E09

Application of Real-time Substructure Testing to Soil Structure Interaction System

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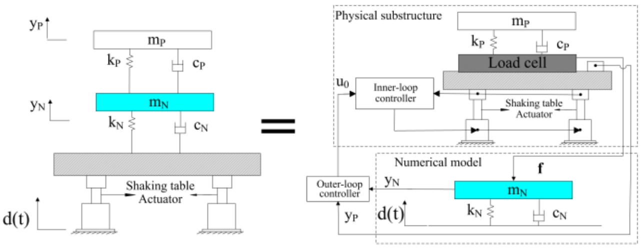
1. Introduction

The investigation of soil-structure interaction (SSI) phenomena is often performed on a shaking table with a model foundation-structure system embedded in a soil container. However, the space and power of shaking tables accessible to researchers limits the size of the specimen to small scale. The real-time dynamic substructuring (RTDS) supplies a good option to overcome this disadvantage.

Fig. 1 shows a principle of RTDS for shaking table tests of SSI where the interface response between a foundation and a superstructure is numerically solved and input to a shaking table. The reaction force of the foundation from the superstructure is fed back to the numerical substructure through an online load cell.



(a) Whole system (b) RTDS system

Figure 1. Principle of RTDS for shaking table tests

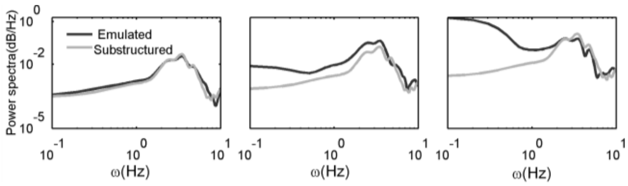
2. Control strategy for RTDS

A successful application of a RTDS requires that the displacements of the shaking table track those of the interface outputted from the numerical substructure. For reproducing the interface response accurately, a tailored outer-loop controller is necessary. The commonly used scheme in RTDS is delay compensation, which assumes that the dynamics of the shaking table is pure time-delay. However, due to the high-order characteristics of the shaking table, the over simplification of time delay introduces unacceptable error in magnitude and phase, which may cause inaccuracy and even instability in RTDS.

To enhance the stability and accuracy in the RTDS shake table testing, an integrated model of a shaking table test was developed. This model was used to develop a new controller called Full State Compensation via Simulation (FSCS) based on the conjunction of inverse dynamic control and full state feedback control.

3. Comparative tests

To verify the performance of FSCS and evaluate the validity of RTDS to simulate SSI, comparative tests were conducted; one was an emulated shaking table test, where a soil container was designed to work with a single mass oscillator, and the other was a RTDS test, where the soil container is described by a linear model. Figure 2 presents the acceleration of superstructure when excited by a same input with different amplification coefficient (α). The measured results show that FSCS achieved good agreement between the two tests when the input is small. However, divergence between the two results with larger excitations showed the need for a comprehensive model including the nonlinearity and rocking of the soil-foundation system.



(a) (b) (c)

Figure 2. Acceleration power spectra of superstructure; (a) $\alpha = 1$, (b) $\alpha = 2$ and (c) $\alpha = 3$