Current State of Seismic-Isolation Design

Kani, N.

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Executive Director, JSSI

1. INTRODUCTION

- SI structures in Japan increasing since the Kobe quake in 1995.
- SI buildings shown good performance during and after recent quakes.
- Recent problems on the design for SI systems discussed here.

2. SEISMIC ISOLATION PROFILE IN JAPAN

Japan has suffered many disastrous earthquakes. Many condominiums and detached houses were damaged in the 1995 South Hyogo prefecture earthquake, and the collapse of several hospitals shocked people. The structural design strategy of "Seismic Isolation (SI)" is a technology capable of substantially mitigating seismic disaster. Seismic Isolation provides opportunities for flexible, diverse, and highly earthquake-resistant designs. It also controls both acceleration and story drift of the superstructure during an earthquake.

No. of SI Buildings:	2,000
Condominiums:	45 %
High-rise Condominiums:	6 %
In Kanto Area:	45 %
Retrofit:	80
Isolator:	6,000
Damper:	1,500
Detached Houses:	3,000

Figure 1 Kamikuzawa Condominiums in Sagamihara city, Kanagawa prefecture (the largest SI Housing Estate in Japan, site area(120 m by 300 m) seismically isolated)

Figure 2 High-rise condominiums with SI, MM towers, Yokohama city, Kanagawa prefecture

3. PERFORMANCE OF SI BUILDINGS(Brand-new Report)

Activities of this hospital shown in figure 3 did not cease at all during or after the 2008 Iwate-Miyagi Inland quake. Many people felt a slow shifting of the building, but neither employees nor inpatients were injured.

Figure 3 Kurihara City Central Hospital with SI, Miyagi prefecture

Doctors were able to cope with the treatment of the people injured in the quake. The hospital served as the local disaster protection center. Response displacement was about 90 mm from traces of rod movements of oil dampers.

4. PROBLEMS WITH SI SYSTEMS

The effect of SI systems has been positive in many occurrences of quakes over the last two decades, and structural engineers have been improving SI systems since 1980. However, the following problems related to SI systems must be solved in order to provide better structures.

Problems for structural design

- Seismic waves of long period components and of long duration directly affect SI systems.
- In the connecting parts of devices fixed to the structure, anchorage parts were broken in a recent quake, due to a design and construction defect. The design details of the parts of installed devices, which are expected to achieve good performance, are important.
- Structural rigidity for frames of superstructures with SI is sufficiently stiffer than the rigidity for SI sections with devices, but recently several buildings with SI have been designed with low rigidity, especially in high-rise structures with SI. When the seismic isolation ratio is low, response accelerations are not reduced much in buildings with SI.
- Performance tests of large-size elastomeric isolators should be carried out. It is difficult to directly determine the properties of the isolators by using manufacturers' own testing machine.
- Wind response and characteristics of the device for seismic isolation became apparent against typhoons and seasonal winds.

Problems related to near-future systems

- High-durable elastomeric isolators will be requested near future.
- Seismographic monitoring of vibration of SI buildings during earthquakes should be done.
- New systems such as SI systems with semi-active control to be used in the near future should be developed. SI systems must be much more feasible to accomplish performance based design with response control systems in the near future, in order to orient direction to control the behavior of structures by using response control devices.
- More dissemination and expansion of public relations about SI must be carried out for structures to be able to maintain basic performance, such as securing human life, preserving property and maintaining functionality of buildings and to provide seismic protection during and after earthquakes for business continuity planning.