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[Research Topics]

Real Time Hybrid Tests of Semi-Active Control Using Shaking Table - Proposal and Verification of Test Method for Mid-Story Isolated Buildings -

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1. Introduction

It's expected that near future's earthquake disasters are by huge pulse-type ground motions of an inland earthquake or long-period type ground motions of a subduction zone earthquake. Some concerns about seismic-isolation buildings can be also pointed out as follows:
1) Extra-large deformation of isolators exceeding the design criteria due to those types of earthquakes,
2) Degradation of seismic-isolation effects for reduction of acceleration response reduction due to the continuation of the long-time vibration.
To overcome those problems, authors focus on introducing semi-active control systems on isolated layer. In this study, real time hybrid tests[1)] are performed on the mid-story isolated structures with semi-active device using the rotary inertia mass damper encapsulating magneto-rheological fluid[2)] (MR rotary inertia mass damper). In this test, isolated layer and superstructure are actually created as the test specimen, and lower part of structure is simulated by lumped mass system model in a computer. By using actual equipment of damper which has not been exactly clarified its behavior, modeling errors seem to be avoided, and the accuracy of the results on the hybrid test can be secured. This paper reports about constructing the system for real time hybrid test, verifying its validity, and verifying the reproducibility of shaking table to confirm the reliability of this test.

2. Real time hybrid test

Figure 1 is a photo of the shaking table and test specimen. Table 1 shows the specifications of the shaking table. The object of the test is a mid-story isolated building.

Figure 2 is a schematic diagram of the application of the mid-story isolated building to the test. The test specimen consists of an isolation layer and superstructure, while the substructure (structure under the isolation layer) is modeled using a computer.

Figure 3 is a schematic diagram of the real-time hybrid test. The test specimen of the superstructure consists of four floors, as shown in the photo in Figure 1, and the substructure calculated by DSP (AD5436-I7 from A&D Company Limited) in a computer is a two-mass system. The stiffness of the spring of the first layer of the test specimen is small, corresponding to the isolation layer. First, earthquake ground motion is caused to act on the mass system model inside the DSP to perform a time-history response analysis. The absolute displacement of the top mass (the floor under the isolation layer) of the two-mass system obtained in this way is reproduced by commanding the shaking table. The spring reaction and damping force of the damper installed on the isolation layer of the test specimen are input back to the two-mass system on the DSP to be used for the time-history response analysis. The response of the test specimen and the two-mass system on the DSP are both successfully recorded, and their values are used to perform semi-active control.

Figure 4 shows the story drift of each story and Figure 5 shows the time-history of the floor accelerations. The results obtained by the real-time hybrid simulation that used a mid-story isolated building as the model were compared with the time-history response analysis results for the entire building modeled for all stories, showing good conformity.

3. Conclusions

As results, high reproducibility of displacement of the shaking table by real time calculation could be observed and controlling errors could be manipulated to be negligible. At the same time, generated accelerations on the shaking table are observed performing accurately. However there is a little error in the reproduced acceleration for some cases. As a concluding remark, it is confirmed that reliable experimental system to operate real time hybrid test is constructed through this research.

Acknowledgements

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Fig. 1 – Shaking table and test specimen

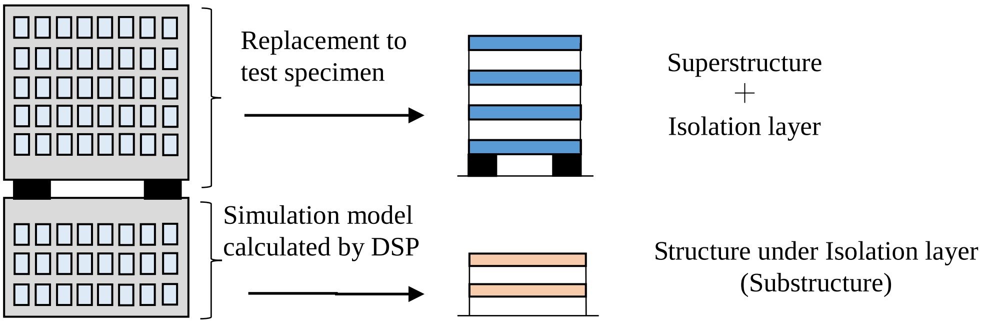

Fig. 2 – Concept of modeling of a mid-story isolation for real-time hybrid test

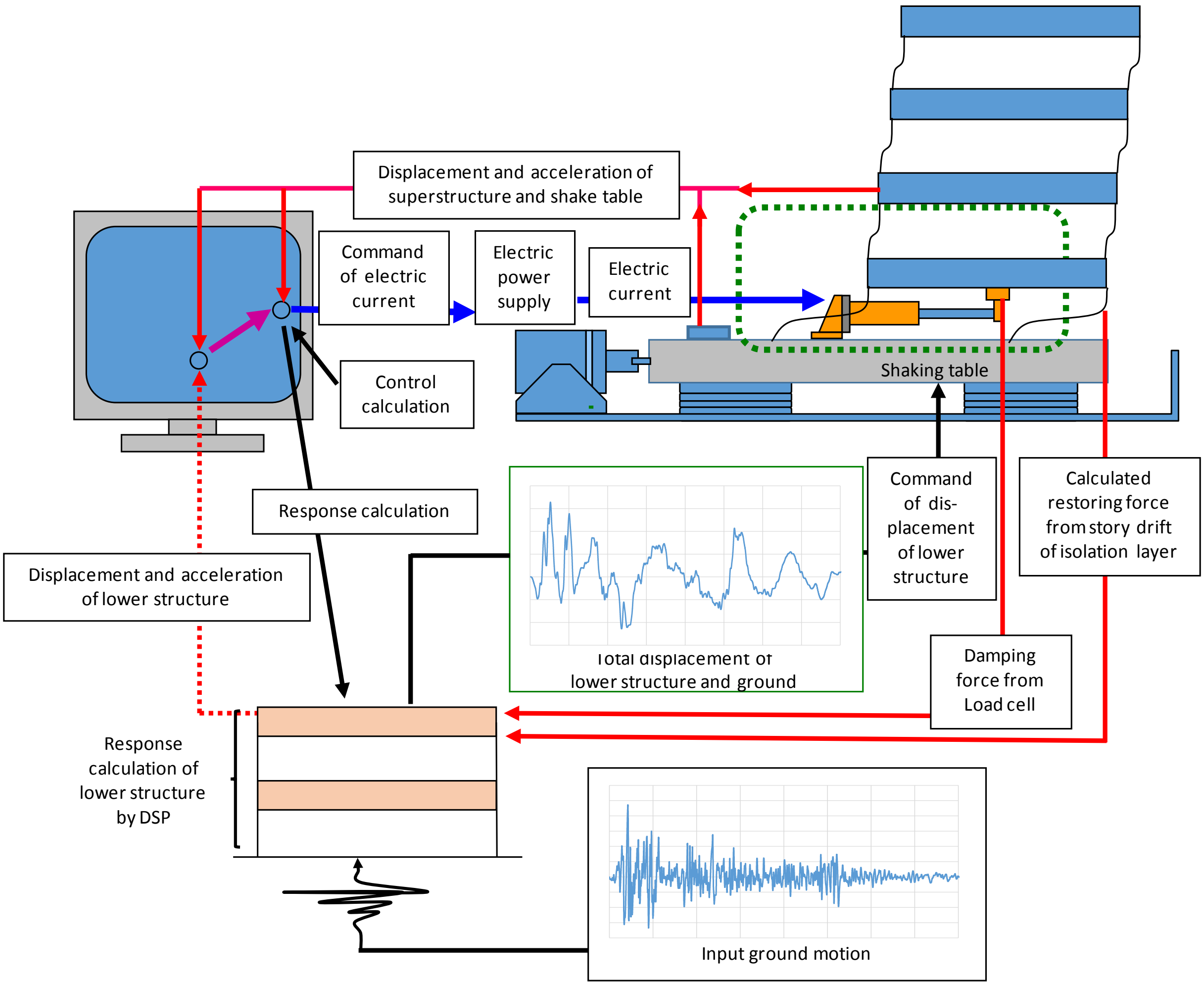

Fig. 3 – Diagram of real-time hybrid test by using shake table of a mid-story isolation

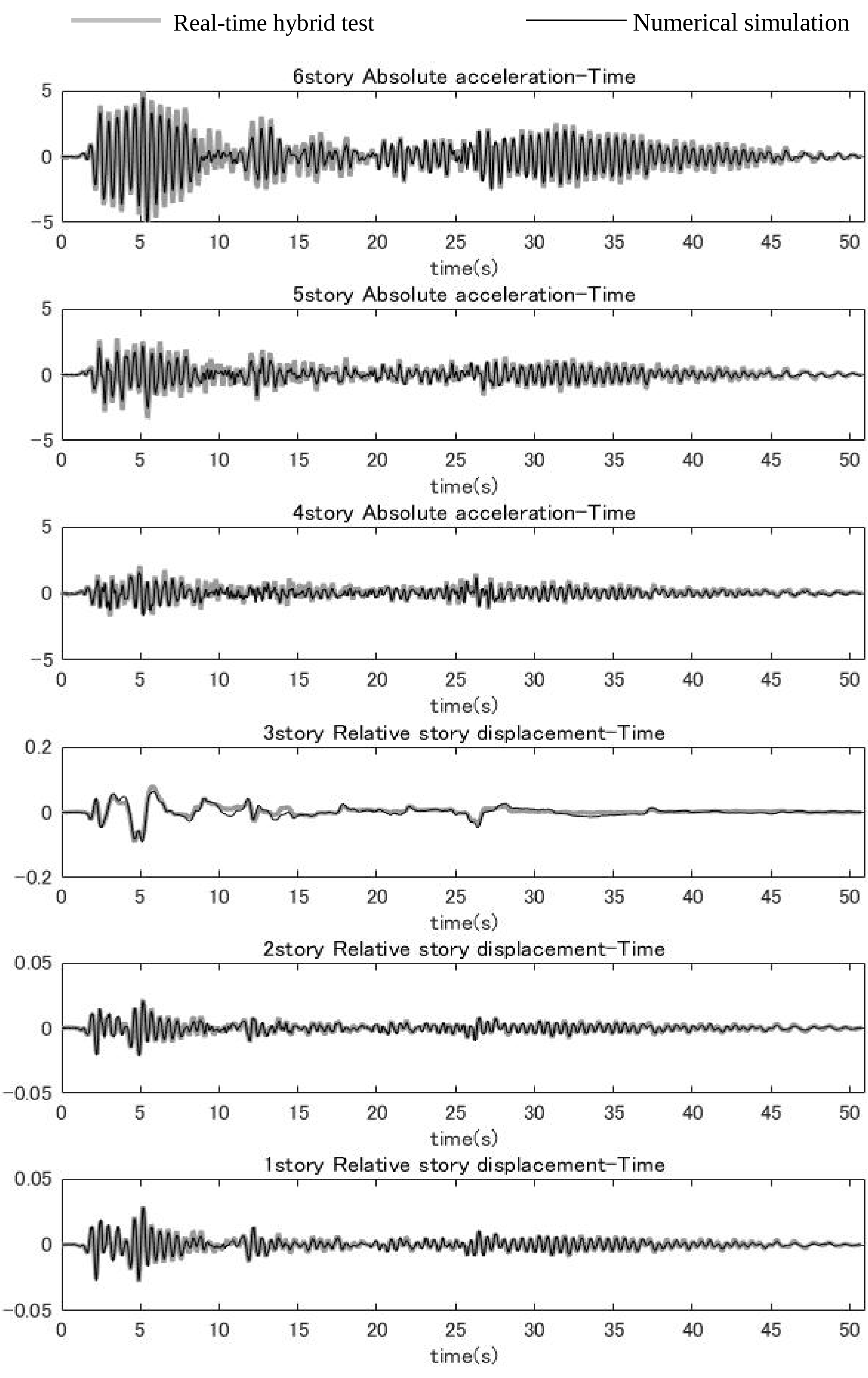

Fig. 4 – Comparison of story drift between real time hybrid test and numerical simulation

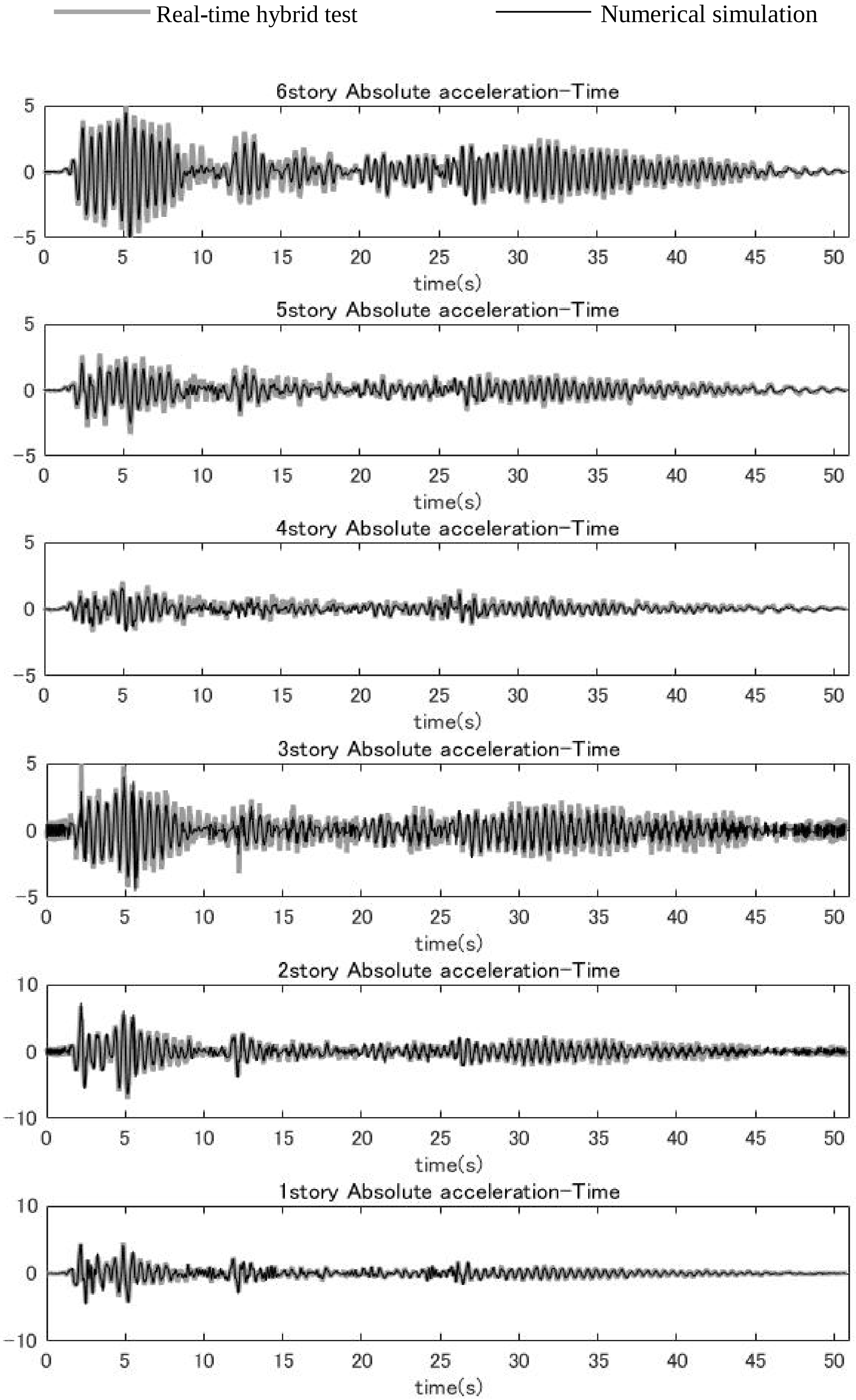

Fig. 5 – Comparison of floor acceleration between real time hybrid test and numerical simulation