Aso Medical Center

1. Introduction

The Aso Medical Center is a medical facility located in the caldera of Mount Aso.

It opened in 1950 as Aso Central Hospital, and in 2014, a new hospital facility with a seismically isolated structure was completed, and it was renamed Aso Medical Center.

During the 2016 Kumamoto Earthquake, the distance to the Futagawa fault zone, the epicenter of the earthquake, was about 10 km, and the horizontal deformation of the seismic isolation layer was measured at a single amplitude of 46 cm, which is probably the largest displacement ever, and about 90 cm in both amplitudes.

During this visit, we were able to hear valuable information from Aso Medical Center's Director and Advisor Zenichi Akatsuka, General Affairs Manager Hiroshi Ino, and Nikken Sekkei's Chief Engineer Hiroshi Yamamoto about the design policy of the building and the situation at the time of the Kumamoto Earthquake.

Building Overview

Construction site: 1266 Kurokawa, Aso City, Kumamoto Prefecture

Client: Aso City

Design and supervision: Nikken Sekkei Ltd.

Construction: Toda Corporation

Main use: Hospital (124 beds)

Scale and structure: Reinforced concrete

Building area: Approximately 6064 m^2

Total floor area: Approximately 11336 m^2

Seismic isolation materials: 45 lead-plug laminated rubber bearings, 27 natural rubber laminated rubber bearings

Total construction period: January 29, 2013 to June 30, 2014

Photo 1 Outpatient building (earthquake-resistant)

Photo 2 Central medical building (seismically isolated)

2. Building Introduction

As a disaster-resistant base hospital in Aso, the Aso Medical Center is designed with the central medical treatment building and hospital wards in a seismically isolated structure, and the outpatient building in a seismic safety classification of Class I (1.5 times the seismic force of a major earthquake) in a seismic resistant structure. Taking advantage of the unique location in Aso, the plan features a distinctive "panoramic zone" with a 360° view.

The facility was designed with the lessons learned from emergency medical care at Ishinomaki Red Cross Hospital and other facilities during the 2011 Tohoku Off the Pacific Coast Earthquake in mind, and the building and facilities were designed with redundancy, for example by distributing water tanks in multiple locations, to improve business continuity in the event of a disaster.

3. Structural Plan Overview

The building is designed to connect the central examination and hospital wing (structurally integrated) with a seismically isolated structure and the outpatient building with a earthquake resistant structure with Exp. J.

The foundation structure is made of precast concrete piles (PHC piles) with a layer of consolidated sand at a depth of about 20 m as the support layer.

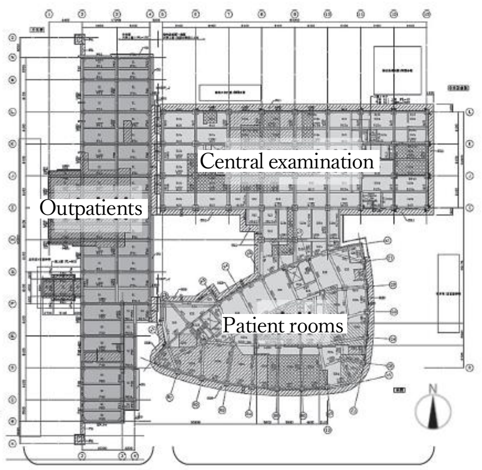
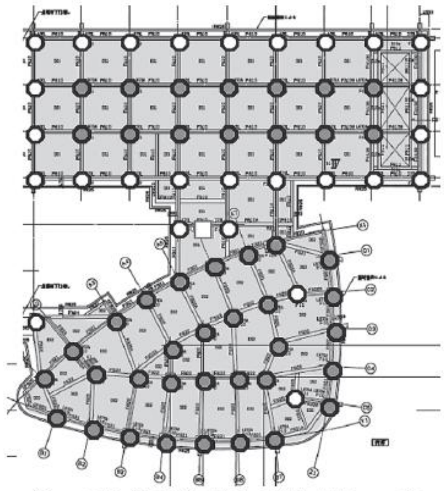


Figure 1: First floor plan and construction method



○ 27 Natural Rubber Bearings
● 45 Natural Rubber Bearings with lead plug
□ Scratch

Figure 2: Seismic isolation device layout diagram

The seismically isolated building was designed in accordance with the seismic isolation standards established by government notification, but its dynamic performance was also confirmed through time history response analysis. Response results for Level 2 notified waves and site waves simulating an earthquake on the Futagawa fault showed that the maximum displacement in the seismic isolation layer was approximately 35 cm at one amplitude. Lead-plug laminated rubber and natural rubber laminated rubber bearings with a diameter of 700 mm were used to increase the deformation capacity of the seismic isolation layer, because it is a low-rise building, the average surface pressure remains at approximately 6.5N/mm^2.

The damper amount is 4.3%, and the natural period is Teq=2.8 sec (δ=35cm).

Photo 3: Devices

4. About the Kumamoto Earthquake

The foreshock of the Kumamoto earthquake, which occurred at 21:26 on April 14, 2016, caused almost no shaking in the building, and the mark left by the scriber installed almost in the center of the seismic isolation layer was only about the size of a hole in a five-yen coin.

On the other hand, the main shock at 1:25 on the 16th recorded a very large displacement of the seismic isolation layer, measuring 46 cm in single amplitude (Equivalent to about 330% strain of laminated rubber bearing with a diameter of φ700). Subsequent inspections showed some cracks in the earthquake-resistant building, but no damage was found to the structure of the seismically isolated building. As for the condition of the seismic isolation material, the rubber covering the perimeter had only shifted, and the rubber itself was sound, and when the displacement history of the scriber was examined, it was found that the remaining performance was sufficient.

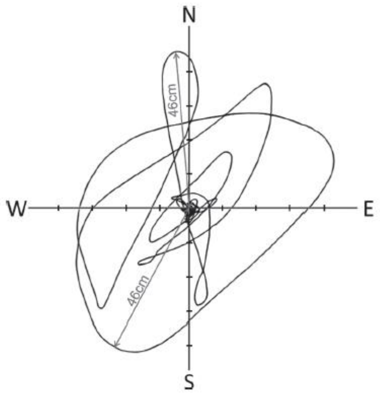


Figure 3: Record of the scratch gauge

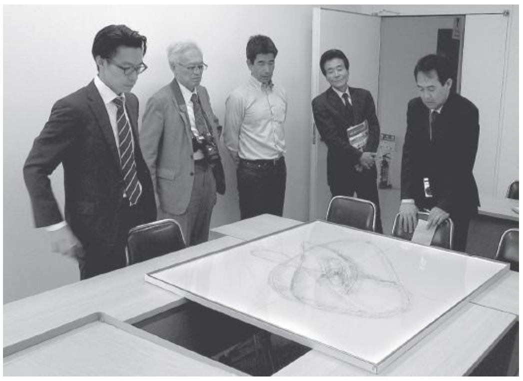


Photo 4: Explanation of the scratch marks (replica) by Hiroshi Yamamoto

During the main earthquake, the Exp.J (photo 5) between each building came loose, and inside the seismically isolated building, lockers collapsed and items fell off the shelves (photo 6). However, since it happened in the middle of the night, some patients in the ward did not realize that the earthquake had occurred.

Photo 5: Exp.J and sleeve wall between the seismically isolated building and the seismic resistant building

Photo 6: The situation on the second floor

The earthquake caused a power outage throughout the area, but the hospital was able to continue functioning without any problems until power was restored 40 hours later with the help of Shikoku Electric Power's power

supply vehicle, using the facility's emergency power generator.
The water supply, which is extremely important for dialysis treatment and other treatments, was also able to continue using the water stored in the water tank.
Because the building was able to continue functioning without any problems even immediately after the earthquake, it was able to not only accommodate and treat the approximately 200 nearby residents who evacuated, but also served as a base of operations for the Self-Defense Forces, DMAT (Disaster Medical Assistance Team), and JMAT (Japan Medical Association Team).
In addition, a heliport was planned in anticipation of roads freezing in winter, making transportation to Kumamoto city difficult, and was made effective use of for Self-Defense Force helicopters to take off and land.
The beverage vending machine installed in the waiting room was equipped with a function to provide free beverages in the event of a disaster, and was used to support evacuees and volunteer staff. (Photo 7)

Photo 7: Disaster-response food-cup vending machine

5. Questions and Answers
Q1. Were the staff aware that the hospital building was of seismically isolated building? Also, has there been any change in the staff's awareness after the Kumamoto earthquake?
A1. They knew about the seismically isolated building, but after the earthquake, they became more aware of the importance of layouts that take into account the possibility of shelves collapsing or items falling, and of fastenings. Currently, the only requirement for a disaster base hospital is that it must be of an earthquake-resistant building, but after experiencing the high seismic performance of the seismically isolated building in the Earthquake, we should actively adopt the seismically isolated building.

Q2. Since the new building was completed and before this earthquake, had any disaster training been conducted?
A2. We conduct training twice a year in accordance with the Fire Service Act, and triage training assuming an eruption of Mount Aso. Since we had not anticipated a disaster at night like the recent earthquakes, we are currently formulating a response method.
*Triage: In an emergency situation where a large number of patients need to be treated, selecting patients according to their priority for treatment.

Q3: What other lessons were learned from the 2011 Tohoku Off the Pacific Coast Earthquake?
A3: The corridors (photo 8) and the large eaves in front of the entrance (photo 1) are designed with ample space to accommodate patients temporarily.
The heliport is also planned to be located on the ground near the emergency entrance, so that patients can be transported without any problems even if the elevators are not operational due to a power outage. (Photo 9)

Photo 8: Outpatient building corridor with ample space

Photo 9: Approach from the heliport to the building (foreground)

Q4 What do you think is the reason for the large deformation of the seismic isolation layer?

A4 The extent to which the Futagawa fault zone moved in this earthquake was longer to the east than previously known, and the distance to the building was closer than expected at the time of design. When checking the velocity response spectra from the K-NET observation results, the predominant period was around 1 second in Kumamoto (KMM006), 2 to 3 seconds in Otsu (KMM005), and 3 to 4 seconds in Ichinomiya (KMM004), which is closest to this site, and the period gets longer the further east. It is thought that the response became larger as it became closer to the natural period of the seismically isolated building. There have been reports of liquefaction occurring in the vicinity. It may also be influenced by the fact that the inside of the caldera was a marshland in the past.

Photo 10: Question and answer session Photo 11: Group photo

6. Conclusion

Amid the beautiful yet harsh nature of Aso, this building evokes a strong desire to contribute to the local residents and to be fully prepared for unexpected events. The Kumamoto Earthquake caused great damage to valuable historical buildings, including the collapse of the tower gate, an important cultural property, at Aso Shrine, located about 4km east of the hospital. There are still tens of thousands of people living in temporary housing. We pray for a speedy recovery. Finally, we would like to thank Mr. Akatsuka, Mr. Ino, and Mr. Yamamoto for taking the time to respond to our interview requests despite their busy schedules. We also received cooperation from JSSI Publication Committee members Hirokuni Kato, Masaaki Saruta, and Toru Nakajima.

(Reported:Yasunori Yoshii, Fujita Corp., Keizo Iwashita, Seismic Isolation Engineering, Yusuke Ohara, SWCC)