Precast Wall-Columns Realizing a Randomly Combined Portal Structure — KASHIYAMA DAIKANYAMA —

ランダムに構成される門型架構を実現した PCa・SRC 壁柱 — KASHIYAMA DAIKANYAMA —


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Synopsis
A structural system consisting of steel reinforced concrete (SRC) wall-column + S beam portal units combined with core seismic shear walls was proposed to realize a building scheme in which nine large and small portal units were assembled randomly in both plan and elevation in a commercial building with five stories above ground and two basement levels constructed in Tokyo. Also, precasting was adopted for the SRC wall-columns to improve constructability on site. A major issue was the joints in each of the precast wall-columns, for which an arrangement and detailing were devised that were as simple as possible considering stress transfer. This article reports on the structural scheme and the construction plan.

Structural Data
Location: Daikanyamachō, Shibuya-ku, Tokyo
Use: Retail shops, restaurants, event space
Number of Stories: 2 basement levels, 5 stories above ground
Building Area: 826 m^2
Total Floor Area: 2,466 m^2
Height: 19.95 m
Structure: Steel reinforced concrete (SRC)
Owner: Onward Holdings Co., Ltd.
Designer: Taisei Corporation
Contractor: Taisei Corporation
Construction Period: Dec. 2016 – Nov. 2018

1. Introduction
This is a commercial building constructed in Tokyo, with two basement levels and five stories above ground (**Fig. 1**). The requirement of the client (a large apparel manufacturer) was to provide an attractive building space as the flagship store for the company's brand that included not only space for the company's products but also dining and event spaces. Oki Sato of Nendo, the design supervisor, proposed a design concept in which a simple box is divided into large and small portal

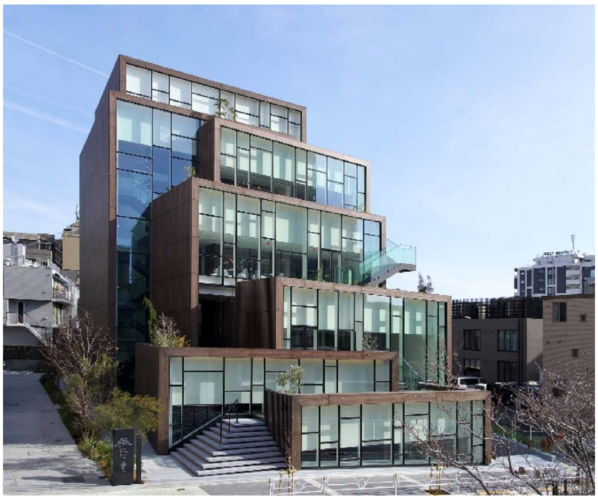


Fig. 1 KASHIYAMA DAIKANYAMA

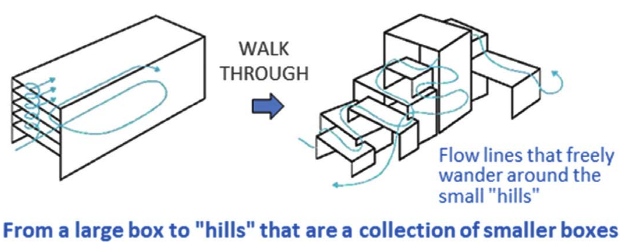


Fig. 2 Design concept

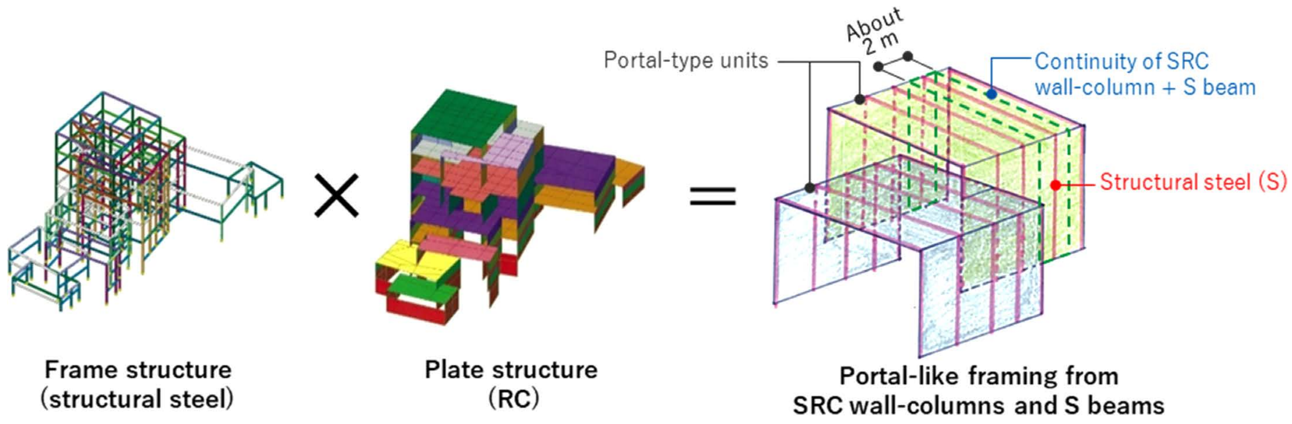


Fig. 3 Approach to the structural scheme

units, which are then combined randomly in plan and elevation to produce new and unconventional building spaces that are rich in variety (**Fig. 2**). The units were combined in a "skip floor" layout forming "hills" such that the goods and restaurants arranged on each floor can be approached freely from various positions. Realizing this new form required starting with the framing scheme.

2. Approach to Realizing the Concept

The issues considered for the structural scheme of this building were ealiza light façade design and orma random combination of many small and large boxes. Work to resolve these issues started by comparing two structural forms that are polar opposites: a frame structure and a plate structure. A comparison was made between a structural steel frame that could be easily constructed into complex forms and a reinforced concrete (RC) plate structure in which spaces could be formed using slabs and walls as they were. Ultimately, a structural system was devised in which units could be combined freely using a portal structure with SRC wall-columns + structural steel (S) beams, which utilizes the advantages of the two forms (**Fig. 3**).

3. Three Proposals for Realizing the "Hills"

This section describes the details of the building's structural system. The scheme was based on the following three points, which achieved both the required design and seismic resistance.

(1) Portal structure with SRC wall-columns and S beams.
(2) Multi-level wall-columns incorporating a core.
(3) Connection scheme assuming precast method
Details of each point are described below.

(1) Portal Structure with SRC Wall-Columns and S Beams

By making the SRC wall-columns about 2 m wide and the S beam portal structure continuous in the wall direction, the nine large and small units can be combined structurally in accordance with the plan. The vertical load-bearing members are the SRC wall-columns, and by reducing the pitch of the portal frames, the wall-column thickness could be reduced (to 250 mm), enabling a light frame to be achieved. In each unit, the walls do not start from the floor but are brought down to ground level. In this way, an excessive load is not applied to the horizontal members, the thickness of each wall can be the same, and by having many members intersecting, the overall stiffness of the frame is increased (**Fig. 4**). The wall-columns appearing within the rooms add a dramatic effect to the interior retail space and create free spaces that are rich in variety (**Fig. 5**).

(2) Multi-Level Wall-Columns Incorporating a Core

In the beam direction, the wall-columns are continuous and a sufficient amount of wall is provided. On the other hand, in the span direction, the structure mainly

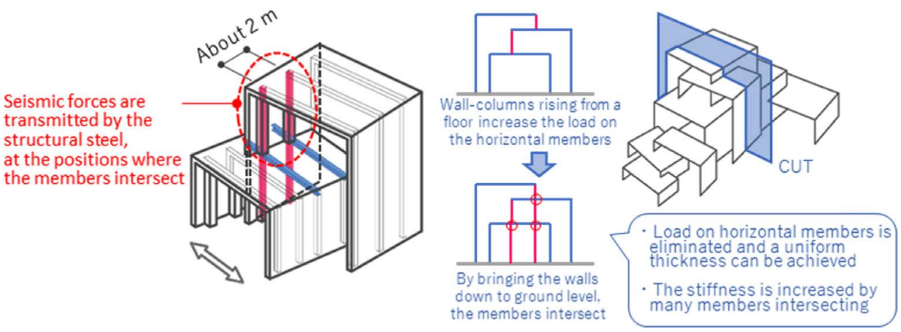


Fig. 4 Effect of combining boxes

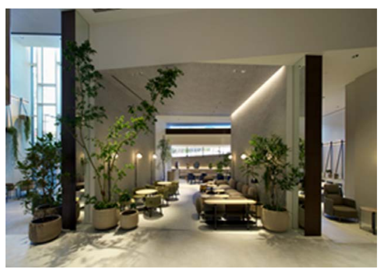


Fig. 5 Spaces rich in variety created by the boxes

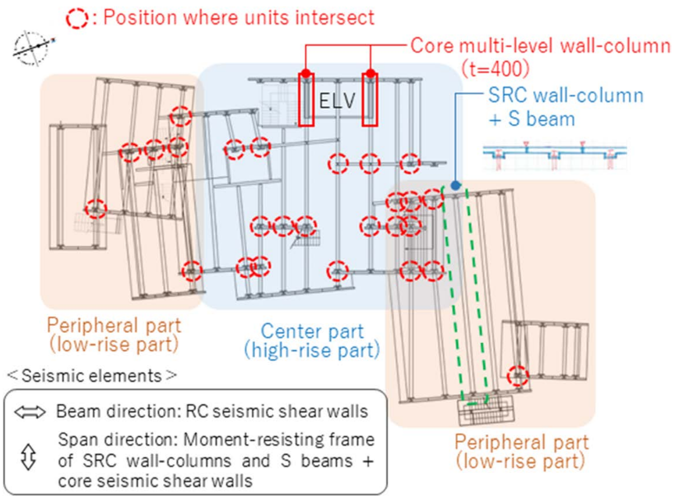


Fig. 6 Framing plan

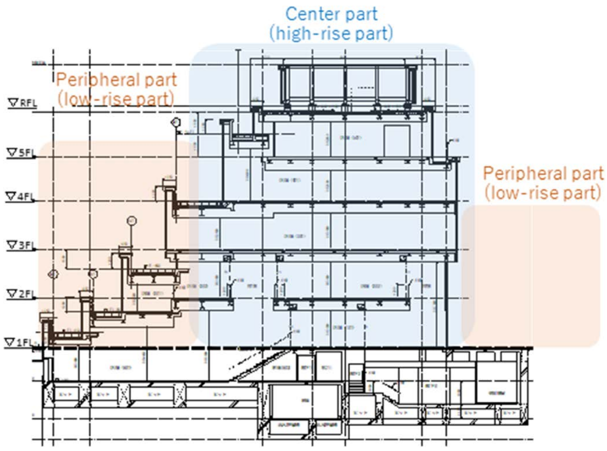


Fig. 7 Framing elevation

consists of moment-resisting frames consisting of the SRC wall-columns and the S beams. Therefore, multi-level wall-columns (40 cm thick) on the sides of the elevator shaft of the core in the center of the building were used to increase the stiffness. By providing the multi-level wall-columns in the center where the load is large because of the high-rise part of the building, the transfer of the seismic forces of the high-rise part to the surrounding low-rise part is minimized, thereby achieving a balance in the building mass and the distribution of shear forces during an earthquake (**Figs. 6** and **7**).

(3) Connection Scheme Assuming a Precast Method

Consideration was given to how to simply and smartly produce the form in which the portals were randomly combined in both plan and elevation. With the image of combining the portals like building blocks, it was proposed that the SRC wall-columns should be precast. Precasting was adopted because it offered several advantages, such as improving the constructability on site and ensuring quality. Detailing the joints of each of the members was an issue with precasting. From the initial design stage, arrangements and details were investigated for transmitting stresses, and the work proceeded to simplify the joints as much as possible.

As shown in the image of stresses in the portal structure during an earthquake (**Fig. 8**), it

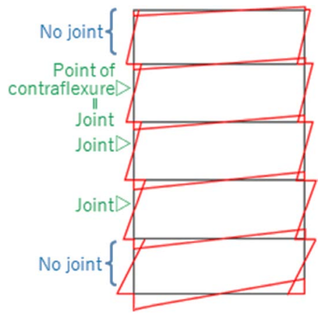
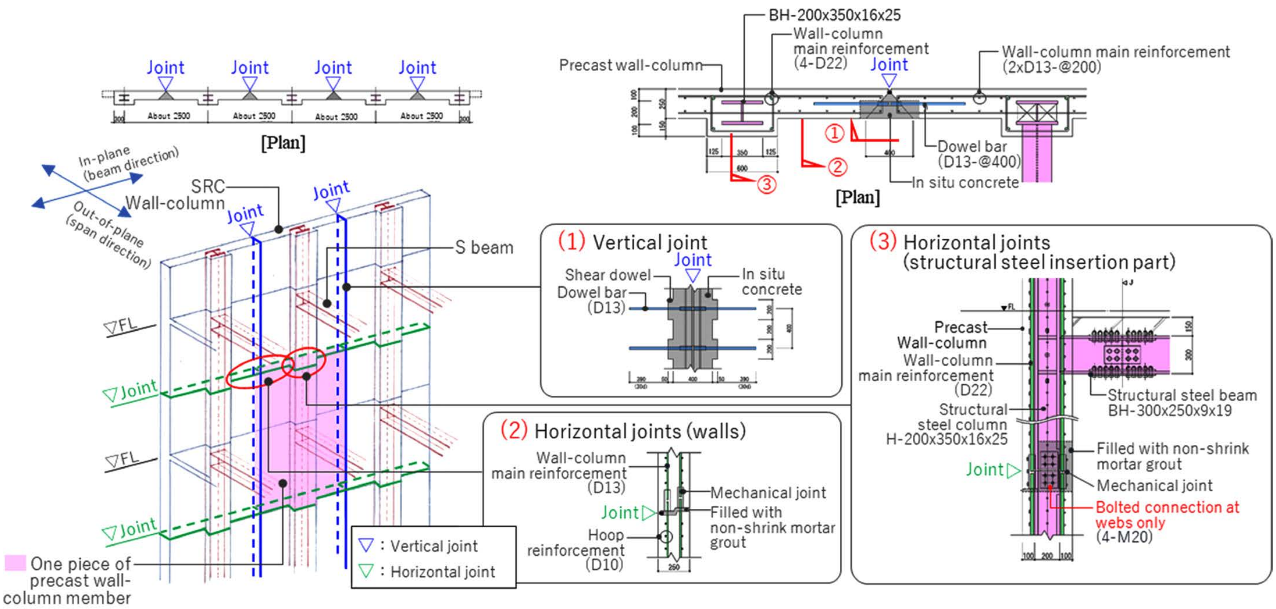


Fig. 8 Image of stress during an earthquake



(a) Image of division of precast wall-column members **(b) Details of each joint**

Fig. 9 Overview of the precast wall-column scheme

was considered that the joint arrangement could be simplified by providing the joints at the mid-height of each story where the bending moments are small. Note that in the uppermost and lowermost stories, it was considered that the position of the points of contraflexure would vary because of the evaluation of the stiffness of the foundation beams, etc., unlike in the intermediate stories, and thus joints were not provided in these stories.

Figure 9 shows the division of the precast wall-columns and the details of each of the joints. Horizontal joints were provided in the center between stories, and vertical joints were provided between wall-columns. The part (A) in the figure was precast as one piece.

There was one type of vertical joint, namely, that between two wall-columns [(1) in the figure], and there were two types of horizontal joint, namely, the wall part [(2) in the figure] and the structural steel insertion part [(3) in the figure]. The joining method of each is shown below. As stated previously, the horizontal joints are provided where the stress is small, and thus only the webs were bolted without connecting the flanges. Because it was envisaged that the points of contraflexure in each story would vary somewhat above or below the center, the main reinforcement bars were all joined with mechanical joints, allowing them to transmit bending moment. Also, the arrangement at each joint was standardized such that the operations from fabrication to erection could be carried out smoothly.

4. Creating “Hills” with Building Blocks

In this project, because of the site and the building layout, materials were brought in from the road on the front, and it was not possible to have a fixed tower crane position. Therefore, a special construction method named “Tatenige” was adopted, which erects the frames from bottom to top per each grid line and shifts the erection location to cover the whole area.

The building is composed of intersecting units of different shapes and dimensions; thus, to determine the extent to which the volume had to be completed in order to become free-standing, the stability was verified at each step using models and other means, and the scheme was formulated for the timing of placement of slabs, temporary braces, and the like.

Using the intersecting structure, portal units were fixed in sequence from the interior of the site toward the front, and by leaving the erected frames from the rear, the stability during erection was ensured. The precast wall-columns could be erected speedily by assembling them like building blocks using standardized joint details (**Fig. 10**).

5. Conclusion

A structural scheme with a randomly assembled effect was proposed in response to a new form created from the designer’s idea, realizing the concept of attractive “hills” where people can gather and enjoy.

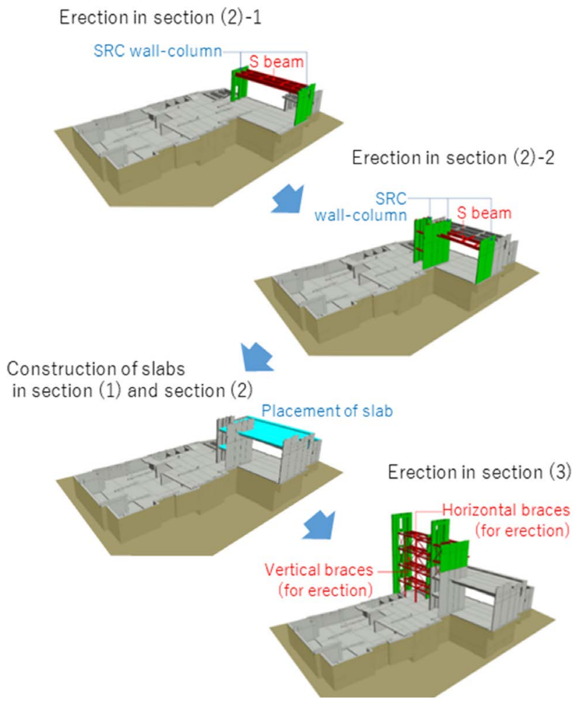


Fig. 10 Steps during erection

概　要

KASHIYAMA DAIKANYAMA は都内に建設された地上 5 階地下 2 階の商業建築である。筆者らは，大小 9 つの門型ユニットが平面・立面ともにランダムに組み合わされた建築計画を実現するため門型ユニット架構を SRC 壁柱構造とし，SRC 壁柱にプレキャスト工法を採用した。本計画は，同一形状となる部材が極めて少ないという条件であったが，現場施工性向上のメリットが高いと考え，プレキャスト工法の採用を前提として計画がスタートした。プレキャスト工法では，設計・施工的に各部材の接合部の計画が課題となる。特に，本建物では SRC 壁柱を採用していることから，通常の柱梁部材の接合よりも複雑となることが予想された。そこで，設計の初期段階から，応力伝達を考慮した配置やディテールを検証し，極力シンプルとすることを意識して計画を行った。