Structural Design of a University with Slender Columns and Large Eaves
— Inamori Hall Liberal Arts and Science Building —

PCaPC 細柱と大庇を用いた大学の構造デザイン
— 稲盛記念会館 —

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Synopsis
Inamori Hall Liberal Arts and Science Building at Kyoto Prefectural University was constructed as a facility associated with three universities of Kyoto Prefecture. It has precast prestressed concrete (PCaPC) peripheral columns, T-shaped slabs for laboratory space, and large roof eaves. Not only were these PCaPC members incorporated in the architectural, structural, and environmental design, they also reduced the environmental loading appreciably. The joints between the PCaPC slender columns and T-shaped slabs are confirmed experimentally to have good and sufficient deformation performance. Carefully placing and curing the PCaPC during casting production ensured a high finish. By construction analysis, management values and construction validity of erection planning were achieved by high-precision building.

Structural Data
Name of Building: Inamori Hall Liberal Arts and Science Building
Location: Kyoto Prefecture
Owner: Kyoto Prefecture
Architecture and Engineering Design: KUME SEKKEI Co., Ltd.
Contractor: Matsumura – Nakagawa – Heiwa JV
Construction Period: Oct. 2012 – Mar. 2014
Covered Area: 3,811.044m^2
Total Floor Area: 9,088.736m^2
Maximum Height: 14.03m
Number of Stories: 3 above ground, 1 underground
Structure: Reinforced concrete (RC) construction using prestressing
Foundation Type: Individual foundation
Structural Type: Rigid frame with shear wall

1. Architectural Scheme
This building was planned so that it would blend into the surrounding environment with minimal height. The main entrance is at the center of the southern side of the building, with a secondary entrance on the north side. That way, the building can be accessed from both sides of Kitayama Street and the main square.
The floor plan is centered on a great hallway and includes lecture rooms and laboratories. With a width of approximately 4.3m, the hallway gathering spot "TAMARI" has a void for sunlight and allows glimpses into the lecture rooms and laboratories through glass partitions. It also functions as an interactive space when this facility is open to the public. The roof eaves are large, horizontal, and reduce the solar radiation and environmental loading. They were designed to mimic the Kyoto style by matching the peripheral architecture. **Fig.2** shows the plan of the third floor.

Fig.1 Outside view

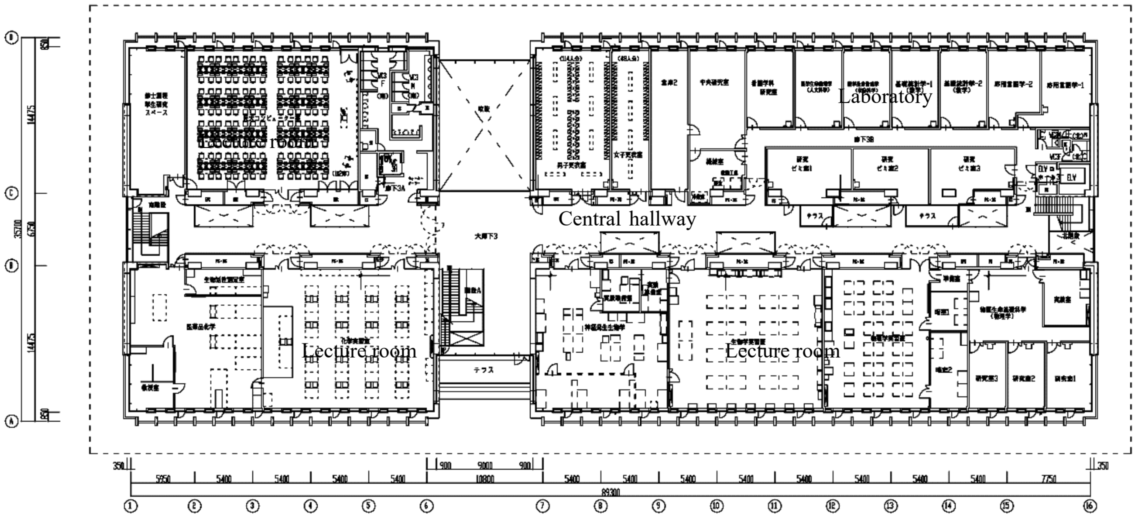

Fig.2 3rd Floor plan

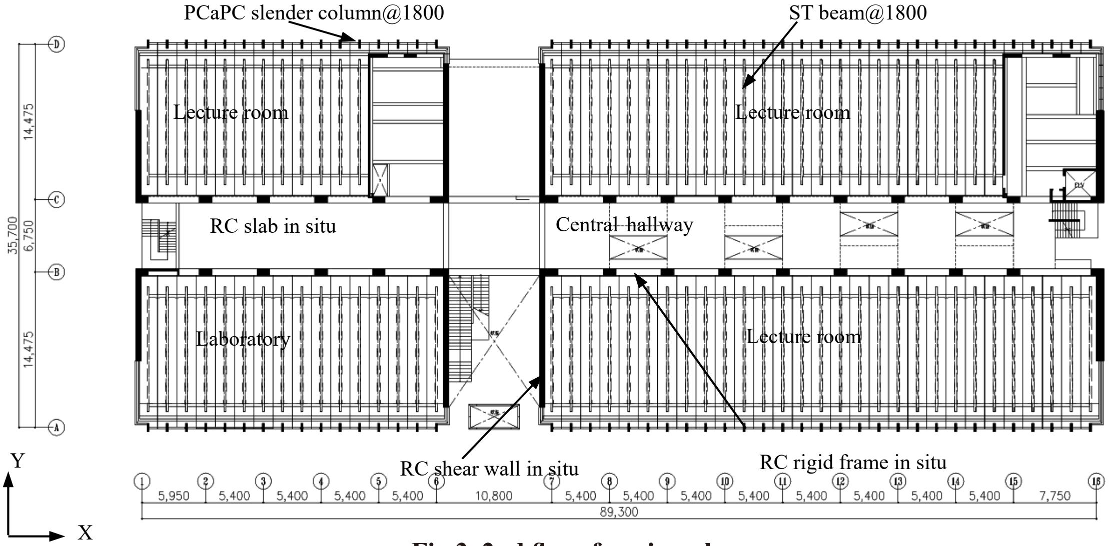

Fig.3 2nd floor framing plan

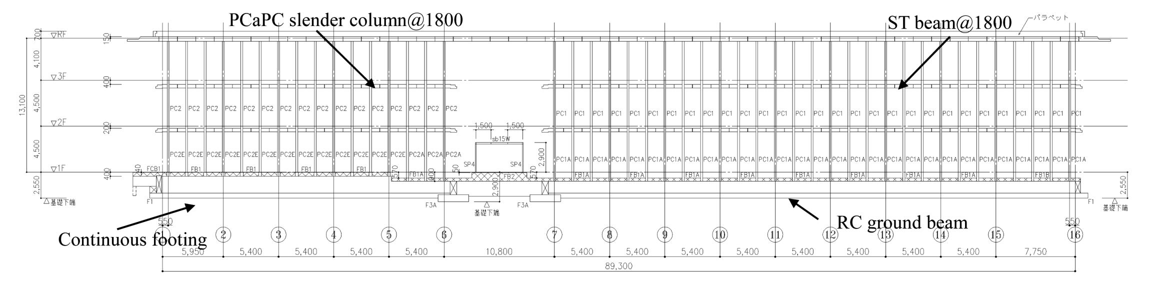

Fig.4 Framing elevation plan for long direction

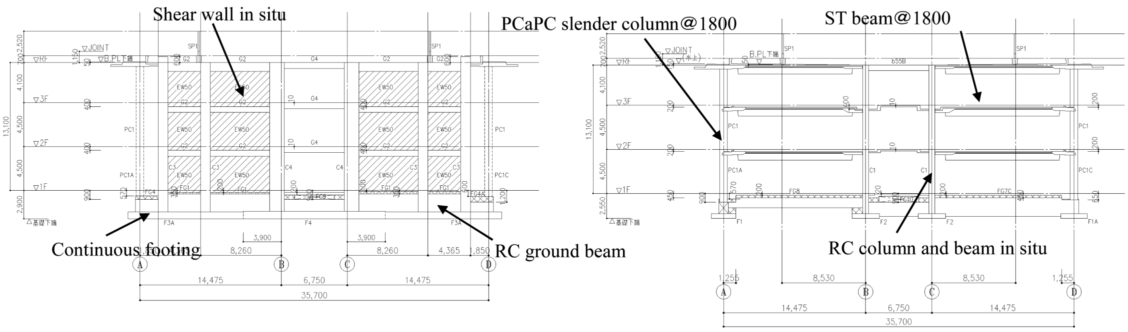

Fig.5 Framing elevation plan for short direction

2. Structural Scheme

The building is shaped in rectangular planes of approximately 36m × 90m. The longitudinal of the X direction is basically a 5.4m span, short span direction of Y is planned the lecture rooms, laboratories etc. of 14.475m span on both sides of the 6.75m central hallway.

The frame of this structure comprises both PCaPC and cast-in-place RC. The slender PCaPC peripheral columns in the X direction support only stationary loads, that column connected to PCaPC floor beam (ST beam: T-shaped beam). Each PCaPC slender column and to PCaPC beam were joined on site using the post-tensioning. The flatness large beam and column placed plat of cast-in-place RC was set on the central hallway area because of the increased strength and rigidity. In the Y direction, strong shear walls of thickness 500–700mm were set on the middle and at both ends. During an earthquake, the central rigid frame for the X direction and the shear walls for the Y direction would resist against almost all horizontal force.

According to this design, the PCaPC peripheral columns, which support only stationary loads at all times, could be more slender, thereby increasing the degrees of freedom and allowing a more delicate and airy structure.

Calculation of the structure was the plan to ensure the importance factor 1.25 (ultimate horizontal resistant force capacity / necessary horizontal ultimate resistant force) in the X direction 1/100 rad and Y direction 1/200 rad deformation.

Trying to this structural design, these plans increased the planning flexibility, allowing excellent support facilities.

Fig.6 Inside view of the canteen

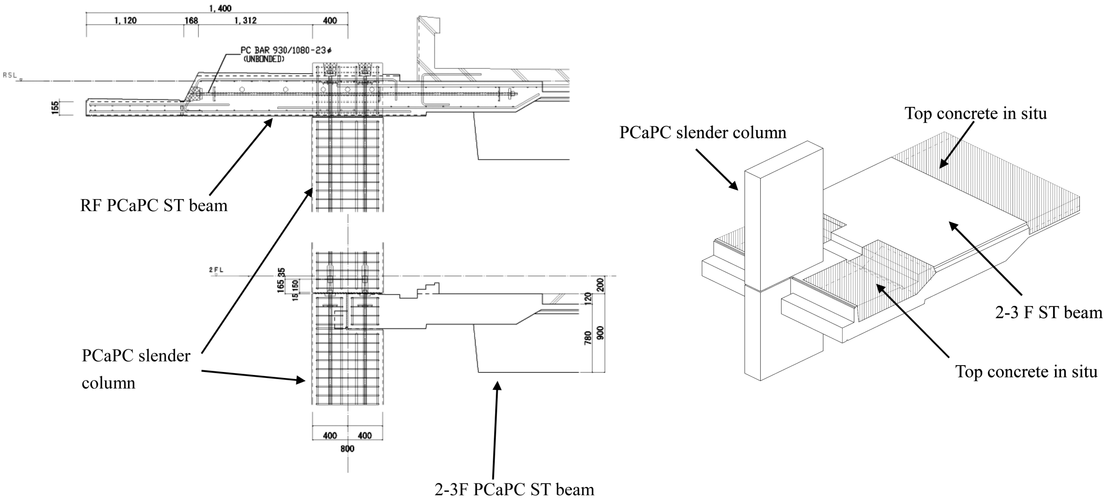

Fig.7 PCaPC joint of slender column and ST beam

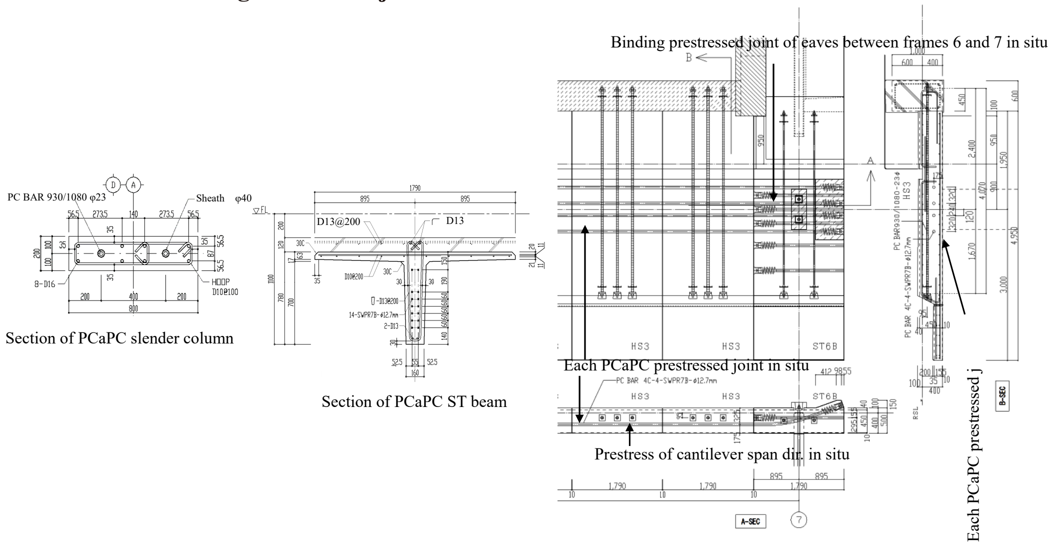

Fig.8 PCaPC joint detail of slender-width column and ST beam and roof ST beam

3. Outline of PCaPC Members

PCaPC had used in the following parts 1–3.

1) *PCaPC peripheral slender columns*
   These support only stationary loads at all times. The member size of a 1.8m pitch is 200mm × 800mm of standard to consider appearance from outside.
2) *PCaPC beams (ST beams) of second and third floors*
   On these floors, the ST beams of the laboratories and lecture rooms have a 14.475m span built on PCaPC that is 1.8m in pitch.
   The end edge section of an ST beam is 300mm × 1,800mm of none rib shape. that has an exterior length of 1,445mm to allow for the exterior sash, and an interior length of 1,000mm in planning of the ceiling, pipe laying, ducting, and electrical facilities. The ST beams and PCaPC slender columns were joined on site using the post-tensioning, whose detail had 1/2 depth notched under column to insert the end of ST beam. The ST beam end designed pinned joint in structure, but the periphery end had done in considering the column-beam joint stiffness.
3) *Large PCaPC eaves continuous to roof ST beams*
   The large PCaPC roof eaves peripheral side are 3.0-m-long cantilever slabs, tapered 155mm tip to edge 400mm end edge thickness. These large eaves of 16.835m in length are continuous to the roof ST beams of the laboratories and lecture rooms. The eaves over the end panels and the central entrance are continuous to the top of the cast-in-place concrete shear walls. That eaves had only prestressed at site for cantilever span direction but also used post-tensioning for other direction and integrate each PCaPC large eaves.

Fig.9 Periphery PCaPC view

4. Full-scale Tests of PCaPC Joints

The PCaPC slender columns with ST beam joints of this building have an expected deformation performance of up to 1/100 rad for a large earthquake. Full-scale horizontal loading tests have been conducted to check the horizontal tracking and joint performance. These confirmed that the joints suffer no harmful damage and there is sufficient deformation performance up to 1/100 rad during horizontal loading.

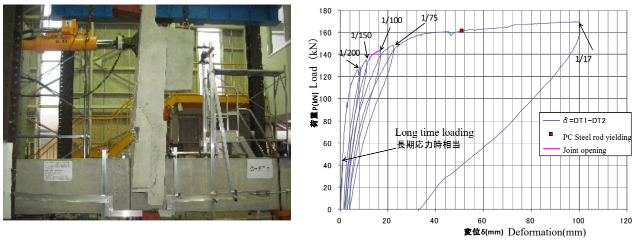

Fig.10 Specimen view and test result

5. Construction

Fig.11 shows the construction of PCaPC members at each stage.

Column and ST beam joint

PCaPC slender columns

Second-floor PCaPC ST beam

Roof-floor PCaPC ST beam

Fig.11 Construction view of PCaPC

6. Conclusion

The architecture was designed to blend into the surrounding townscape and reduce environmental loading by using natural energy, leading to a new university educational facility. The authors would like to thank the owners and everyone involved in the design and construction for their corporation at each stage.

概　要

京都市北山地域にたつ教養教育の連携拠点と府民・学生の交流を図る大学施設に対して，外周部の PCaPC 細柱，研究室等の PCaPC 床版，R 階の大庇 PCaPC 屋根版によって意匠，構造，設備を融合させ，環境負荷を大きく低減する大学施設を実現した。PCaPC 細柱と床版との接合は，実大実験により十分な変形追従性能を有することを確認した。PCaPC 部材の製作は，打込み，養生に配慮して高い仕上がりを確保した。現場施工においては，施工時解析により建方計画の確認と管理値を設定して精度の高い建物を実現した。