

Reproduction of high-rise buildings' seismic responses by full-scale shaking table test using feedback control techniques

○ Xiaodong Ji, Ryuta Enokida, Kouichi Kajiwara, Takuya Nagae, Toko Hitaka, Masayoshi Nakashima

1. Introduction

Large velocity and displacement responses can be observed in the top story of high-rise buildings when subjected to long-period earthquakes. However, full-scale tests for reproducing large responses cannot be directly performed due to the restraint of shaking table's capability. Herein, feedback control techniques are used to produce input waves of shaking table, and a rubber-and-mass system is used to enlarge the input waves to reproduce high-rise building's responses.

2. Experimental specimen and target wave

The experimental specimen is a full-scale five-story steel frame with total mass of 397 ton and total height of 20 m. Two rubber stories and one huge concrete plate are served as rubber-and-mass system. A nonlinear time history analysis of a 30-story building model subjected to GMhigashi ground motion is carried out. The top story's responses are used as the target wave for reproduction of shaking table test.

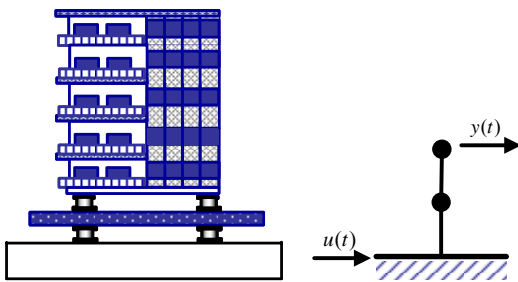


Fig.1. Sketch of test system

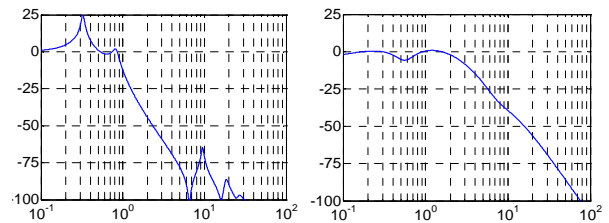
3. Production of shaking table's input wave



Fig.2. Feedback control system

A feedback control system is shown as Fig.2, in which B and W denotes the experiment model and controller.

In order that specimen's response y is identical with the target wave r , model matching method and H_∞ method are used to construct the controller W and produce shaking table's input wave u . The transfer functions of experiment model and the whole control system are shown as Fig.3.



(a) Experiment model (b) Control system

Fig.3. Transfer function

4. Shaking table test results

A shaking table test is performed in E-denfence using the wave produced by feedback control system as shaking table's input. The measured specimen's response is shown in Fig.4. It shows that specimen's response has high consistency with target wave.

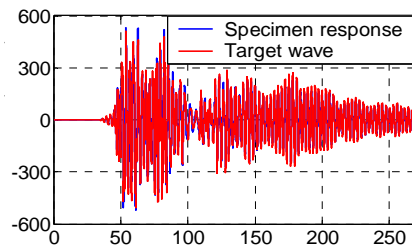


Fig.4. Specimen's response and target wave

5. Conclusions

- (1) Feedback control algorithms can construct controller to produce shaking table's input waves.
- (2) Shaking table test can reproduce tall building's large responses using the produced waves as input