Using Concave–Convex Slabs to Accommodate Air Conditioning Units and Lighting in a Seismically Isolated Building — SHOGAKUKAN Building —

凹凸スラブ内に空調・照明を納めた免震本社ビル — 小学館ビル —


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Synopsis

Located in Jimbocho, Tokyo, this building is the headquarters of Shogakukan Inc., a well-established publishing company (**Fig. 1**). Based on a thorough study, the authors aimed for a place that integrates flexible and wide-ranging working hours for diverse job positions with an energy-conscious, pleasant indoor environment that accounts for floor-to-ceiling height limitations. External concrete wall insulation was installed, as well as a radiant ceiling heating and cooling system with desiccant-based humidification–dehumidification that operates 24/7. This heating and cooling system creates an excellent, comfortable work environment while also achieving minimal energy consumption.

In addition, inverted beams and floors were designed into perfectly combined concave–convex slabs. The radiant ceiling cold/hot water piping was installed on the upper convex slab surfaces covered with insulation panels to prevent the warm air from rising. The spaces created by alternating upper and lower slabs against the beams allow for the housing of motion sensor lighting fixtures, exhaust duct channels, and ventilation systems. Architectural design, building structure, and facility systems were all integrated beautifully into a dynamic form (**Figs. 2 & 3**).

Structural Data

Main Use: Office, shop
Building Area: 1,661.71 m^2

Fig. 1 Appearance (photograph: Gankosha)

Total Floor Area: 17,910.73 m^2
Heigh: 51.39 m
Number of Floors: 10 above ground, 3 below ground
Structure: Steel-framed reinforced concrete structure, seismically isolated building
Owner: Shogakukan Fudosan Inc.
Designer: NIKKEN SEKKEI LTD.
Contractor: Kajima Corporation
Construction Period: Apr. 2014 – Sep. 2016
Location: Tokyo, Japan

Fig. 2 Interior view (photograph: Gankosha)

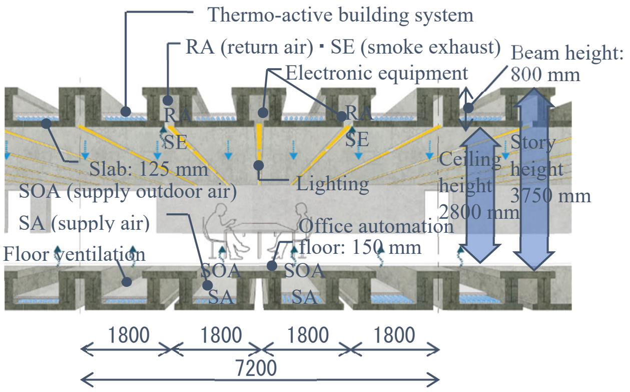


Fig. 3 Concave–convex slabs

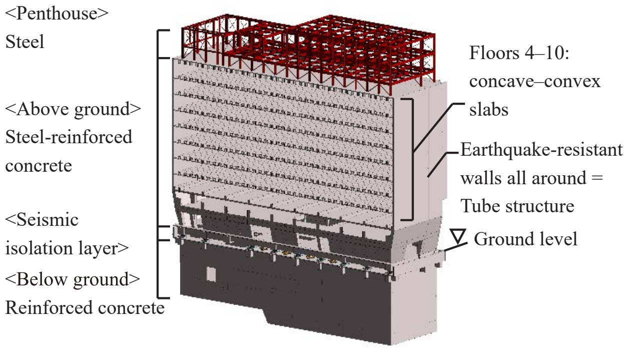


Fig. 4 Overview of structural concept

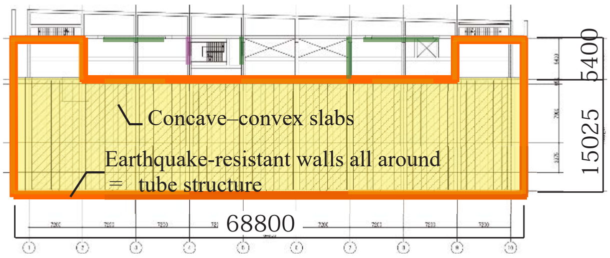


Fig. 5 Office floor plan

1. Introduction

Hakusan Street—which this site faces—is designated by the Tokyo Metropolitan Government as an emergency transportation road in the event of a disaster. As a result of a study to make its former headquarters more earthquake resistant, the owner opted to rebuild the building. For reconstruction reasons, the authors decided to base-isolate the building. The footprint was squeezed to maximize the workspace within the height restrictions imposed by the district plan and to ensure seismic isolation clearance, which is reflected directly in the exterior features.

2. Structural Design

The building has 3 floors below ground, 10 floors above ground, and 2 floors in the penthouse. It is made of reinforced concrete in the below-ground structure, steel-framed reinforced concrete above ground, and a steel frame in the penthouse (**Fig. 4**).

The concrete-based structure was chosen because of its thermal storage radiation and exterior insulation, which were revealed from the research on working style.

For a project with many fair-faced concrete walls, the shrinkage ratio of concrete was limited, and more reinforcing bars than typical were used as a measure to reduce drying shrinkage cracking.

In addition, posters had been pasted on the windows of the former headquarters building, and the owner of the building wanted smaller windows if they would reduce the heat load. Thus, the authors decided to surround the building on all four sides with earthquake-resistant walls with small windows.

The client wanted a well-formed office space with no columns or beams, and thus columns and walls have the same thickness to create an easy-to-use, column-free space.

(1) Seismic Isolation Structure Design

A seismic isolation structure was adopted to secure the main functions of the headquarters building in the event of a disaster.

The design is effective for load levels ranging from small to large earthquakes, using a combination of laminated rubber isolators, steel U-shaped dampers, and oil dampers.

The basement frame was constructed inside the existing frame, which is consistent with the use of the basement exterior wall of the existing building as a retaining wall and other workability considerations, as well as the creation of seismic isolation clearances.

(2) Tube Structure

The interior of a standard floor is a column-free space of approximately 70 m × 15 m with no beams. The building structure is a tube structure with load-bearing walls on all four sides except for a cantilevered section on the west side (**Fig. 5**).

The rigid tube structure reduces deformation and response amplification in the upper section, further improving the seismic isolation effect.

Because of the rectangular plan with an aspect ratio of 1:3, seismic forces are concentrated on the seismic wall on the gable sides, and there is concern about the pull-out force of the isolators due to the overturning moment. The tube structure makes the isolators extremely safe against overturning because of the

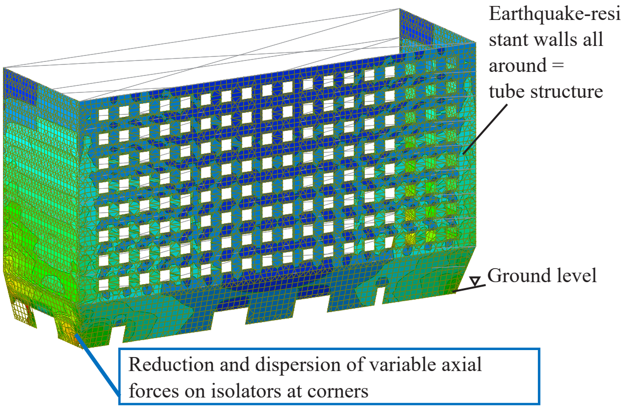


Fig. 6 Wall stress in short-direction earthquake

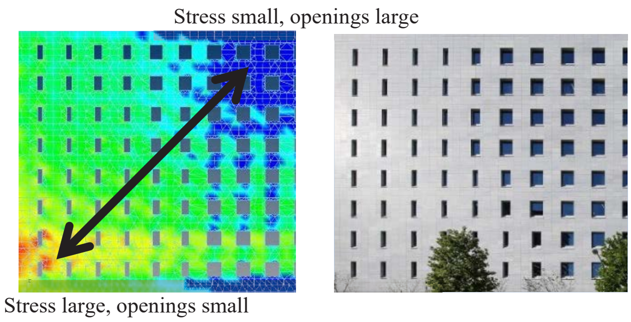


Fig. 7 Stress diagram of the exterior wall and facade

reduction and dispersion of variable axial forces on the isolators (**Fig. 6**).

Because horizontal forces can be resisted on all four sides, interior beam stresses are reduced, and maximum ceiling height is achieved within the limited story height.

In response to the design concept of gradation of window sizes on the facade, the openings in the earthquake-resistant walls are made smaller on the lower floors and gable ends, such that the horizontal force and the three-dimensional force flow are matched with the exterior design (**Fig. 7**).

The small openings and thick tubes are compatible with the intention of reducing the solar heat load and the facility plan with a thermo-active building system. Also, energy savings arise from the external insulation on the outside of the tubes and the concrete frame heat storage.

(3) Concave–Convex Slabs

The floor height was reduced by embedding the equipment in the slabs and exposing the ceilings to the frame.

The concave–convex slabs have an H-shaped steel frame built into the concrete in the vertical profile area (**Fig. 8**).

The visible surfaces of the ceilings and walls were designed with fair-faced concrete for the interior space design. The walls can be freely customized with posters

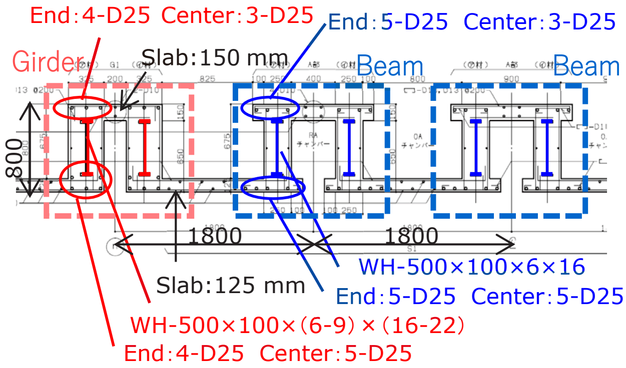


Fig. 8 Concave–convex slab structure

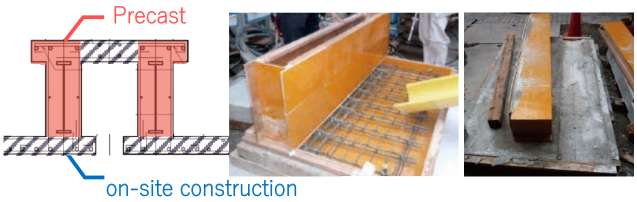


Fig. 9 Checking fillability of the lower slab in on-site construction

and other materials, which matches Shogakukan's concept of office spaces suited to the way of working at a publishing company.

As mentioned above, the lower surface is used as a radiant air-conditioning surface, and the concave–convex shape is used for the air supply and return chambers, which also incorporates lighting, sensors, and other equipment. Taking advantage of the large thermal capacity of concrete, the building frame can store heat and maintain a constant indoor temperature, making the space comfortable year-round.

3. Construction

Taking advantage of the fact that the same shape is repeated, the structure was partially precast to enable a shorter construction period and easier construction.

For design purposes, a portion of the upper slabs and beams were precast, and the lower slabs, which were to be fair-faced, were constructed onsite. One could say that it was the opposite of a conventional method.

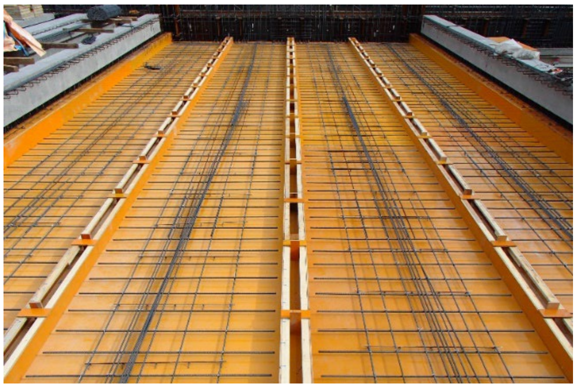
The authors carefully studied the reinforcement and other aspects to ensure that the concrete would be properly constructed in the lower slabs, which were to be constructed later.

The authors conducted construction tests and confirmed the good filling performance of the concrete (**Figs. 9 & 10**).

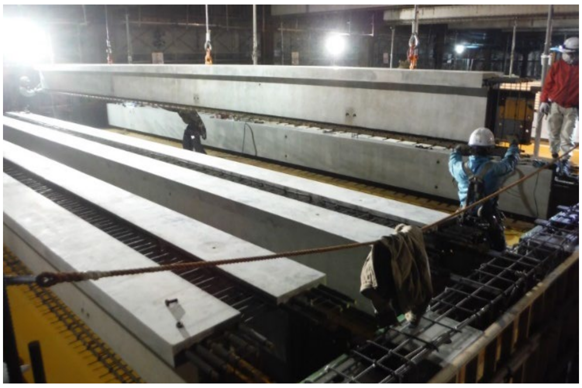
4. Conclusion

The distinctive interior and exterior views are the result of a structural design that integrates architectural and equipment planning.

1) Half of the girders were installed at the same time as the steel erection



2) Lower slab formwork, under reinforcement



3) Remaining precast girders and beam installation

4) Lower slab upper reinforcement

5) Concrete construction on the lower slabs

6) Concrete construction on the upper slabs

Fig. 10 Construction procedure for concave–convex slabs

概　要

神保町に建つ老舗の出版社，小学館の本社ビルである。旧本社の働き方を徹底的にリサーチした結果を元に「出勤・退社時間に自由度があり，働く時間帯に大きな幅のある働き方」と「省エネ・快適性」の両立を限られた階高で実現することを目標にした。冷水配管を巡らせたコンクリート天井（躯体蓄熱放射冷房）と外断熱のコンクリート壁を組み合わせることで，放射環境の向上と温度変動の少ない安定した環境を実現し，エネルギー・ミニマムでありながらいつでも快適な質の高い仕事場をつくりだした。

実現にあたっては，逆梁と順梁を組合せた凹凸形状の特殊スラブを採用。放射冷房用の冷水配管を凹部スラブの上面に敷設し，熱が上部に逃げないように断熱パネルで押え下階の天井面を放射面とした。梁に対して上付きのスラブと下付きのスラブを交互に設けたスペースには，人感センサー照明，換気・排煙の経路を表裏一体に納め，意匠・構造・設備が統合された建築計画とした。