Exposed Structure of Precast and Prestressed Concrete
— Aichi High School of Technology and Engineering —

プレキャスト・プレストレストコンクリートによる見せられるスケルトン構造
― 愛知総合工科高等学校 ―


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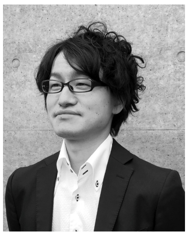
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Synopsis
Aichi High School of Technology and Engineering was established as the center of engineering education in Aichi Prefecture. The architectural design concept of this building is a simplified exposed building with no ceiling finishes. Its structure comprises two frames, one to support only vertical loads（hereinafter referred to as the "vertical frame") and the other to resist seismic loads while supporting vertical loads (hereinafter referred to as the "seismic frame"). The exposed structure comprises mainly long-span corrugated prestressed concrete (PC) slabs, blade columns, a deformation beam, and thick shear walls.
This building was built of precast concrete to obtain a high-quality structure and shorten the construction period. For example, the blade columns were made of fully precast PC and the corrugated PC slabs were made in a factory and brought to the construction site.

Structural Data
Building Site: Nagoya, Aichi Prefecture, Japan
Use: Technical high school
Gross Floor Area: 30,407.39m^2
Number of Stories: 5, with no basement
Building Height: 24.08m
Structure Type: Precast prestressed concrete, Reinforced concrete
Construction Period: May 2014 – Mar. 2016
Designe: Kume Sekkei Co., Ltd.
Contractor: Joint venture between Toda Corporation and Meiko Construction

1. Introduction
Aichi High School of Technology and Engineering is a new industrial high school located on Higashiyama Street in Nagoya City. We made student activities visible from the street, thereby allowing better interactions with the local community. We reduced the impact on the surroundings by lowering the building height, using green walls, and creating a communication plaza.
The rooftop has various amenities such as furniture and a garden to provide a comfortable space for the students. Based on the concept of utilizing the building as an educational tool, building components such as PC slabs and mechanical equipment are exposed for viewing.

Fig.1 Bird's-eye photo

Fig.2 Main entrance with rooftop having expansion joint

Fig.3 Rooftop view from a bridge

2. Structural Design

(1) Structural Plan

This project comprises four main buildings. In Japan, buildings are separated by expansion joints to be independent in distribution of horizontal force in an earthquake, and each building is calculated independently. In this project however, three buildings on the west side (hereinafter referred to as “W-Bldg”) were calculated together, considering transmission of horizontal force in an earthquake. W-Bldg and the east-side building (hereinafter referred to as “E-Bldg”) are connected by bridges and a rooftop having expansion joints. For the longer span for each building, the vertical frame with blade columns bears vertical loads and the seismic frame with primary columns supports horizontal loads in an earthquake. For the shorter span of each building, both vertical and horizontal loads are supported by thick concrete shear walls. To have classrooms with long spans, the blade-column section is 260mm × 600mm and the basic deformation-beam height is 500mm. Each classroom floor is a corrugated precast PC slab with an unfinished exposed skeleton frame.

Fig.4 shows the basic structural concept. The blade columns in the vertical frame are of fully precast PC, the primary columns in the seismic frame are of precast PC, and both types of column were manufactured in a factory. The beams attached to the blade and primary columns were cast-in-place concrete. A cast-in-place concrete topping over each corrugated precast PC slab provides structural stability for the frame (**Fig.5**). The beams that receive the offset columns, such as the 3m cantilever beams or the supporting 5m stair landing, are of a post-tensioned prestressed structure. **Fig.6** shows a vertical frame under construction.

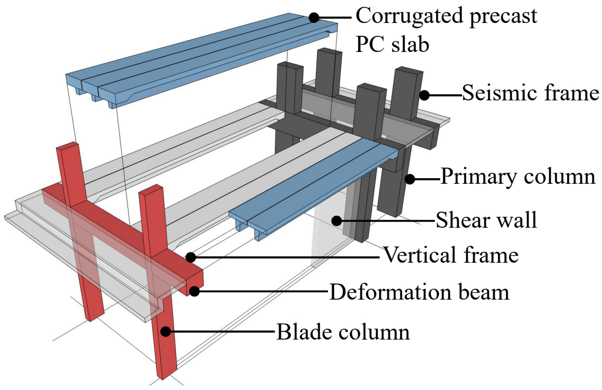


Fig.4 Basic structural concept

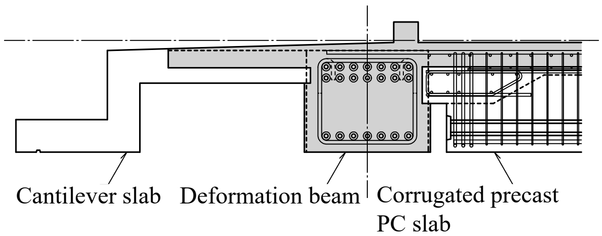
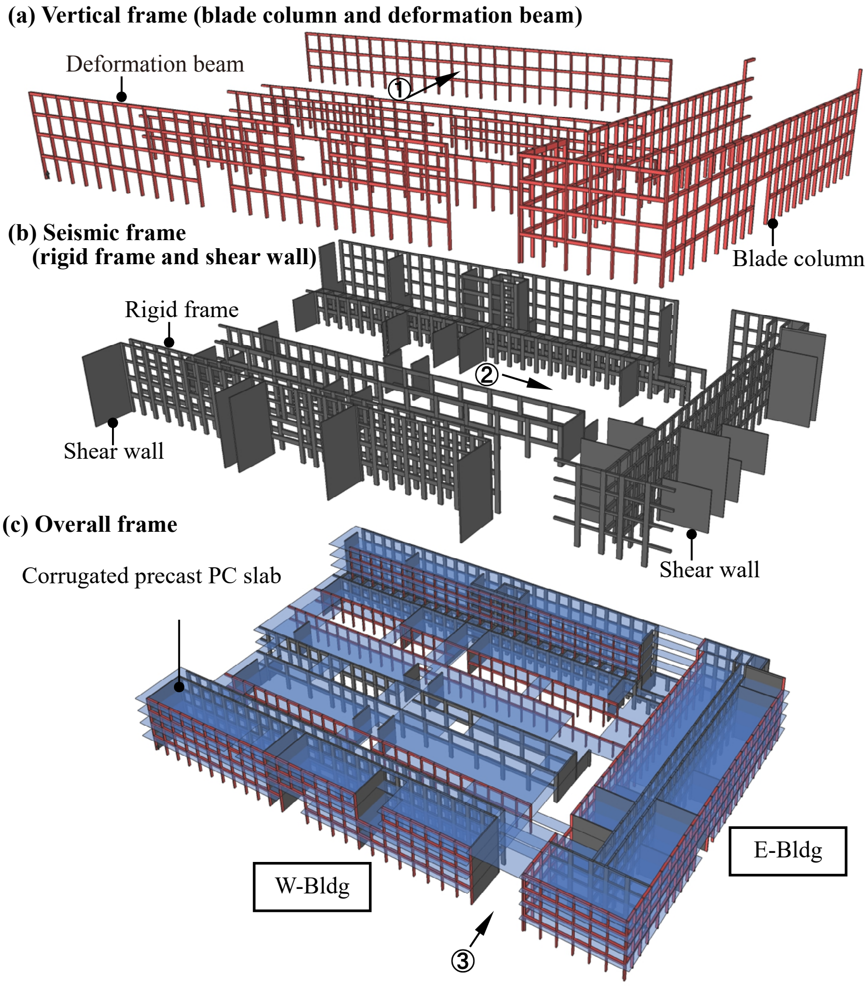


Fig.5 Connection detail in vertical frame

Fig.6 Vertical frame



Vertical frame from rooftop (①→)

Seismic frame (②→)

Expansion joint between W-Bldg and E-Bldg (③→)

Fig.7 Outline of Structure

3. Structural Design Detail

(1) Connection Details of Blade Column and Deformation Beam

Each blade column bears a vertical load only and does not resist a seismic load in the structural plan. This means that the stress on a blade column in an earthquake is less than the yield strength. A blade column is a hybrid of reinforced concrete and PC used to make sure a structural plan, and its normal section is 260mm × 600mm. Each blade column is made of fully precast concrete and each deformation beam is made of cast-in-place concrete. A joint of rebar in columns and beams is used mechanical joints.

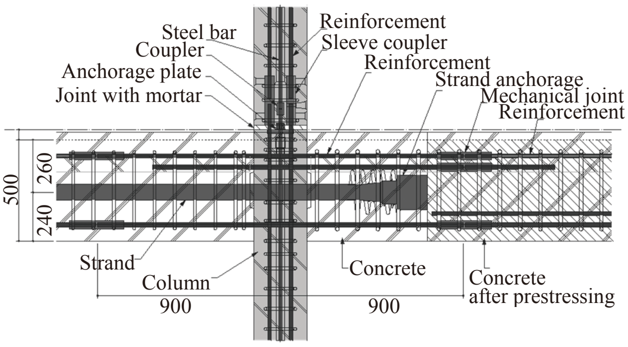


Fig.8 Details of column and beam (vertical frame)

Fig.8 shows the details of the connection between a blade column and a deformation beam.

(2) Corrugated Precast Prestressed Slab and Beam

The bottom of each beam is aligned with the bottom of a corrugated precast PC slab to make a continuous corrugated-shaped space (**Fig.9**). Because the beam length is large and the beam depth must be small to achieve alignment with the bottom level, a post-tensioned PC beam structure is used.

Fig.9 Mall between buildings in W-Bldg

(3) Prestressed Cantilever Landing

There are stairs with a prestressed cantilever landing on the north side of E-Bldg. The cantilever length and thickness of the landing are roughly 5.0m and 370mm, respectively. The structure of this landing is post-tensioned PC with 21.8mm strands to reduce displacement of the landing, and hollow voids are used to decrease the weight of the landing. **Figs.10** and **11** show a photo and the details, respectively, of the cantilever landing.

Fig.10 Stairs with prestressed cantilever landing

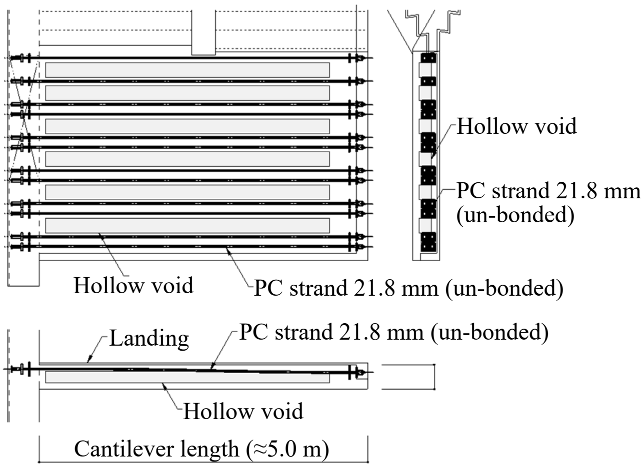


Fig.11 Details of cantilever landing

4. Conclusion

The architectural design concept of this building is a simplified exposed building with no ceiling finishes. This building structure consists of a vertical frame with blade columns and a seismic frame with primary columns. As part of the architectural concept, the structural concept is a “smart exposed structure.” The smart exposed space is made mainly of blade columns and corrugated prestressed precast slabs, and the details of their connections were designed carefully.

During the construction, students from neighboring schools (university, high school, and institute) visited the site to understand the actual processes of building and construction.

Fig.12 Construction of blade column

Fig.13 Construction work in W-Bldg

概　要

愛知総合工科高等学校は，愛知県の工業教育の中核校として新設された。建物そのものをものづくりの教材とすることをコンセプトとし，構造体，設備機器，配管配線等あらゆるものを露出させ，「見える化」を行っている。

「見える化」に対し，「見せられる構造」を構造のコンセプトとし，地震力を負担する耐震フレーム，細柱と扁平梁からなる鉛直フレームおよびリブ付き PC スラブによる大きなスケルトン空間を実現している。また，エキスパンション・ジョイント，梁とリブ付き PC スラブとの取り合いおよび PC による階段等の細かなディテールについても「見せられる化」を行っている。施工では，高い品質と耐久性および工期短縮のため PCa 工法を採用し，細柱はフル PCaPC 部材，耐震フレームの柱は PCa 部材，リブ付き PC スラブはハーフ PCa 化としている。施工中においても県内外から大学，高専および工業高校の生徒が見学に訪れ，生きた教材として活用された。