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Blind analysis of a full-scale steel frame with dampers tested on E-defense shaking table

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SUMMARY

Shaking table tests of a full-scale five-story steel frame building specimen with dampers were carried out in March 2009 at the E-Defense shaking table facility. To predict the results of these tests, a blind analysis contest was hosted by National Research Institute for Earth Science and Disaster Prevention. The contest was arranged into four categories by the combination of analytical methods (2-D and 3-D) and kinds of dampers (steel and viscous). The competitors vied for accuracy of analysis in each category. The authors entered all categories and were awarded the prizes in all of them. The authors describe their 2-D analysis in this paper.

The building specimen consisted of three structural frames. In the analysis, these frames were gathered into one 2-D frame model where elements' sections were simply combined. Dampers were inserted into the structural 2-D frame model. The frame model consists of line elements, hinge elements, panel-zone elements and column's base elements. The masses were concentrated at panel zones. Although the hinges and panel-zones were modeled with elasto-plastic characteristics, all the elements' response remained in the elastic range for the time-history analysis. The frame models were kept unchanged for different kinds of dampers. The steel dampers were modeled based on Menegotto-Pinto model, considering the stiffness of the attaching portion. The viscous dampers were modeled according to the provided experimental data, considering their compression stiffness. The model took into account the variation of frequency and amplitude.

In this analysis, the model was provided with temporary elastic springs instead of nonlinear elements, and then the differential force from original nonlinear element was fed back. Although time-lag occurred in the analysis, accuracy was ensured by making the time step small (less than 0.002s). While the stiffness of these temporary elastic springs was defined as a second stiffness for the panel-zone elements, it was assumed as 1/1000 of the initial stiffness for the other elements. Ordinary differential equations by state space representation were used for this analysis through MATLAB/Simulink version 7.0 (R2007b).

The analytical results were compared with the experimental results. As for the steel damper model, the response at first story was different from experiment. The overestimated stiffness of the frame at first story might be the reason. Similar tendencies were observed for both viscous damper model and steel damper model. As for the viscous damper model, the estimated responses were smaller than that of experiments. The 0.5 mm-gap existing in the hinge of the viscous dampers is suspected to be the cause. In the case of viscous damper model, the first natural period was a little longer than that of experiment. All these differences might have affected the result of analyses.