School Building with Vertical Keynote Design using Mixed Structure — Hokkaido University of Science Central Building (Building E) —

混合構造を用いた縦基調デザインの学校建築 ― 北海道科学大学中央棟（E 棟）―


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Synopsis

The Hokkaido University of Science Central Building (Building E) is located in Sapporo, Hokkaido, and is a mixed structure of reinforced concrete and structural steel, with four stories above ground, one basement level, and a building height of 20.4 m (**Fig. 1**).
Because of its location in a region with heavy snowfall, a requirement was that construction of the structure should avoid the snow season. Therefore, an industrialized construction method with repeating 3-m units was adopted.
The vertical keynote design resulting from the precast concrete columns was adopted taking into consideration snowfall and accumulation of snow, and it enabled the formation of the aesthetic in the campus as a whole, where the design was established in the area as a memory of the former Hokkaido Institute of Technology.

Fig. 1 Hokkaido University of Science Central Building (Building E)

Building Data

Structure: Reinforced concrete, structural steel
Foundations: Piled foundations
Number of Stories: Four stories above ground, one basement level
Building Height: Maximum height 20.4 m
Total Floor Area: 4,794.85 m^2
Client: Hokkaido University of Science
Design: Taisei Corporation, Registered First Class Architect's Office
Construction: Taisei Corporation, Sapporo Branch
Construction Period: May 2015 to January 2017
Building Location: Teine-ku, Sapporo City, Hokkaido

1. Introduction

At Hokkaido University of Science, redevelopment of the Maeda Campus has been in progress since 2012 with the aim of becoming "Hokkaido's No. 1 practical-based comprehensive university" by 2024, the centenary of establishment of the university. In this re-organization of a collection of several universities, there was a requirement for characteristic design elements in accordance with common rules for the campus as a whole, and the ability to change the internal spaces.
The characteristic vertical keynote design was realized through a structure with precast columns, and by

adopting structural steel beams, a building with large and changeable internal spaces was realized.

2. Design

This building comprises a technological lecture zone, east and west research and experimentation zones, and a common space, which also serves as the main entrance.

The first-floor entrance hall/interaction station is adjacent to a tree-lined avenue, and the student cafeteria faces a courtyard, so this space was composed as an open two-story atrium (**Fig. 2**). There are large and small lecture rooms on the third and fourth floors, arranged so that they are easy to use from the research and experimentation zones. Also, the building height was set as 20.4 m in order to heighten its symbolism, taking into consideration the external view from the tree-lined avenue (**Fig. 3**).

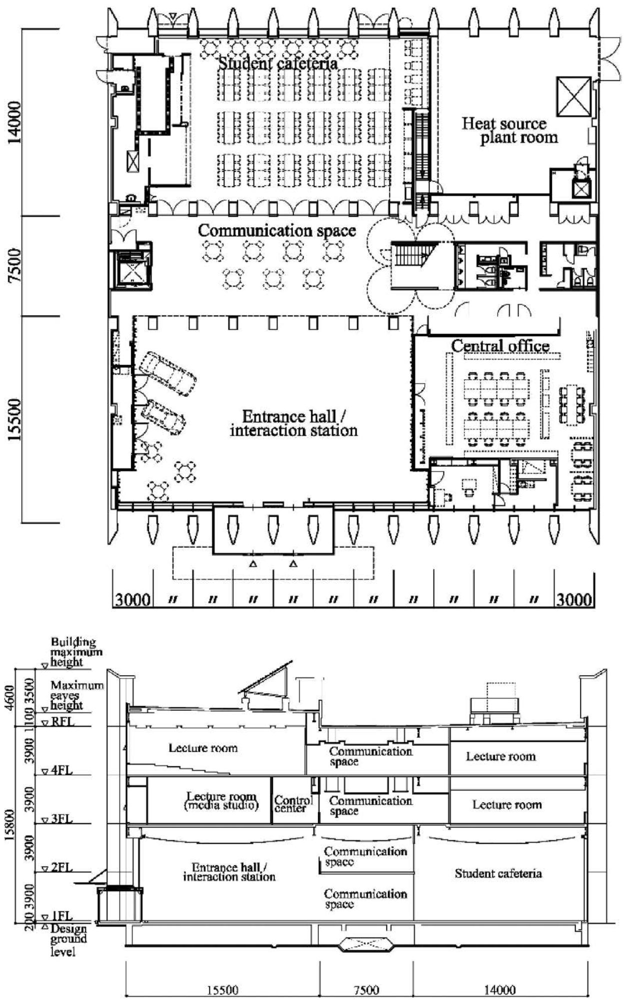


Fig. 2 First-floor plan and cross-section

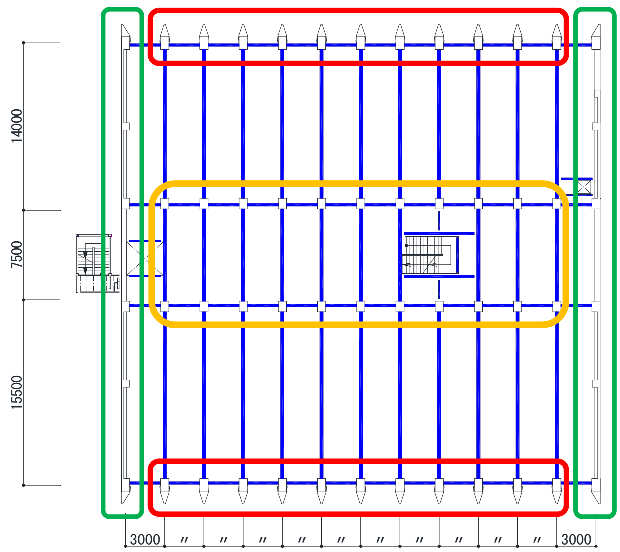
Fig. 3 View from tree-lined avenue

3. Structural Design

This building has a mixed structure with reinforced concrete columns combined with structural steel beams. In the X-direction it is a moment-resisting structure, and in the Y-direction it is a moment-resisting structure with seismic shear walls (**Fig. 4**).

The columns on the periphery of the building are precast concrete columns, and the columns and beams around the seismic walls are in situ reinforced concrete. In this mixed reinforced concrete and structural steel structure, the beam-to-column connections are a feature in terms of both design and construction. In the beam-to-column connections, high-strength concrete with a strength of 45 N/mm^2 was adopted, and the structural steel beams were strengthened. Large diameter main reinforcement is used in the columns to reduce the number of bars, which provided a simple arrangement in terms of construction (**Fig. 5**).

In the foundation design, the existing high-bearing-capacity concrete piles going down to the fine sand-bearing stratum at about GL−36.0 m were used.



□ : Precast concrete columns

□ : Conventional columns

□ : Seismic shear walls

— : Structural steel beams

Fig. 4 Structural diagram

4. Characteristic Vertical Keynote Design and Changeability of Internal Spaces

In the campus redevelopment, a requirement was for characteristic design elements to conform to common rules throughout the campus as a whole. Therefore, a design was adopted for the group of school buildings in which the form of the columns created a vertical keynote (**Fig. 6**), taking into consideration the accumulation and falling of snow in this region with heavy snowfall, and as a façade that would not affect the ability of the internal spaces to be changed. The design with the form of the columns creating a vertical keynote was inherited from the existing school buildings as a memory of the former Hokkaido Institute of Technology (**Fig. 7**), and it evolved to form the landscape of the campus as a whole with a design that has become established in the area. To realize the vertical keynote design and changeability of internal spaces, it was necessary to resolve the following issues at the structural planning stage:

(1) construction of the above-ground structure in the limited time period to avoid the snowfall season;
(2) realization of spaces without columns with spans of about 15 m;
(3) cross-sectional shape of the columns forming the vertical keynote design.

To construct the structure in this cold region with heavy snowfall, it was necessary to avoid the snowfall season and thus major curing measures were required. By examining whether it was possible to supply a building that could satisfy the client in the limited construction period, it was decided to adopt an industrialized construction method. However, making wide use of the industrialized construction method to shorten the construction period would increase the cost compared with the conventional construction method. Therefore, the industrialized construction method was adopted for the precast concrete columns because a high-quality finish was required for the columns of the façade having an acute-angle cross-section and which would become the face of the building, and conventional construction methods were adopted for the internal spaces. By adopting the precast concrete columns, a fine textured concrete finish could be achieved by using steel formwork surfaces, which contributed to reducing the cost of finishing materials and eliminating the cost of curing in winter.

Next, for changeability of the internal spaces, normally there is a requirement to provide as few columns as possible so that room partitions and the like can be easily changed, and for the lecture rooms, spaces of about 15 m were required in consideration of the use and capacity of the rooms. Because the columns were reinforced concrete, post-tensioned prestressed concrete beams and steel reinforced concrete beams were also considered. However, considering that

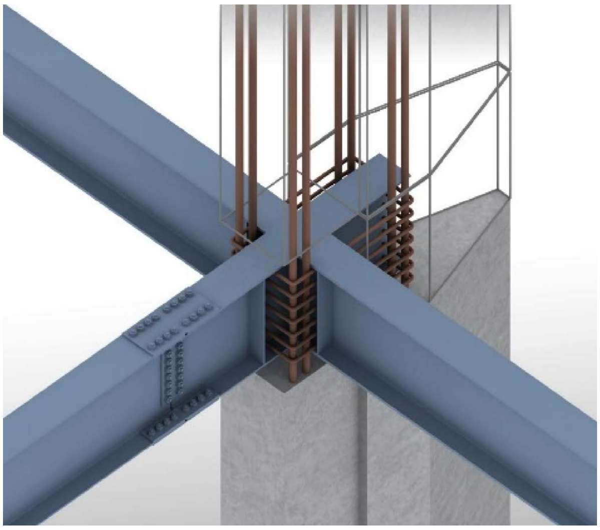


Fig. 5 Beam-to-column connection

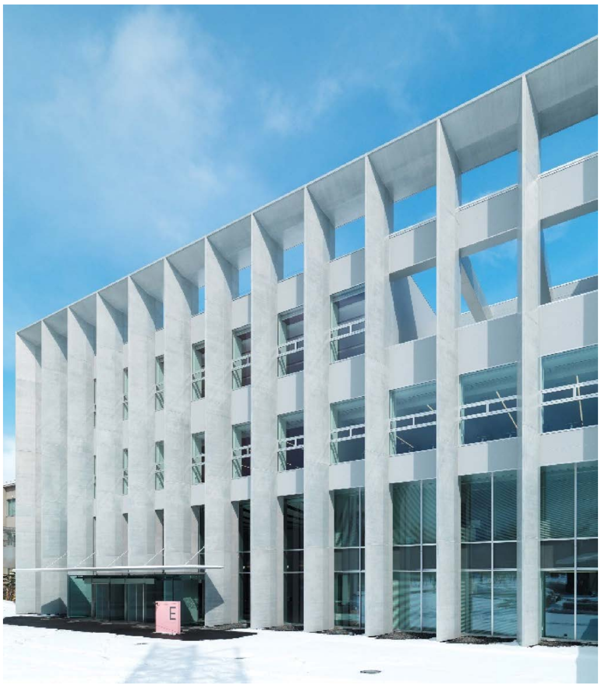


Fig. 6 Vertical keynote design of the column form

Fig. 7 The former Hokkaido Institute of Technology

construction of the structure had to avoid the snowfall season, it was difficult to adopt prestressed concrete beams or steel reinforced concrete beams because of scheduling problems, so structural steel beams were adopted to shorten the construction time. The connections between the precast concrete columns and the structural steel beams were made in situ. A rational structure was provided by supporting the high axial loads due to the long spans on precast concrete columns. In addition, the self-weight of the building could be reduced by adopting structural steel beams, and this enabled rational design of the foundations and design against seismic forces.

Regarding the third issue, while determining the cross-sectional shape for the vertical keynote design, opinions were expressed that it would also be possible for the structure to have additional functions. Therefore, a study was performed to determine whether it was possible to add a sunlight shielding function by the louver effect by giving the columns depth, as an environmental consideration (**Fig. 8**). The cross-sectional shape adopted is a shape that provides depth to the finished façade surface necessary for shielding sunlight, the cross-sectional dimensions necessary for structural design, and provides the building with a fine architectural effect from the concrete finish. In addition, to exhibit the louver effect, the column span was chosen to be 3.0 m.

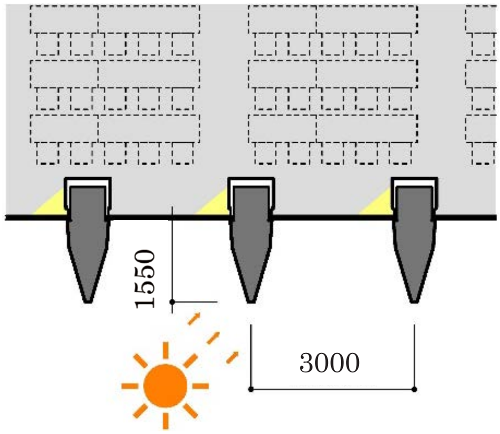


Fig. 8 Column shape with added sunlight shielding effect

5. Conclusion

This building was realized by adopting a rational structural form combining reinforced concrete and structural steel to satisfy the requirements of characteristic design elements that conform to common rules for the whole campus, and changeable internal spaces, forming a landscape with a vertical keynote design, while also adding the function of energy efficiency and consideration for the local environment both within the campus and in the surroundings (**Figs. 9** and **10**).

Fig. 9 Entrance hall

Fig. 10 Overall view of Hokkaido University of Science Central Building (Building E)

概　要

北海道科学大学中央棟（E 棟）は北海道札幌市に位置し，地上 4 階地下 1 階，建物高さが20.4 m で鉄筋コンクリート造と鉄骨造を組み合わせた混合構造である。

2024年の創立100周年に「北海道 No. 1の実学系総合大学」の実現を目指して，2012年より前田キャンパスの再整備を進めている。

多雪地域であるため降雪期間を避けての躯体施工が求められ，工業化工法を取り入れた3 m ユニットを繰り返す工法により解決した。プレキャストコンクリート柱による縦を基調としたデザインは，積雪・降雪への配慮の他，旧北海道工業大学の記憶として地域に定着したデザインによりキャンパス全体の景観形成を実現している。また，柱断面形状の工夫により日射遮蔽効果や繊細な意匠性の表現を実現している。