Hybrid isolation system using friction-controllable sliding bearings

Hybrid Isolation System Using Friction-Controllable Sliding Bearings

Système hybride d'isolation basé sur des appuis glissants à friction

Hybride Isolation mit Gleitlagern beeinflussbarer Reibung

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1. INTRODUCTION

The sliding isolation system represents a reliable vibration suppression technology. Such a sliding isolation system, however, has some limitation in its capability; it is not efficient for small to medium earthquakes, and it tends to suffer a large sliding displacement during large earthquakes. The objective of this research then is to develop a hybrid isolation system using friction-controllable sliding bearing, where by controlling the friction force, the sliding displacement will be confined within an acceptable range, while keeping the overall isolation performance optimal under the circumstances.

2. HYBRID ISOLATION SYSTEM

In the hybrid isolation system, a friction controllable sliding bearing or variable friction bearing (VFB) is used instead of an ordinary sliding bearing. The VFB is a carved out steel disk with a sliding material placed around its perimeter and a fluid chamber inside. The fluid pressure and the corresponding up-lifting force created by the fluid pressure can be controlled, resulting in a controllable friction force. Pressure control hardware system including computers connected to the VFB's controls the pressure according to a control algorithm so as to achieve an optimal isolation performance .

A simple one-degree of freedom model composed of a mass supported by VFB's is considered. A control algorithm based on the instantaneous optimal control theory[1], has been developed.

3. SHAKING TABLE TEST [2]

3.1 Description of Test

A pilot isolation system, including the VFB's and a pressure control system, has been constructed and tested on a shaking table. The model structure was a rigid body with the total mass of 12 tons supported by four VFB's The sliding surface of the VFB consists of 1 mm thick brass plate while a stainless steel sheet is placed on the shaking table to provide a sliding surface over which the VFB's can slide.

The control system consists of a 16 bit microcomputer with a numerical co-processor , and 12 bit A/D and D/A converters. Based on the response signals measured by sensors, the computer calculates the pressure control signal according to the control algorithm, and the signal was sent to the servo amplifier.

The shaking table test was conducted under unidirectional (horizontal) earthquake as well as sinusoidal excitations.

3.2 Test Result

A test performed off-line indicated that the friction force decreases linearly as the pressure increases within the interface. Also in another test, the relation between the pressure and the friction force under control signals was established. The results of these tests are modeled and used in the simulation. Performance of the hybrid control system is compared with that of the passive isolation system under different intensities of input seismic motion. As shown in Figure 1, the hybrid control system performs better than the passive system in the sense that the reduction of response acceleration has been achieved for small to medium seismic inputs, and at the same time, the maximum displacement has also been reduced. The residual displacement has been found to be nearly zero under hybrid control, which appears to be another advantage of this hybrid system.

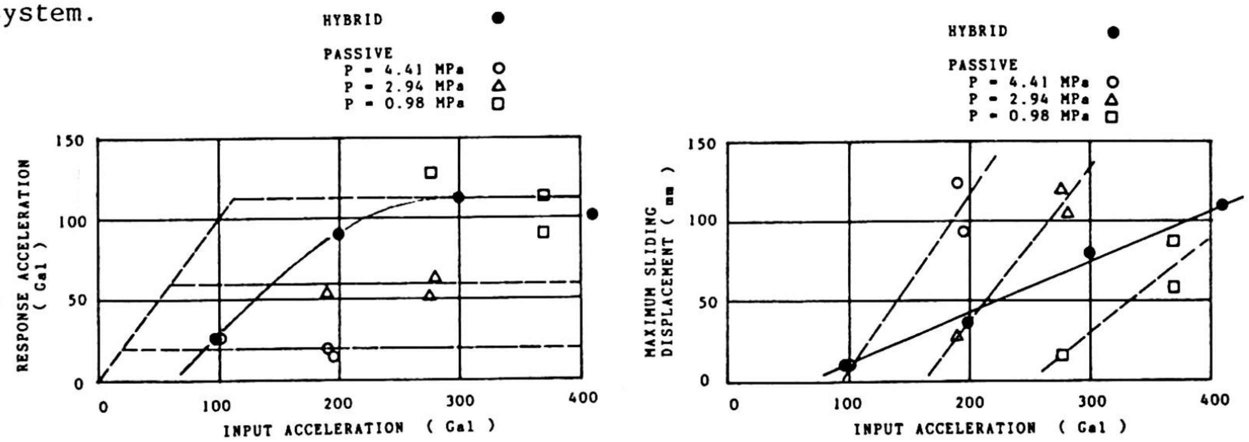

Fig. 1 Hybrid and Passive Cases

4. SIMULATION

The test results were simulated numerically exhibiting reasonably good agreement. Since some of the parameters and mathematical models involved some degrees of uncertainty, the good agreement observed is an indication of robustness of the hybrid system. The parametric study performed, also by means of simulation, identified most appropriate control parameters.

5. CONCLUSIONS

(1) Significantly beneficial effect of the hybrid control on the reduction of the sliding displacement as well as the reduction of the input force, has been verified through shaking table test.

(2) The pilot hybrid isolation system using the VFB's appears to be quite robust in the fact of uncertainty involved in various aspects of the control model.

(3) Structural response simulated by the numerical analysis showed good agreement with the observation in the shaking table test, implying that the numerical model identified in the present study represents the reality reasonably well.

REFERENCES

[1] YANG,J.N.,et al., " Optimal Control of Nonlinear Flexible Structures", Technical Report of NCEER-88-0002. (1988)

[2] FENG,Q.,et al.," Hybrid Isolation System Using Friction Controllable Sliding Bearings", 8 th VPI and SU Symposium on Dynamic and Large Structures, May 1991.