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Semi-active Controlled Floor Isolation System for Accommodating Live Load Changes

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1. Introduction

Floor isolation is an isolation system designed for only one floor or one room of the structure to protect a group of sensitive and expensive equipment in earthquake events. Rearrangement or moving in and out of equipment on the floor is sometimes necessary. In these situations, the weight of the system is likely to change. For a passive floor isolation system, the change in weight of the system will result in change of the system properties such as the damping ratio. To solve this problem, a semi-active control with MR damper is adopted.

2. Semi-active control and passive control

A semi-active controlled floor isolation system is designed as shown in Figure 1 with rolling pendulums and an MR damper. For comparison, an oil damper controlled passive control system is also designed by replacing the MR damper.

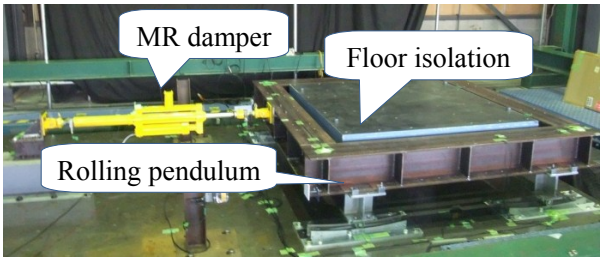

Figure 1. Floor isolation system

Three different weights, i.e., 35 kN, 62.5 kN and 82.5 kN, are adopted to simulate the load changes on the floor. For the passive floor isolation system, the oil damper has a constant damping coefficient of 10 kN.s/m, which results in three different damping ratios, 0.68, 0.38 and 0.29, corresponding to the three weights.

On the other hand, the force of MR damper is controllable through a control algorithm. An LQR control with scheduled gain (LQRSG) method is proposed to calculate the control force that is proportional to the weight of the system. The LQRSG control also enables the floor isolation system to be efficient under different types of ground motions, including both short period and long period motions.

The maximum oil damper force and MR damper force were designed to be the same , i.e., 10 kN.

3. Test results

A series of shaking table test was performed to verify the performance of passive controlled and semi-active controlled floor isolation systems for the three different weights. Figure 2 shows the comparison of test results. The test results show that the passive controlled floor isolation system is not able to accoumadate the weight change of the floor isolation system, and the responses for the three different weights vary significantly. On the other hand, the responses of the semi-active controlled floor isolation system using LQRSG remain similar for three different weights under both the short period motion JMA and the long period motion SAN, thanks to the capacity of semi-active control to adjust the control forces for different weights.

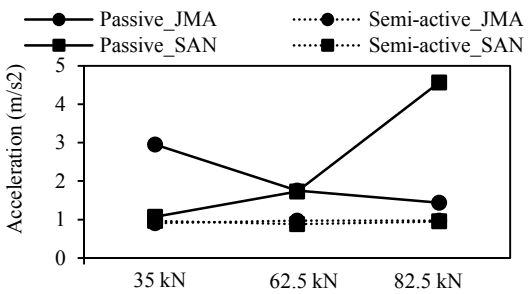

Figure 2. Comparison of test results