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Study on Performance of Seismic Retrofitting of Super High-rise Building Based on Earthquake Observation Records

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SUMMARY

It is pointed out that great earthquakes such as the Tokai Earthquake, the Tonankai Earthquake, and the Nankai Earthquake, may occur in the near future. When such an earthquake occurs, long-period ground motions will reach the Kanto, Nobi, and Osaka plains, where Japan's three major urban areas have developed, and shake high-rise buildings violently. Since some of old high-rise buildings were designed without considering long-period ground motions, retrofitting such buildings is an important issue.

An effective method to retrofit existing high-rise buildings is installing additional oil dampers. However, a problem with ordinary oil damper is that they require reinforcement of surrounding columns and girders to support large reaction forces generated during earthquake ground motion. To solve this problem, we developed a deformation-dependent oil damper. The most attractive feature of this damper is to reduce the damping force at the moment when the frame deformation comes close to its maximum value. Thanks to this feature, no reinforcement of columns, girders, and foundations is required.

We applied this deformation-dependent oil damper to an existing 54-story office building located at Shinjuku ward, Tokyo Metropolitan in 2010, to suppress vibration under the long period earthquake ground motions. This building was completed in 1979.

This paper describes the applied building and its dynamic characteristics, the specification of the deformation-dependent oil damper, the earthquake observation system, and the confirmation of the control effectiveness based on the observation records.

The main records of the building was observed in the 2004 off Tokaido Earthquake, in the 2004 Mid Niigata Prefecture Earthquake (in the condition without oil damper), and in the 2011 off the Pacific coast of Tohoku Earthquake (with the deformation-dependent oil damper). An ARX model is fitted to these observation records to evaluate the control performance of these oil dampers as equivalent damping ratios in the first vibration mode. The damping ratios for the x-directional and y-directional first modes of the building were increased by these oil dampers to 0.6 and 1.4 per cent, respectively. The simulation analysis of the 2011 off the Pacific coast of Tohoku Earthquake in the condition without oil dampers is also conducted. It was found that these oil dampers effectively reduced the maximum displacement response of the building to about 80 per cent. Finally, the performance of the seismic retrofitting of the super high-rise building was confirmed.