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Test of hybrid floor isolation system employing magnetorheological damper

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1. Introduction

Base isolation is one of the most successful and widely-applied techniques for mitigating the structure vibration during earthquakes. It is also designed to protect valuable equipment and facilities to maintain the functionality of the structure, such as a hospital, during and immediately after the earthquake. Compared with the isolation strategy applied to the entire structure, floor isolation designed for only one floor of the structure is more cost-effective to protect equipment and facilities. To examine the effectiveness of the hybrid floor isolation system proposed by the authors which employs semi-active control technology to a floor isolation system, a series of shaking table test was conducted.

2. Test setup and control algorithm

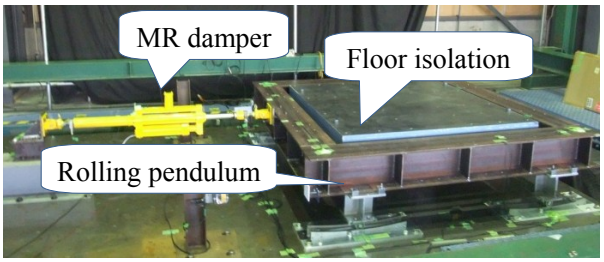

Fig.1. Experimental setup

The proposed hybrid floor isolation system shown in Fig. 1 consists a single-mass model supported by four sets of rolling pendulums installed at four corners of the floor isolation and a magnetorheological (MR) fluid damper that was controlled via a current supplier. A displacement transducer was used to measure the displacement of the piston-rod of the MR damper. The displacement measurement and the velocity calculated from the displacement were used as the feedback signal. Digital control of the current to MR damper was carried out by using a Texas Instruments TMS320C6701 DSP chip and I/O boards with 16-bit A/D and D/A converters. Sampling frequency of the control signals from DSP was 1000 Hz.

A linear quadratic (LQ) optimal control algorithm is selected in this research which has been extensively used for active and semi-active control.

3. Test results

A series of preliminary tests was conducted to identify the basic properties of the MR damper. A PI controller was then builted to describe the relationship between the desired force calculated from the LQ algorithm and the input current to the MR damper, considering the time lag problem of the MR damper.

A four story RC building served as a hospital was tested in E-defense in which the behavior of equipment and facilities was studied. To reconstruct a hybrid floor isolation system placed on top of that hosptial building, the roof responses in the test were used as the ground motions. It is found that the roof responses were amplified and filtered from the input ground motions which distinguses the floor isolation from the base isolation. A method to choose the balance parameter between reducing acceleration and displacement was proposed in this research. The test results show the rolling pendulum isolated hybrid floor isolation could work more effectively than the passive floor isolation system did. It maintained the displacement at an acceptable level, while reducing the acceleration response effectively. The results also show that the semi-active controlled floor isolation system could effectively help reduce the response of the furniture placed on top of the isolation system.