the fundamental structural performance. It prevents the separation of concrete cover when subjected even to high stress conditions and consequently enhances the effective concrete section as shown in **Fig.8**.

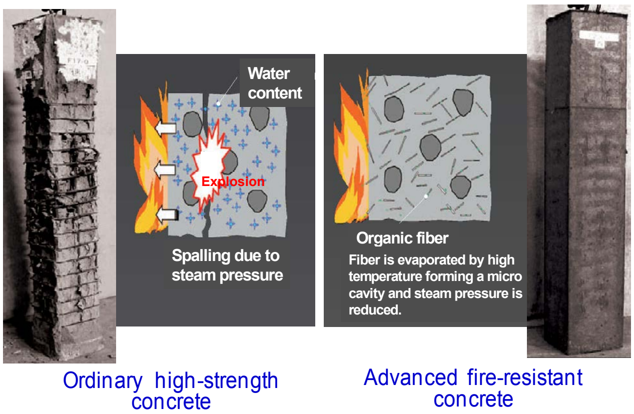

Fig.7 Comparison of fire resistant concrete column and ordinary concrete column

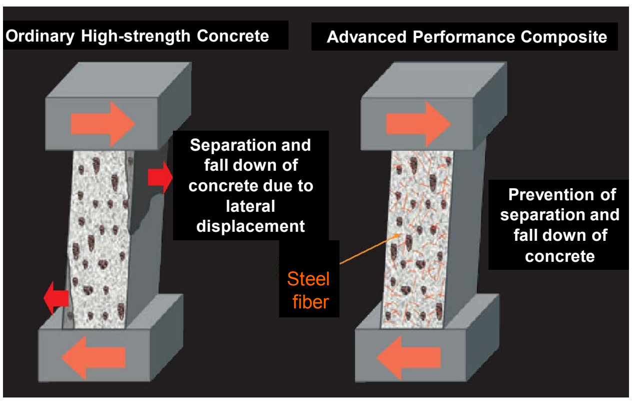

Fig.8 Comparison of damage to columns with and without steel fiber

4. Precast Concrete and Seismic Devices

The superstructure of the building is made of different structural precast elements, columns, sets of beams with beam-column joints, corner beams and balconies, as shown in **Fig.9**, except the lowest 4th floors, which were cast in-place. To ensure the members were properly filled with concrete, some forms were made with transparent acrylic plates.

To assemble the precast beam with beam-column joints, its joint-body was provided with vertical ducts to pass through the main bars of the lower column. Some of the exterior elements including columns were provided with tile-coating. The main bars protruding at the upper part of lower precast columns were spliced using grout-type mechanical sleeves embedded at the bottom of upper columns. The space remaining in the ducts after passing the main bars of the bottom columns through and the gap of 10 mm left intentionally between the precast columns and the joint-bodies were also filled with high-strength mortar. The construction of the building started with a 6-day floor cycle and reached a 4-day cycle at the last stage of construction.

To minimize and control the vibration level of the building, vibration control devices are installed at each story. **Fig.10** shows the wall-viscous damper system and another aseismic system named column-type damper made of a relatively low yield-strength steel panel.

5. Concluding Remarks

Improvement of the elemental technology relative to the application of super high-strength concrete of 150 MPa is considered for a possible future use of higher strength concrete (200 MPa or more) in RC and CFT (Concrete filled tube) construction, as well as in increasing story height, in spanning long distances to reach the application range of steel constructions and realize new space structures. This project is a threshold to achieve progressively that aim and is regarded as an excellent asset by its highly-technical degree of completion as well as its aesthetic value and environment considerations.

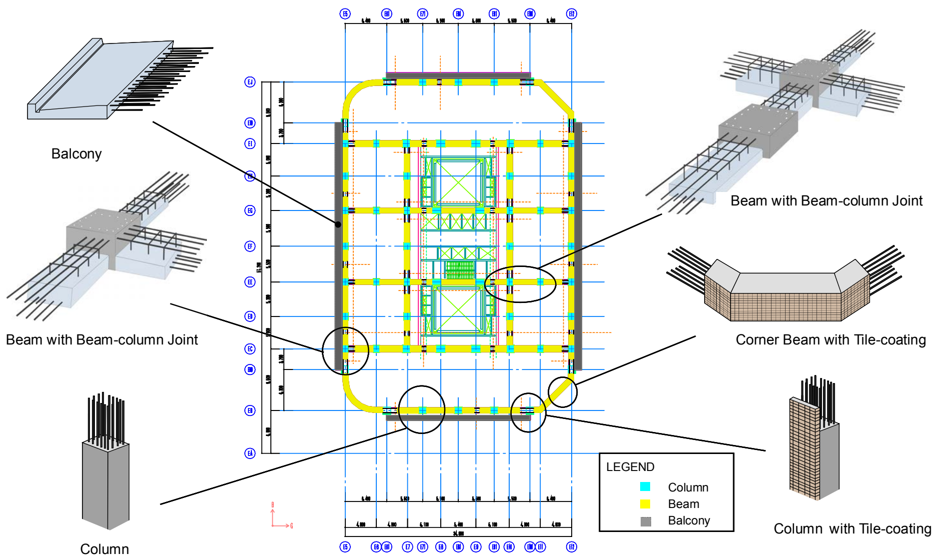

Fig.9 Precast element parts of the building

Fig.10 Installation of vibration control devices

概　要

「パークシティ武蔵小杉」は，神奈川県川崎市で開発が進む武蔵小杉駅前に建つ，階数59階と47階から成る集合住宅として国内最高の高さ（完成時点）203.45m，総戸数1,437戸の超高層 RC 造ツインタワーであり，この土地に息づいている自然環境や都市機能を生かした新しい環境の創造を担って建設された。これは企画当初からの街づくりに対する想いである「経年優化」（木々と共に育まれていく街，時の経過とともに価値を深めていく街づくりを目指す）というコンセプトが企画，計画，設計，建設の各場面においてプロジェクト全体の根底に流れており，この想いが最高の形で結実し完成に至っている。

さらに，わが国で初めて採用した Fc150N/mm^{2}の超高強度コンクリートの要素技術は，今後200N/mm^{2}を超える更なる超高強度コンクリートの RC 造や CFT 造への適用拡大，鉄筋コンクリート造建築の更なる高層化，スパンの長大化，従来は鉄骨造の範疇であった建築用途への進出など，新しい空間構造実現のための第一歩として注目に値するものと考えられる。