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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	陳星辰	指導教員（主）： Academic Advisor(main)	竹内徹
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This study proposes an innovative controlled spine frame system to prevent damage concentration and ensure continuous usability of buildings after large earthquakes. The proposed structural system consists of stiff spine frames, replaceable energy-dissipating members (i.e., dampers), and envelope moment-resisting frames. The spine frames prevent deformation concentration in specific stories. The envelope moment frames are designed to remain elastic and ensure sufficient self-centering capacity. Input seismic energy is absorbed by dampers, which feature significant energy dissipating capacity, and if required can be easily replaced following a large earthquake.

Superior seismic performance of the proposed system in deformation distribution, energy dissipation, self-centering capacity, robustness against severe earthquakes and irregular stiffness, are validated and compared with the conventional shear damper (SD) and post-tension strands equipped uplifting rocking systems (LU) by dynamic analysis with various ground motion intensities. Structural models are created based on a typical 5-story school building. When subjected to a design level earthquake, the proposed controlled spine frame model exhibited smallest peak deformation, mildest deformation concentration, smallest damage in main frames, and similar small residual deformation as that of the LU model, even when vertical stiffness and strength of the main structure are not well balanced. In incremental dynamic analysis, both regular and irregular spine frame models show stable seismic performance with increased input ground motion intensity. On the contrary, severe damage concentration in the irregular story was observed in the SD model, and the first-story irregular LU model exhibited a high risk in the failure of bottom diagonal members in the rocking frame against larger earthquakes.

Effect of key structural characteristics on seismic performance of the controlled spine frame system with various heights has been investigated by extensive parametric study. A simplified dual multi-degree-of-freedom (DMD) model with a nonlinear dynamic analysis program is developed for the proposed system, which greatly improves the computing efficiency of the parametric analysis. The benchmark model utilized in the numerical analysis represents a typical office building with height ranging from 5 to 30 stories and natural periods ranging from around 0.8s to 5.0s. The stiff spine shows effect in achieving a more uniformed deformation distribution even for structures as tall as 30 stories. To ensure the effectiveness of the spine frame, the minimum requirement of spine-to-frame stiffness ratio is established for buildings with different heights. It is also fund that increasing damper amount is not always effective in reducing seismic response of the spine frame structures. The optimal damper-to-frame stiffness ratio is clarified for the typical range of spine-to-frame stiffness.

A concept of segmented spine frames (Sgt) is proposed for an easier application of spine frames in tall buildings by avoiding immense demand on energy-dissipating amount of dampers or strength of spine frames. In a Sgt structure, there are more than one spine frames arranged in series along the height of the structure. The segmented spines are pin-connected with each other and dampers are equipped at the bottom of each spine frame. Optimal number of segments and optimal location of each segment has been investigated. The 20- or 30-story buildings utilizing the two-segment spine frames (Sgt2) exhibit similar peak story drift and largely reduced strength demand on spines compared to the continuous single spine frame (Cnt) structure, as long as the segment height is 50%-75% of the structural height. Optimal value of the 'upper damper'-to-'bottom damper' stiffness ratio is also established for the Sgt2 structures. Spine frame structures adopting more than two segments does not exhibit advantageous seismic performance compared to the Sgt2 structures for buildings lower than 30 stories. Therefore, two segments configuration is recommended for tall buildings when damper amount at one story is limited.

A simple seismic evaluation and design procedure based on equivalent linearization technique and response spectrum analysis is developed for the proposed spine frame system, based on the further simplified single-degree-of-freedom (SDOF) models. Two sets of processes are developed respectively for structures whose seismic response is first-mode dominant, and structures whose higher-modes effect cannot be ignored. For the low-rise, first-mode dominant structures, the design procedure is verified by time-history analysis. For taller structures, the evaluation method is verified by modal pushover analysis for seismic response of each mode, and by time-history analysis for the entire response. Seismic response of both Cnt and Sgt2 models are well estimated with appropriate conservatism by utilizing the proposed evaluation method. Distinct limitation for applying the design procedure is established in terms of structural vibration characteristics. Boundary of key structural index such as the damper-to-frame stiffness ratio and spine-to-frame stiffness ratio is determined based on a desired accuracy of the evaluated results.