論 文 の 内 容 の 要 旨

論文題目　Hybrid Seismic Retrofit Systems Using TMD and Soft-first Story Principle
（同調マスダンパーとソフトファーストストーリーを用いた制振改修法に関する研究）

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Steel buildings have exhibited considerable response during recent earthquakes. The response was so large that people could directly observe with their naked eyes and take it to video images. In most of the cases the structural damages were very small, but the large response of skeletons had caused lots of non-structural damages and severely influenced the living quality of the buildings. In order to improve this, some measures to reduce the seismic response of the existing steel buildings should be proposed and realized urgently. To this end a new hybrid retrofit system using TMD and Soft-first story principle is proposed and its applicability is investigated in this thesis.

The followings are the main works described in this thesis.

Firstly, the basic theory of optimization methods for TMD was reviewed and some popular optimum methods were summarized and analyzed. An example of traditional TMD was selected and numerically calculated for 60 earthquake waves. Then, a non-traditional TMD was proposed and studied to derive an optimum expression, for two kinds of dampers, viscous damper and friction damper. Finally, the hybrid TMD, which combined with traditional TMD and non-traditional TMD, was proposed.

Secondly, a numerical simulation, including frequency response analysis and earthquake response analysis, has been carried out to explore the dynamic property and vibration mitigation effect of this proposed retrofit system. The parameter variations

used for the numerical studies include 6 kinds of number of floors, 5 types of TMD mass ratios, 4 stiffness soften ratios and 9 stiffness harden ratios. The result of frequency response analysis shows that the TMD combined system can reduce the resonance of the structure significantly. Finally, the earthquake response analysis has been carried out using 60 types of earthquake records. The acceleration of the top floor and the drift from the first floor to the top floor were compared to study about the effectiveness.

Then, a shaking table test was carried out to explore the feasibility and effectiveness of the proposed retrofit system. For the shaking table test a three-story steel frame Benchmark model was used, and two kinds of retrofit patterns, TMD1 and TMD2, were applied. With these two patterns, 7 cases of structures were prepared; the original structure, the SFS structure, the SFS_HUS structure, the SFS with TMD 1 structure, the SFS_HUS with TMD 1 structure, the SFS with TMD 2 structure and the SFS_HUS with TMD 2 structure. Each model has been tested by loading of Sweep wave, Whitenoise wave, and other 5 earthquake records.

Furthermore, some practical problems were considered for practical application. First, the effect of additional stiffness due to the TMD was considered and analyzed. Then, the double adjustment procedure was proposed when make use of the additional stiffness. The system robustness has been also considered for various mass ratio and additional stiffness. Finally, an initial displacement method was introduced, which was often considered to obtain more effectiveness especially when the system is mainly subjected to impulse excitations.

Finally, a new vision based method for displacement measuring was proposed and studied. It may be used to the structures with large displacement response such as high-rise building, structures with soft story or isolated story. A shaking table test has been carried out to see the feasibility for obtaining an historical displacement response. Then the theory was applied to a video record from a surveillance camera of the

high-rise buildings at Shinjuku during the Great East Japan Earthquake.

In brief, a hybrid seismic retrofit systems using TMD and soft-first story principle is proposed in this thesis in order to reduce the large seismic response of existing steel buildings. Its applicability is investigated through numerical simulations with 6 types of models and a shaking table test using Benchmark model. The results showed that the proposed retrofit system can significantly reduce the response of the original structure especially the acceleration response of the top floor.