Seismic-Isolated Hospital by Precast Concrete Construction Method — Hyogo Prefectural Awaji Medical Center —

工業化工法による免震病院 — 兵庫県立淡路医療センター —


*

**

***

* Nobuhiro YAMAURA: Yasui Architects & Engineers, Inc.
山浦　晋弘：(株) 安井建築設計事務所
** Satoshi AKITA: Yasui Architects & Engineers, Inc.
秋田　智：(株) 安井建築設計事務所
*** Naoko IKEDA: Yasui Architects & Engineers, Inc.
池田　直子：(株) 安井建築設計事務所
Contact: nobuhiro-yamaura@yasui-archi.co.jp
Keywords: precast prestressed concrete, seismic-isolated structure, planar large structure
DOI: 10.11474/JPCI.NR.2018.15

Synopsis
The Awaji Medical Center was constructed as a disaster prevention bass hospital in the Awaji area of Hyogo Prefecture, Japan. A seismic isolation (SI) system has been adopted to fulfill important functions during major earthquakes.
The post-tensioning method has been adopted for the above ground frame to reduce the environmental load at the construction site and salt damage in the coastal area. This is a notable feature of the hospital.

Structural Data
Structure: Precast Prestressed Concrete (PCaPC) and steel
Number of Stories: 8
Basic Span: 12.6m (X-dir.), 9m and 12m (Y-dir.)
Total Floor Area: 35,333m^2
Height: 33.05m
Owner: Hyogo Prefecture Government
Designers: Yasui Architects & Engineers, Inc., Hyogo Prefecture Government
Constructor: Toda/Muramoto/Maekawa joint venture
Construction Period: Oct. 2010 – Mar.2013
Location: Hyogo Prefecture, Japan

1. Introduction
The planned area is adjacent to the Sumoto Bus Center, the gateway to Sumoto City, and is part of the area in which the Kanebo Factories flourished as part of the spinning industry. Since the factory structures used red bricks, Sumoto City Library and Sumoto Cultural Gymnasium in the vicinity also reused red bricks, and a style based on bricks has been used in the nearby region. To continue the history of the area and harmonize with the surrounding landscape, bricks and Awaji tiles have been used in the exterior of the medical center.

Fig.1 Bird's-eye view of the hospital

Fig.2 Panoramic view of the hospital

2. Overview of Structural Planning

The plan dimensions of the site are 117.0m × 98.7m, and those of the ward part of the third floor and above are 30.0m × 86.1m. To ensure flexibility in the planning, the span in the X direction was taken as 12.6m and that in the Y direction as 9.0m and 12.0m, thereby forming the basic grid (**Figs. 3**–**5**).

The post-tensioning method is adopted for the above ground frame and the moment resisting frame. The rooftop, on which the helipad is placed, is a steel frame with braces.

High strength and reliability of the construction are required for the base part of the joint with the column, hereinafter referred to as a "base isolation" block. These are located under the PCaPC columns, and the base isolation device is mounted. Accordingly, the base isolation blocks were also made as PCaPC members. However, to avoid the prestress influencing the SI device, the first floor reinforced concrete beams are cast-in-situ (**Fig.6**).

Awaji Medical Center has pile foundations with independent footings. It is supported by 109 cast-in-place reinforced concrete piles, and 10 prestressed high-strength concrete piles were used for the top frame of the canopy. Ground improvement based on subsurface investigation was carried out 5.7m below the foundation bed to prevent liquefaction in the event of a major earthquake.

The SI system uses rubber bearings, tin rubber bearings, and cross linear bearings (**Fig.7**). In addition, eight oil dampers (maximum damping force 1,000kN) are arranged in each direction. In the event of "extremely rare" seismic motion, these devices would keep the deformation of the base isolation layer within the guaranteed performance deformation (600mm).

The SI system uses rubber bearings, tin rubber bearings, and cross linear bearings. In addition, eight oil dampers (maximum damping force 1,000kN) are arranged in each direction. In the event of "extremely rare" seismic motion, these would keep the deformation of the BI layer within the guaranteed performance deformation (600mm).

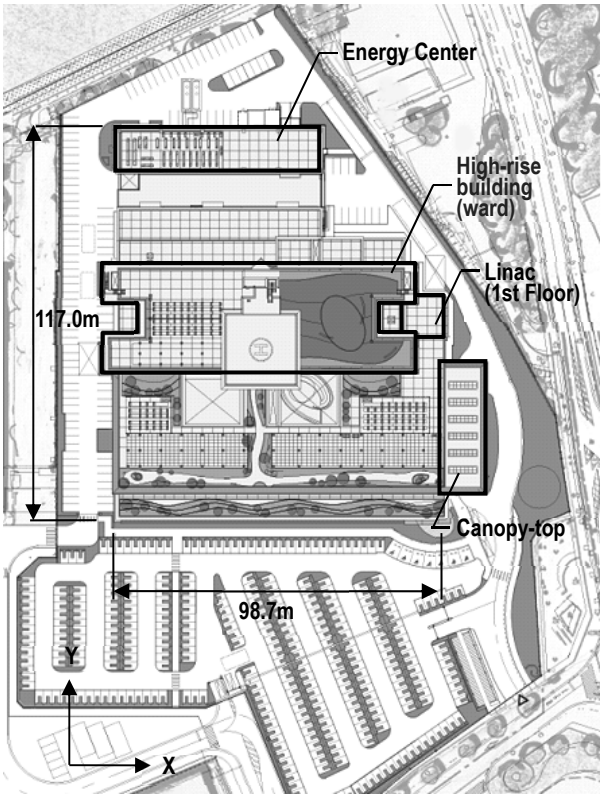

Fig.3 Layout

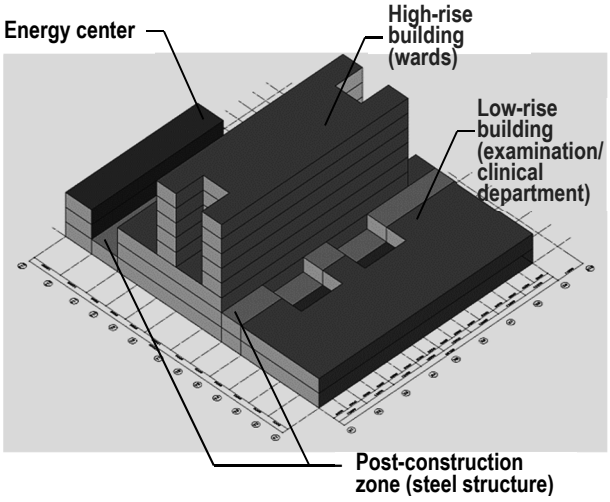

Fig.4 Zone diagram

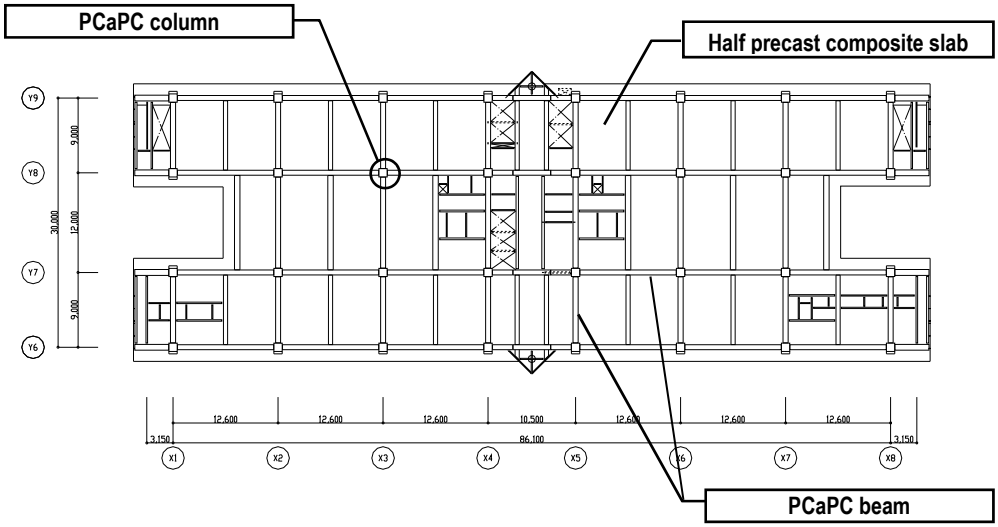

Fig.5 Typical floor plan

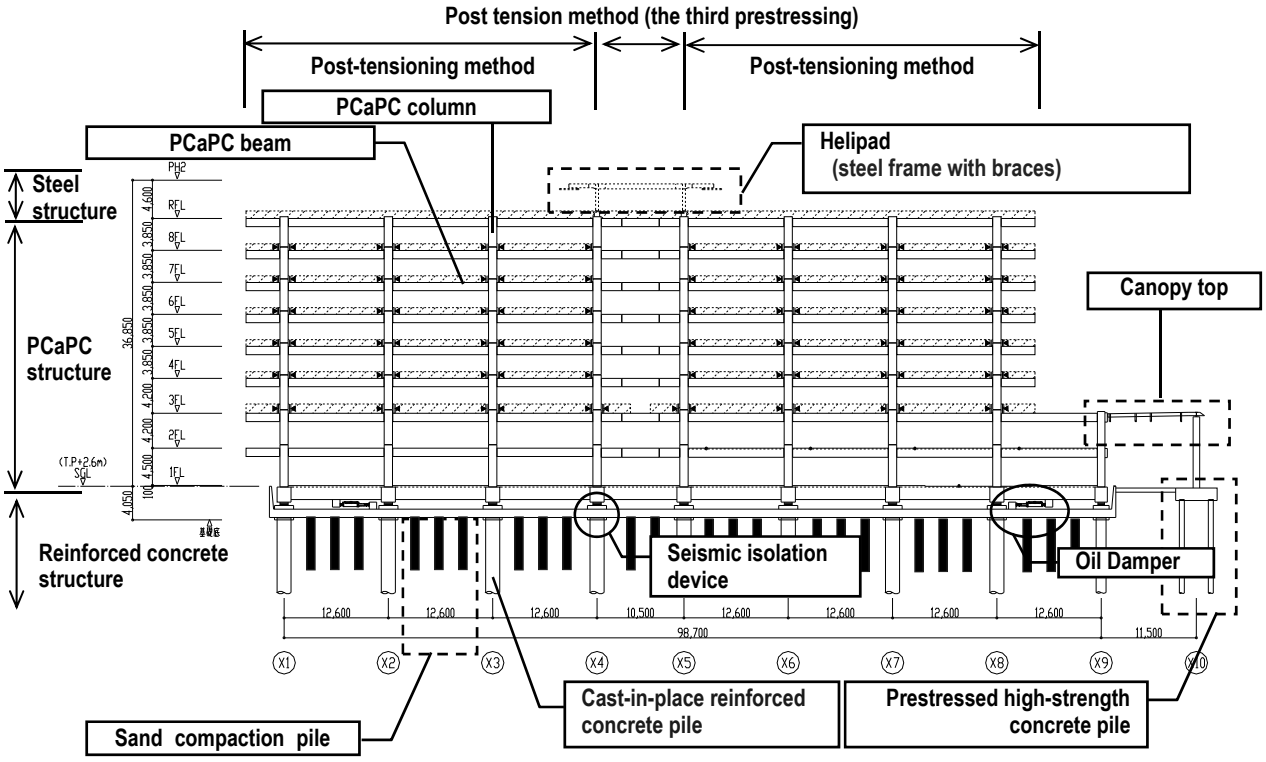

Fig.6 Framing elevation (X-Dir.)

Rubber bearing | Cross-linear bearing | Oil damper

Fig.7 Seismic isolation devices

Solar panels (3rd Floor)

Rooftop garden

Canopy top

Hospital street

Courtyard (1st Floor)

Waiting lounge

Fig.8 Completion photos

3. Building Response Record

The Awaji-shima Earthquake of magnitude 6.3 occurred on April 13, 2013. In Awaji City, a seismic intensity of 6 (lower) was observed and the seismic intensity in Sumoto City was 5 (lower). The number of partially damaged houses climbed to more than 2,000 in both cities.

The Lissajous curve of deformation of the BI layer was recorded by scratching with a pick (**Fig.9**). The maximum amplitudes in the east–west and north–south directions were 80mm and 40mm, respectively. Therefore, the deformation of the base isolation layer was almost the designed value, and the building suffered no damage. Thus, the SI effect has been verified unexpectedly in an actual earthquake.

The completion ceremony was held as scheduled after a week, and the medical center now plays an important role as a disaster-base hospital.

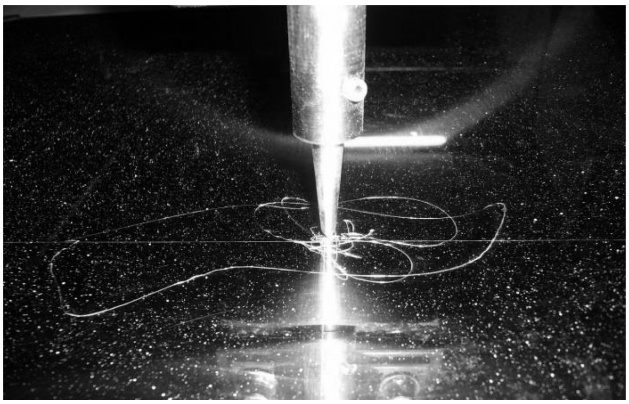

Fig.9 Recorded Lissajous curve of deformation

概　要

兵庫県立淡路医療センターは，淡路地域の災害拠点病院として重要な機能を果たす施設で，大地震後も継続使用させる必要があるため，免震構造を採用した。また，沿岸部という環境下における耐塩害性に配慮するとともに，建設現場での環境負荷を低減し，施工の合理化，工期短縮を図るため，高強度のプレキャスト・プレストレストコンクリート（PCaPC）造で計画した。

建物構成は，低層棟（外来診察部門），高層棟（病棟部門），エネルギーセンター棟（電気機械設備）の 3 つに分割される。構造的にも効果的なプレストレスの導入を考慮してそれぞれの間に収縮緩衝帯を設け，分割して施工した後に一体化し，全体としての収縮を軽減させる方策をとっている。

また、2013 年 4 月13日，淡路島付近を震源とした最大震度 6 弱の地震（洲本市内では震度 5 弱）に対して，免震層内に設置したケガキの記録よりほぼ設計値どおりの変形量であることを確認し，設計の妥当性を検証した。