Intelligent Seismic Isolation System Using EEW

Satoshi FUJITA[1], Keisuke MINAGAWA[1], Shuichi NAGATA[2] and Go TANAKA[2]

1. Tokyo Denki University, 2-2 Kanda-Nishiki-cho, Chiyoda-ku, Tokyo, Japan

2. Oiles Corporation, 1000 Hikari-cho, Ashikaga-shi, Tochigi, Japan

INTRODUCTION

General expectations regarding anti-seismic technology have been increasing in Japan. Seismic isolation technology is one of effective anti-seismic technology. The idea of seismic isolation is to extend the natural period of the superstructure by isolation bearings. It is possible to reduce the response acceleration by almost 1/3 of the response acceleration of a non-isolated structure. On the other hand, long period seismic waves having predominant period of from a few seconds to a few ten seconds have recently been observed in various earthquakes. Also resonances of high-rise buildings and sloshing of petroleum tanks in consequence of long period seismic waves have been reported. Therefore the isolation system having long natural period or no natural period is needed.

Therefore we propose an isolation system having no natural period. The isolation system uses air bearing as an isolation device and EEW system as an activation trigger of isolation. Air bearing is a bearing that can reduce contact friction between floor and the bearing by thin air film produced by compressed air. In this paper, the basic concept and results of vibration experiment are described.

ISOLATION SYSTEM USING AIR BEARING

The strategy of this isolation system is to isolate earthquake waves by floating on a flat surface. The isolation objects are mechanical structure, computer server, floor, and detached house, considering capacity of air bearing. Figure 1 shows the schematic of the isolation system. The isolation system contains air bearings for floating the structure, an air compressor for providing compressed air, an air tank for accumulating compressed air, a computer for analyzing the EEW information and judging activation of system, the EEW terminal and P-wave sensor as seismograph, and Uninterruptible Power Supply (UPS) system for supplying electric power to the computer, the air compressor and the solenoid valve in case of blackout. The air bearing is one of hydrostatic bearing that can reduce contact friction between floor and the bearing by thin air film produced by compressed air. The air bearing floats by blowing compressed air off from small holes in doughnut shape diaphragm made of rubber. The principle of operation is similar to air-cushion vehicle. This air

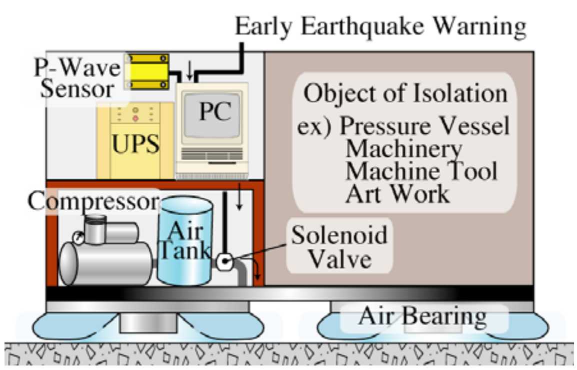


Fig. 1 Schematic of the isolation system

bearing is generally used as heavy machinery moving equipment. The diaphragm type air bearing is able to float on rough surface such as concrete, because it is made of rubber and has sufficient floating height.

Features of this isolation system are summarized as follows; (1) excellent isolation performance by low frictional bearing, (2) fail-safe system using UPS and local seismometer, (3) integrated intelligent disaster prevention system that is able to distribute the information of earthquake to other equipment.

VIBRATION TEST

Vibration tests using a shaking table are examined so as to investigate performance of isolation of the system. Figure 2 shows an experimental model. Four air bearings were installed under each corner as shown in Fig. 3. Each air bearing has capacity of 235 kilograms, diameter of 0.15 meters. Moreover each air bearing requires 0.15 Megapascals of air pressure and 0.12 cubic meters per minute of airflow. The vertical natural frequency and damping ratio obtained by an excitation test were 6.05Hz and 9.58 %, respectively. In addition, fences were placed around the experimental model in order to limit excessive displacement, and sponges were placed inside fences in order to suppress contact shock as shown in Fig. 2. The activation of the system was conducted by a test signal of EEW system.

Basic Performance

Two-dimensional vibration experiment using JMA Kobe NS-UD wave is examined so as to investigate behavior of the isolation system. The amplitude of the input wave was adjusted to 54% of the actual wave according to performance of the shaking table. Figure 4 shows time histories of JMA Kobe NS / UD waves. It is confirmed from the graph that the isolation system suppresses horizontal response acceleration compared with horizontal input acceleration. On the other hand, it is confirmed that vertical response acceleration is slightly big compared with vertical input acceleration. However there are few possibilities that the isolation system resonates, because the experimental model has adequate vertical damping performance. Additionally, the isolation system retains adequate height during earthquake. Therefore there are few risks of vertical collisions between the experimental model and the shaking table.

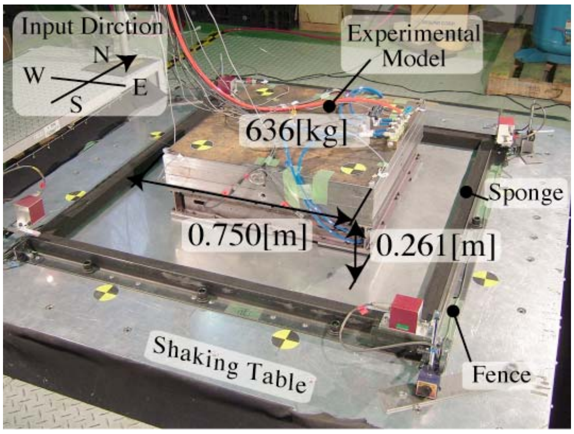


Fig. 2 Shaking table and experimental model

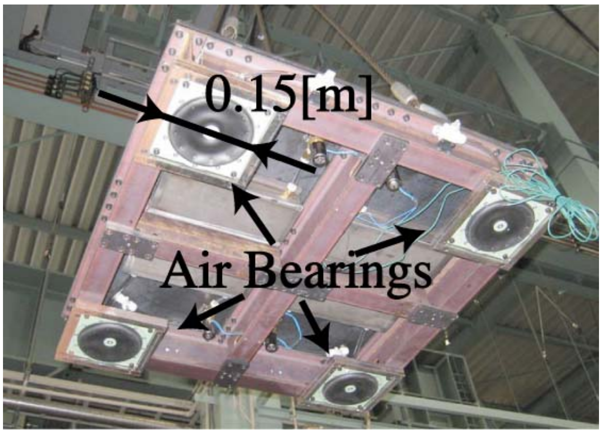


Fig. 3 Bottom view of experimental model

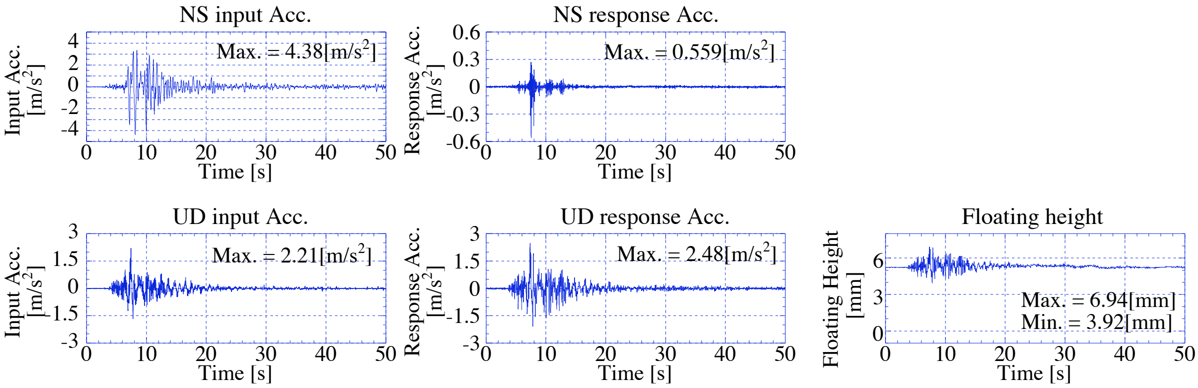


Fig. 4 Time Histories

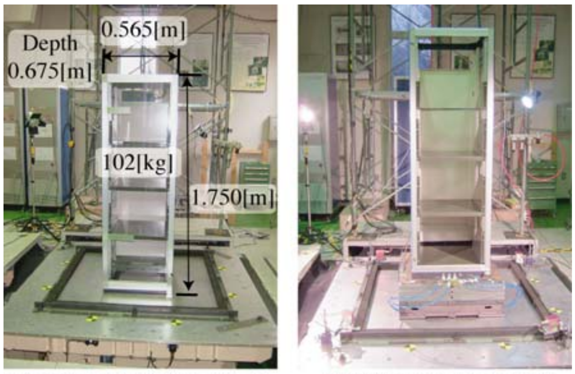
Isolation Performance

In this section, isolation performance of the system against three-dimensional seismic wave is investigated by vibration test using JMA Kobe wave. A computer server rack shown in Fig. 5 was applied as an isolation target. The computer server rack was placed on the experimental model or the shaking table without fixing.

Figure 6 shows comparison of maximum acceleration as an example of experimental results. It is confirmed from the graph that responses of the computer server rack without isolation system resonate on every direction. On the other hand, isolation system suppresses horizontal response acceleration compared with input. Although vertical response of the server rack resonates, it is smaller than the result of the non-isolated case. Therefore effectiveness of the proposed isolation system against three-dimensional seismic wave is confirmed.

CONCLUSION

Isolation performance of the proposed system against horizontal wave was confirmed. In addition, it was confirmed that the system suppresses response against vertical input compared with a non-isolated structure, although the system resonates.



(a) Without isolation system (b) With isolation system

Fig. 5 Computer server rack

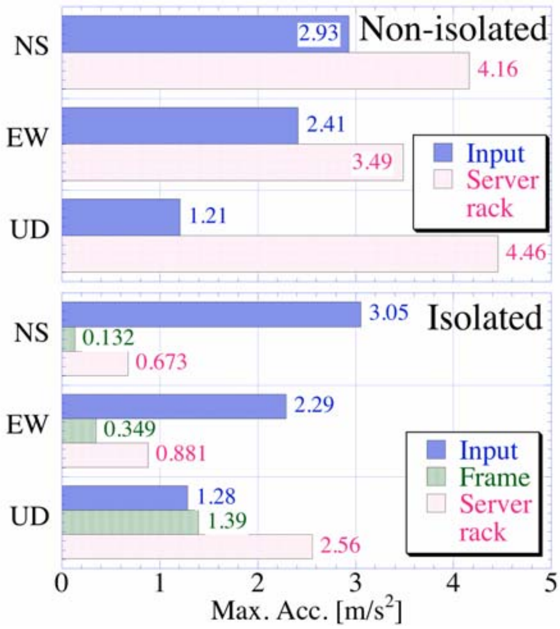


Fig. 6 Comparison of maximum response