

New-type Office Building with Prestressed Concrete and Base Isolation — Futako Tamagawa Rise II-a Tower —

プレストレストコンクリートと免震構造を採用した新しいオフィスビル
— 二子玉川ライズⅡ-a 街区 —



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Keywords: prestressed concrete, high-rise building, seismic design, base isolation system

DOI: 10.11474/JPCI.NR.2018.19

Synopsis

Futako Tamagawa Rise (FTR) II-a Tower is a symbolic tower that is part of the Futako Tamagawa District Redevelopment Project. The FTR II-a Tower is recognized as the first reinforced concrete (RC) high-rise office building in Japan to have a seismically isolated foundation. This structural system comprises precast prestressed concrete (PCaPC) and base isolation (BI), allowing a large column-free office layout, increased comfort against floor vibrations, and good acoustic isolation and thermal insulation. Also, project completion was hastened by building with precast members.

Aesthetically, the exterior of this building is a concrete-framed façade, which is consistent with the underlying design concept of the city's redevelopment scheme.

Structural Data

Location: Tokyo, Japan

Owner: Futako Tamagawa East District City Area Redevelopment Association

Designer: Nikken Sekkei/RIA/Tokyu Architects & Engineers JV

Contractor: Kajima Corporation

Site Area: 28,082.83m²

Building Area: 22,466.02m²

Total Floor Area (Tower): 101,210.79m²

Tower Height: 137.0m

Number of Stories: 30 above ground, 2 below ground

Structure: RC with BI

Occupancy: Offices, hotel

Construction Period: Jan. 2012 – Jun. 2015

1. Introduction

The FTR project was conceived initially as a way to both redevelop the city as an open catchment area for a larger residential community and improve the dated conditions of the city. The latter were exemplified by out-of-style shopping malls, disaster-prone dilapidated wooden structures, and narrow streets.

An aerial view of the FTR site, a street-level view of the II-a tower, an interior view of a typical floor, and a typical floor plan are shown in **Figs.1–4**, respectively. Begun in 1982, this redevelopment project ended in 2016 with completion of the towers in the “II-a” area. The column-free interior of the office tower is due to both the long span achieved by the prestressed concrete beams and the superior seismic performance of the BI system.

On the facades, the RC structural system is expressed as a modular grid with precast concrete members highlighted with pigmentation. The project is summarized herein.

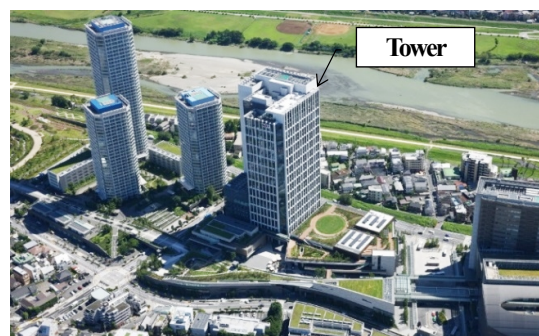


Fig.1 Aerial view



Fig.2 Tower exterior

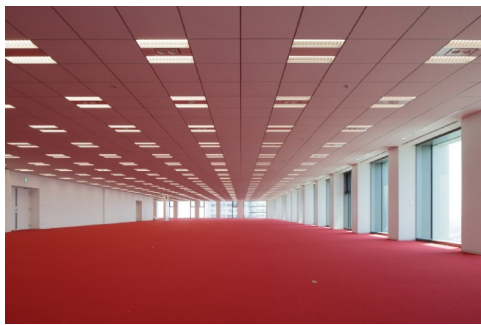


Fig.3 Interior view of typical office floor

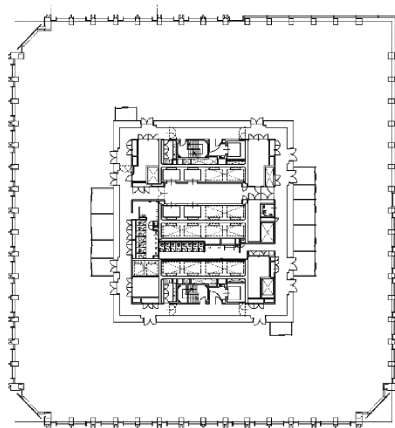


Fig.4 Typical floor plan of the II-a tower, in this case the fourth floor

2. Design

(1) Design Process for Structural System

The owner requested the following design conditions:

- 1) greater net rentable area and flexibility for various floor configurations to improve the lease;
- 2) better seismic and serviceability performance compared to standard office buildings in Tokyo.

The site conditions dictated that a square footprint with an orthogonal structural grid and a central-core wall system would be the most rational scheme given the design requests listed above.

The convention in Japan would be to choose a steel structure for such a high-rise building because of the

unique localized conditions. More precisely, when considering the large accelerations associated with an earthquake, the structural design favors a building with a lower dead load. Also, a small site often dictates a tower with a large aspect ratio, thereby imposing severe tension stress on its structural columns. Therefore, a concrete structural system is assumed to be disadvantageous.

However, contrary to conventional wisdom, the site conditions of the project allowed for a building with a smaller aspect ratio of 1:2. Also, introducing the BI system solved many problems normally associated with RC office buildings (see **Table-1**).

Based on the aforementioned analysis, an RC structure proved to be an efficient and appropriate solution that is competitive for an office building. Also, further analysis has demonstrated the following merits.

- A square plan with a central-core wall provided rigid framing.
- Any seismic load would be transferred primarily through the core wall, thereby mitigating the stress on the columns around the building perimeter. Therefore, the perimeter columns could be made relatively slender, thereby helping to realize the architects' vision of the façades.
- Using precast structural members saved time that would otherwise have been required for concrete to cure on site. In this way, the team achieved a competitive construction schedule compared to constructing a steel structure.
- Precast fabrication makes it possible to shape complex concrete forms highly accurately. Also, by treating the cast concrete surface as its final finish, the time required for interior work was reduced because no further work was necessary.

These merits were analyzed and explained to the owner, and the decision was made to adopt a hybrid structure comprising PCaPC and BI.

Table-1 Problems with high-rise building design in Japan

| Problem | Solution |
|--|---|
| Requirements for various lease patterns and column-free open offices. | Prestressed concrete beams can realize long spans. They also prevent concrete from cracking and improve its durability. Furthermore, the high stiffness and massive characteristics of concrete are good for an office environment. |
| Reduce the dead load as much as possible while considering the bearing capacity of the ground. | The project site had desirable geotechnical conditions with high bearing capacity to support a high-rise building at the bottom of the foundation level. |
| Lack of materials that are both strong and ductile with which to match the high seismic performance of the framing. | BI system mitigates any seismic force and keeps the building in an elastic state during an earthquake. In addition, research into high-strength concrete improved the reliability of the proposal. |
| To minimize the building height, the floor beams often must accommodate sleeve openings for Mechanical/Electrical/Plumbing (MEP) routes. | The depth of a concrete beam includes the slab thickness. Thus, when compared with a steel beam and slab structure, the same beam depth in concrete provides greater clearance between the bottom of the beam and the ceiling. |

(2) Structural Design: Base Isolation + Core Wall + “Octothorpe-Shaped” Framing

On a typical floor, the office space was planned around the central-core walls, meaning that a simple structural system was desired. The slender precast columns around the perimeter are only for vertical support. The central-core wall, which consists of precast columns and beams, frames the cast-in-place concrete wall within, providing vertical support and resisting lateral forces.

The office floor sits on the long span beams that run between the central core and the perimeter columns. The majority of those beams were precast and prestressed, but some were precast and post-tensioned (see Fig.5) and used to compose framing shaped as an octothorpe sign. They function as outriggers on each floor and reduce the story drift due to lateral loads (Fig.11). The top of the beam height of the boundary girder is set lower than the finish floor level, and the space between the two is used for installing tension cables and MEP routing.

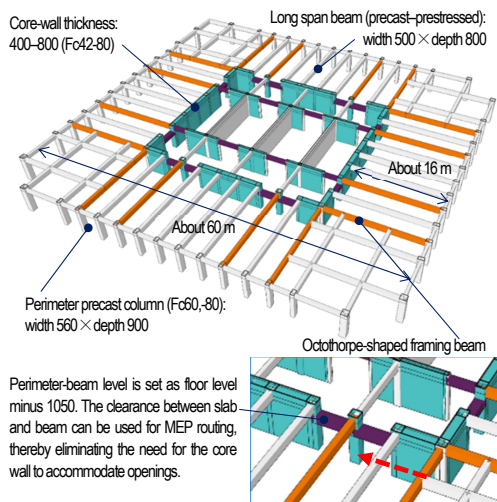


Fig.5 Floor framing concept

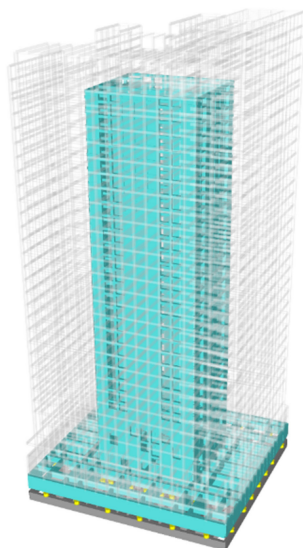


Fig.6 Core wall and base isolation concept

(3) Entrance Hall Design: Utilize the As-Fabricated Concrete Surface as Finish

The ceiling of the entrance hall (which is between two and three stories high) is included in the precast-prestressed design (Fig.7). Named “Wing Beam” from its section profile, its benefits as a precast-prestressed system include its superior accuracy and durability from being manufactured in a controlled environment, as well as being suitable for installation as a finished surface. Also, Wing Beam helped realize the façade design concept and the concrete grid motif of the interior, while reducing the dangers of working at height near the ceiling and stanchion while setting the beams. The section is shown in detail in Figs.8 and 9. Two sections are set aside symmetrically to form one unit together. The two sections are joined as one once cast with topping concrete.

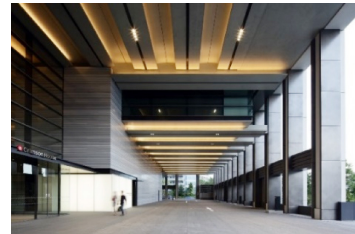


Fig.7 Entrance lobby interior view



Fig.8 “Wing Beam” fabrication

In addition, considering its complex shape, finite-element analysis was conducted to check its structural integrity (Fig.10). The construction procedure reflected the analysis of each loading condition, namely 1) member setting, cladding, finish, and lighting installation, 2) topping concrete casting, 3) live load installation, and 4) upward and downward seismic loads.

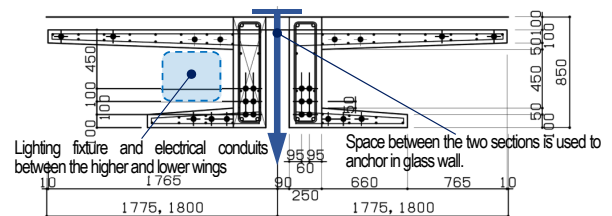


Fig.9 “Wing Beam” concept

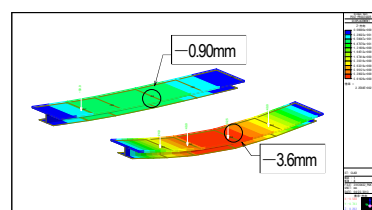
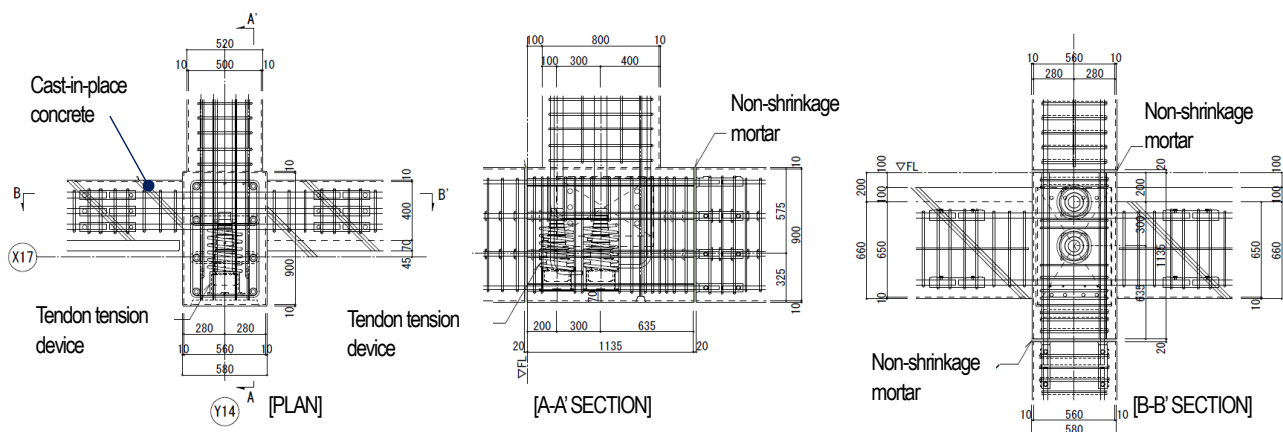


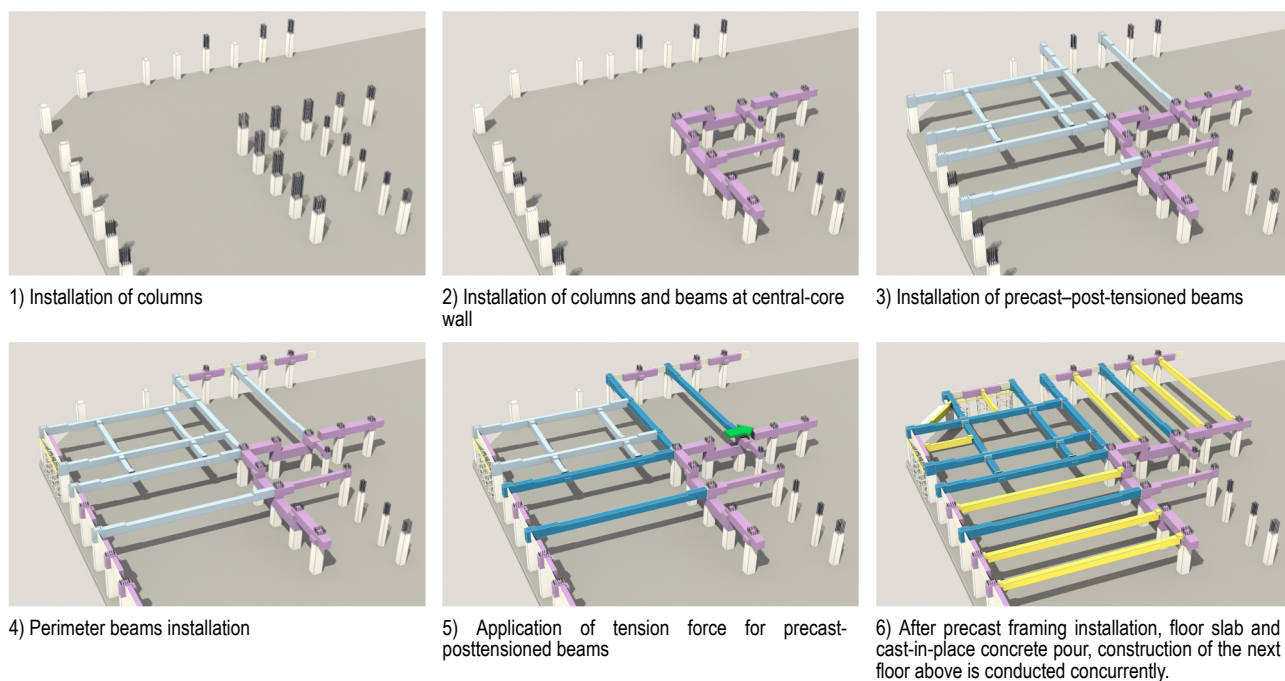
Fig.10 FEM analysis of “Wing Beam”



3. Construction: One Floor in Seven Days

Construction of one typical floor was completed in seven days, which is a construction rate to match that

of any steel structure. The implication is clear, namely that this construction methodology could overcome the disadvantages of a conventional concrete structure.



4. Conclusion

Adopting PCaPC and BI in this project provided more-attractive structural solutions compared to a conventional steel-frame high-rise office building. Because of many of the unique conditions specific

to the project, it became possible for such structural systems to work coherently with one another. However, the lessons learned could be applied in the near future to many different types of project of various occupancy and size.

概 要

二子玉川ライズⅡ-a 街区高層棟は、二子玉川再開発におけるシンボルタワーとして、日本で初めての基礎免震構造を採用した超高層オフィスビルである。プレキャストプレストレストコンクリート構造及び基礎免震構造により、シンプルかつ明快なコンセプトで、大きな無柱空間や高い遮音、断熱、床振動に対する居住性に対し高い性能の付与の実現が可能となった。これらのシステムにより重量の大きいプレコン外装の採用が可能となり、意匠の観点からも再開発全体のデザインコンセプトを踏襲することができた。さらにプレキャストによるユニット化は施工性の改善にも貢献できている。