変位・荷重混合制御によるオンライン応答ハイブリッド実験

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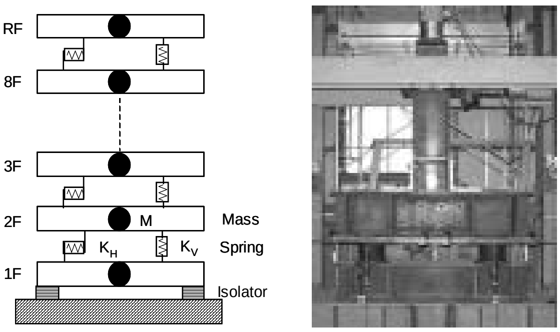
1. Introduction

The hybrid online test is displacement-controlled. Displacement control for stiff members, however, is not an easy task. To expand the capacity of the online test, the writers devised "force-displacement mixed control technique." Two types of mixed control are considered: one is named "combined control," in which one jack is force-controlled and the other displacement-controlled, with fine tuning of motion of the two jacks; and the other is named "switching control," in which one jack is operated by displacement-control but switched to force-control upon request.

2. Tested structural model

The proposed mixed control technique was used to simulate earthquake responses of an eight story base-isolated structure modeled as in Fig.1 (a). The superstructure and base-isolation layer were assigned as the computed part and tested part, respectively. The superstructure was treated as a mass-spring system, with one mass per floor and one horizontal and one vertical spring per story. The specimen of the base-isolation layer is shown in Fig.1 (b).



(a) (b)

Fig. 3. Online tests of base-isolated structure: (a) structural model; (b) test specimen

3. Force-displacement combined control

Earthquake responses of the base-isolated structure when subjected to both horizontal and vertical ground motions were simulated. One jack (named the horizontal jack) was used to impose lateral displacement of the base-isolation layer, and another jack (named the vertical jack) was used to impose axial forces on the layer. The horizontal jack was displacement-controlled in accordance with the standard online test procedure. The vertical jack was force-controlled. The force applied was given as the product of the assumed stiffness and the vertical displacement (estimated by the direct integration of the associated equations of motion). In consideration of rather strong dependency of the horizontal stiffness of the base-isolation layer on the vertical stresses imposed on the layer, application of varying axial forces in tune with the horizontal deformations is justified. The online test with the proposed mixed control was successful, with accurate displacement and force control achieved for both jacks. Fig.2 shows an example of responses obtained from the tests. Some differences are present for the hysteresis loops between the case without vertical motion and the case with.

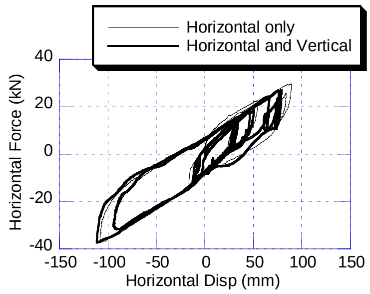


Fig. 2. Hysteresis loops obtained by mixed control

4. Force-displacement switching control

Earthquake responses of the base-isolated structure when subjected to large vertical motions and hence involving tension in base-isolation layer were simulated. To consider significant differences in stiffness when the layer takes compression and tension, switching control was developed, in which force-control (similar to the one used in combined mixed control) was adopted when taking compression and switched to displacement-control once taking tension. Switching from force to displacement or vice versa was satisfactory particularly when adopting time-varying integration to specify the switching point precisely. An example time history obtained is shown in Fig. 3. A large compressive force is notable when switched from tension to compression. This is attributed to a bouncing effect at the instant when the base-isolators start taking compression.

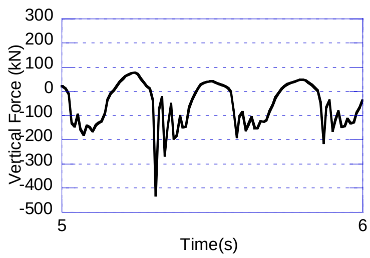


Fig. 3. Time history obtained by switching control