On-line hybrid test using Peer-to-Peer (P2P) system

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1. Introduction

An on-line hybrid test system using the substructure technique was proposed in this paper. In this system, all of the substructures are implemented equally and as independent as possible. A coordinator is used to keep the boundaries between the substructures compatible and equilibrated. Each substructure is simulated by FEM numerically or tested physically, and all structures are connected through Internet. The proposed system is deemed more flexible and capable, especially for large-scale structures.

2. Method Devised

The equations of motion are formulated for each substructure. For each step of analysis, a ground motion is imposed on each substructure, and a set of displacements is imposed on the boundaries between the substructures. The reaction forces on the boundaries are sent to the coordinator. The coordinator deals with the reaction forces from all substructures and calculates the unbalanced forces. If the unbalanced forces are small enough, the structure is viewed as in equilibrium. Otherwise, a new set of displacements are generated using a quasi-Newton procedure, and sent to each substructure. This procedure continues until the unbalanced forces are less than the tolerance. This is an iterative procedure for keeping both the compatibility and equilibrium simultaneously. However, experiment requires no iteration. A predicting-correcting scheme is used for solving this problem. Experimental substructures are assumed to be linear and handled numerically in the predicting stage. Then the predicted displacements are imposed on the experimental substructures, and the boundaries become unbalanced again. The correcting stage eliminates the unbalanced force using a linear assumption once again for the experimental substructures.

3. Experiment by Proposed System

The earthquake responses of a base-isolated structure were simulated using the proposed system. It was treated as a planer frame and shown in Fig.1. The entire structure was divided into three substructures. Substructures A and B, which formed the superstructure (the steel moment frame) were assigned as the computed parts, and Substructure C, which was the base-isolation layer (consisting of two HDRBs), was assigned as the tested part. The superstructure was modeled as a linear spring-mass system, with one mass per floor and one spring per story, and analyzed separately for Substructures A and B. The base-isolation layer was modeled as a single degree of freedom system with a mass and a spring, and tested as Substructure C.

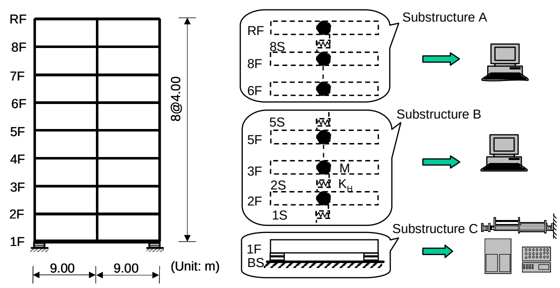

Fig. 1 Eight-story base-isolated structure

A conventional online hybrid test using the operator splitting method was also conducted to calibrate the accuracy of the test results obtained from the proposed method. The fault-normal component of the JMA Kobe record was used for both tests, and the integration time interval was taken to be 0.01s. Both tests were conducted successfully, and the test results are shown in Fig.2. Good agreement between the two results demonstrates the validity of the method.

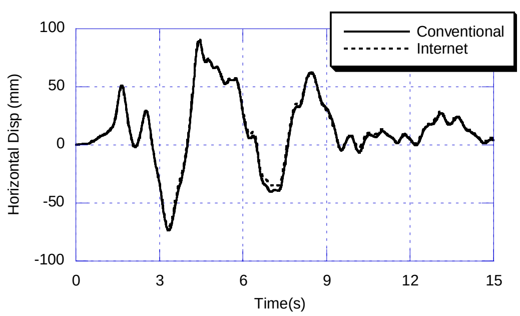

Fig. 2 Displacement response of base level