論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Seismic Retrofit of RC Buildings with Various Energy-dissipation Devices and Elastic Steel Frames including Effect of Composite Behavior
著者(和文)	SAINGAMPANUMAS
Author(English)	Panumas Saingam
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第12115号, 授与年月日:2021年9月24日, 学位の種別:課程博士, 審査員:竹内 徹,坂田 弘安,五十嵐 規矩夫,田村 修次,西村 康志郎
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12115号, Conferred date:2021/9/24, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	建築学 系 建築学 コース	申請学位（専攻分野）： Academic Degree Requested	博士 (Engineering) Doctor of
学生氏名： Student's Name	SAINGAM Panumas	指導教員（主）： Academic Supervisor(main)	竹内　徹(TAKEUCHI Toru)
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Titled as "Seismic Retrofit of RC Buildings with Various Energy-dissipation Devices and Elastic Steel Frames including Effect of Composite Behavior", this study proposes seismic retrofit design methods of RC buildings using various energy-dissipation devices (dampers) installed along with the elastic steel frame (SF) attached as the interface between the damper and the original RC frame including the effect of their composite behavior without iteration, designed using an equivalent linearization approach. The thesis is composed of 7 chapters. The outline of each Chapter is described in the following:

In Chapter 1, the background, motivation and literature review about research fields of seismic retrofit of RC buildings with energy-dissipation devices are summarized and the purpose and objective of this dissertation are explained.

In Chapter 2, buildings' damages from the 2014 Mae Lao earthquake, which is the biggest recorded earthquake in Thailand, are summarized. Then a target four-story RC school building located in Chiang Rai Province, Thailand, is introduced in order to apply the proposed retrofit methods, and the seismic design spectrum based on Thailand seismic design codes is introduced for the following studies.

In Chapter 3, a retrofit method using buckling-restrained brace (BRB) with SF as the BRB attachment element is proposed and the composite behavior between SF and RC frame is investigated. Precise numerical models including the anchor elements are introduced and calibrated against the past quasi-static cyclic loading tests on real-size mock-ups. Then, an approximate equation for estimating the stiffness contribution of the composite behavior is proposed according to the relationship between fully and partially composite stiffness amplification ratios. Then the retrofit design recommendation is proposed and validated using nonlinear response history analysis (NLRHA) under eleven ground motions. The results suggest that the retrofitted buildings achieve target performance, although the required BRB strength is reduced by considering the composite behavior.

In Chapter 4, the seismic retrofit design method is expanded to the option of using viscous dampers instead of BRBs. The optimal damper distribution procedures are newly proposed using the equivalent linearization approach, and the composite behavior is also considered as the design option. The performances of the retrofitted design using the proposed design procedure are validated with NLRHA analysis, and the results suggest that the proposed retrofit method with viscous damper and SF also can efficiently improve the seismic performance of seismically deficient RC buildings. Not only the maximum story drift ratio (SDR_{max}) is decreased efficiently, but the residual story drift ratio (SDR_{re}) of the retrofitted buildings is also substantially reduced.

In Chapter 5, the seismic retrofit design method is expanded to the option of using friction dampers. First, an experimental program is conducted to characterize the dynamic behavior of friction brace dampers with several different materials, finding that a sintered metal compound provided a relatively high and stable friction coefficient of 0.4. Then a strength-based optimal damper design procedure is developed based on the required friction slip force. The retrofit design using the proposed procedure is carried out and validated using NLRHA. The analysis results suggest that the proposed retrofit design method and friction brace dampers effectively improve the seismic performance satisfying the target, and the effects of composite behaviors are also confirmed.

In Chapter 6, the retrofit methods with BRBs, viscous dampers and friction dampers are compared and discussed with their performances. The overall results indicate that the seismic performances of all retrofitted buildings are effectively improved, and the requirements for each damper can be reduced by the composite behavior with controlling the average of SDR_{max} within the target story drift ratio (SDR_{tar}). The retrofit with BRBs shows the closest average of SDR_{max} compared to the SDR_{tar}. While the minor differences were observed in maximum roof acceleration (A_{max}) before and after retrofitting with BRBs and friction dampers, the retrofitted with viscous dampers showed remarkable A_{max} reductions in several cases.

In this chapter, the effects of SF including the composite behaviors are confirmed against with the vertical options only dampers without SF. Incorporating supplemental SF with partial composite behavior tends to decrease the average of SDR_{max} and decrease the variance of the SDR_{re} when compared to the retrofit with only damper options. Although the retrofit with damper+SF increases slightly average of A_{max}, the SF and composite behavior decrease the drift concentration factors additionally when compared to the retrofit with only dampers. It implies that the SF and composite behavior additionally prevent the damage concentration for the retrofitted buildings. The effects of introducing SF on the demands for RC columns around the dampers are also investigated, and it was confirmed that the force response in the RC columns are affectively reduced with SF introduction, which proves the validity of the assumption that the hysteresis of the original RC frames is unchanged by additional energy-dissipation devices.

In Chapter 7, the findings of each chapter are summarized and concluded.