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Seismic Response of Base-isolated Dual-system Reinforced Concrete Buildings at a Near-fault Site

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ABSTRACT: In high-rise reinforced concrete buildings, using base-isolating systems can increase the response of the structure. To overcome this problem, it is suggested to increase the stiffness of the building by utilizing lateral load-bearing systems such as shear walls. In the present study, the seismic response of fixed-base and lead-rubber bearing isolated dual-system reinforced concrete buildings has been compared using nonlinear time history analysis procedure according to the 2800 V4 standard and ASCE/SEI7-16 code provisions. For this purpose, 10, 15, and 20-story reinforced concrete buildings, in a similar and regular plan, with special moment frame and shear wall dual systems have been selected as a case study. A 20-story building has been considered a tall building in this study. Results show that the response of the base-isolated structures including the mean, median, and 16% and 84% percentiles of drift ratio, floor acceleration, and base shear has a significant decrease compared to the fixed-base buildings according to the above-mentioned code provisions. Results indicate that base-isolated buildings with respect to fixe-based buildings, based on the ASCE / SEI 7-16 code compared with the 2800 V4 standard, maximum drift in the structures has a 23% more decrease and mean acceleration and base shear have an 11% more decrease. The results obtained in this study can be the basis for the development of the 2800 standard provisions to investigate the seismic response of base-isolated reinforced concrete structures at a near-fault site.

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1- Introduction

Base isolation can be used effectively to reduce the story drift and acceleration in structures [1]. Recently, lead rubber isolators have been utilized in different kinds of structures [2]. Results of the previous studies show that base-isolated structures have a longer period compared with fixed base one, and base shear in base-isolated structures decreases significantly [3]. Near field ground motions with long period velocity pulses have a significant effect on the seismic performance of the base-isolated structures [4]. These kinds of ground motions cause higher demands on the isolation system and superstructure [5]. Effects of isolation stiffness and pulse period of near field ground motions on the seismic response of base-isolated buildings have been investigated [6]. In high-rise buildings, using base-isolating systems can increase the response of the structure. Base isolation for long period high rise buildings can be effective when a period of structure is in the range of 2 to 2.5 sec. Furthermore, the obtained results indicate that when the period of base-isolated building is longer than 3 to 4 sec, mean displacement demand on the superstructure under the near field ground motions can be increased significantly, although superstructure force can be decreased [7]. To overcome this problem, it is suggested to increase the stiffness of the high-rise building by utilizing lateral load-bearing systems such as shear walls [8].

In the present study, the seismic response of fixed-base and lead-rubber bearing isolated dual-system reinforced concrete (RC) buildings has been compared. To this end, 10, 15, and 20-story RC buildings, in a similar and regular plan, with special moment frame and shear wall dual systems have been selected as a case study. A 20-story building has been considered as a tall building in this study. One of the main goals of this study is to evaluate the 2800 V4 standard [9] and ASCE/SEI7-16 code [10] provisions to examine the seismic response of the base-isolated RC buildings under the near field earthquake-induced ground motions.

2- Methodology

In this study, 10, 15, and 20-story RC buildings, in a similar and regular plan, with special moment frame and shear wall dual systems have been selected as a case study. The considered buildings have five bays with 5 m width on each side of the plan and the height of stories is 3 m. In this study, lead rubber bearing (LRB) is used to isolate the buildings.

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Analysis and design of buildings were conducted according to ACI318-14 [11] utilizing ETABS software. For the nonlinear modeling of beams and columns, the concentrated fiber plastic hinge model is used, in which Concrete and Kinematic models are utilized to consider the hysteretic behavior of concrete and steel bar, respectively. The Rubber Isolator and Layered Shell models are used to model the LRB isolators and shear walls, respectively. To incorporate the geometric nonlinearities, the $P-\Delta$ effect is considered.

According to ASCE/SEI7-16 code specifications, 11 near-field record was selected from PEER database. Focal distance $R \leq 15$ km, moment magnitude $M \geq 6$, shear wave velocity $375 \leq V_{s30} \geq 750$ m/s, and strike slip fault are the main criteria used in the record selection. The selected records have a medium to high-frequency content (PGV/PGA) in the range of 5.40-16.67 Hz. Then, the selected records were scaled according to the 2800 V4 standard and ASCE/SEI7-16 code specifications. It must be noted that the design-based earthquake (DBE) spectrum and maximum credible earthquake (MCE) spectrum are considered as target spectrum for scaling based on 2800 V4 standard and ASCE/SEI7-16 code, respectively. Furthermore, according to ASCE/SEI7-16 code, the scaled records must be rotated in fault normal and fault parallel directions.

3- Results

To monitor the response of structures and compare the obtained results based on the 2800V4 standard and ASCE/SEI7-16 code, story drift, story acceleration and base shear quantities are used. Mean story drift and acceleration for fixed base and base isolated 20-story building according to the 2800V4 standard and ASCE/SEI7-16 code specifications have been shown in Figures 1 and 2, respectively. Results indicate that mean story drift and acceleration based on the ASCE/SEI7-16 is about 100% and 50% higher than the corresponding values based on the 2800V4 standard, respectively.

Figure 3 illustrates the maximum base shear of fixed base and base isolated 10, 15, and 20-story buildings according to the 2800V4 standard and ASCE/SEI7-16 code specifications. Results indicate that the mean base shear of base-isolated buildings shows a 40% and 60% decrease based on the 2800V4 standard and ASCE/SEI7-16 code, respectively.

4- Conclusions

In the present work, seismic response of fixed-base and lead-rubber bearing isolated 10, 15, and 20-story dual system RC buildings has been investigated using nonlinear time history analysis procedure according to the 2800V4 standard and ASCE/SEI7-16 code provisions. The obtained results indicate that base-isolated buildings with respect to fixe-based buildings, based on the ASCE/SEI7-16 code compared with the 2800V4 standard, maximum drift in the structures has a 23% more decrease and mean acceleration and base shear have an 11% more decrease. The selected target spectrum, the utilized scaling procedure, and also the direction of applied records are the main sources of difference between the obtained results based on the 2800V4 standard and ASCE/SEI7-16 code. The results of this study can be the basis for the development of the 2800 standard provisions to investigate the seismic response of base-isolated RC buildings at a near-fault site.

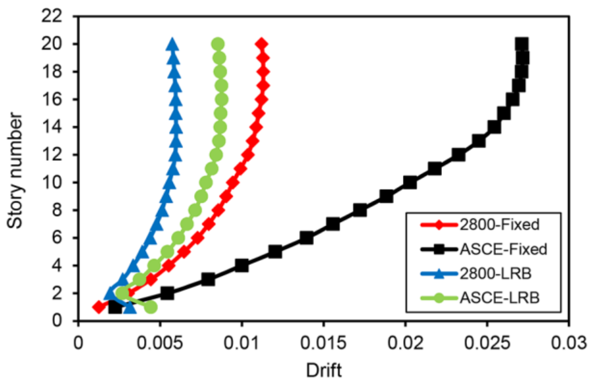

Fig. 1. Mean story drift for the fix-based and base-isolated 20-story building based on 2800V4 and ASCE/SEI7-16

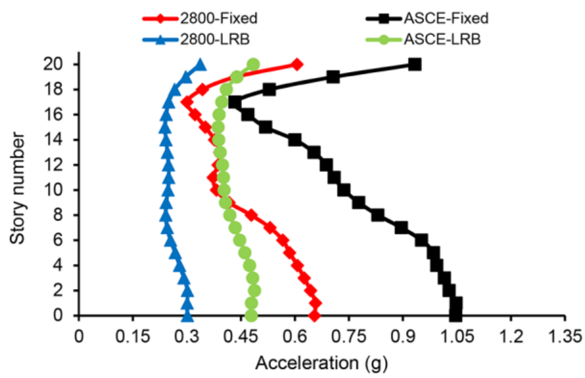

Fig. 2. Mean story acceleration for the fix-based and base-isolated 20-story building based on 2800V4 and ASCE/SEI7-16m

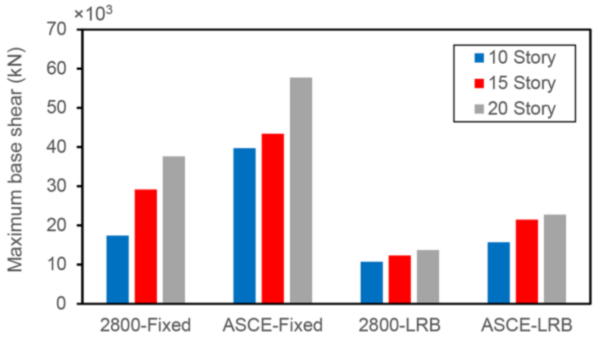

Fig. 3. Maximum base shear for fix-based and base-isolated 10, 15 and 20-story building based on 2800V4 and ASCE/SEI7-16

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