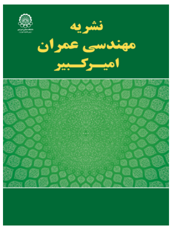

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Providing Seismic Design Considerations of Low-Rise High Ductility Reinforced Concrete Frames Using Nonlinear Analysis

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ABSTRACT: Traditionally, the seismic design of buildings has been based on strength criteria. In design using elastic codes, the damage was very high because the elastic method of seismic design has failed to provide insight into how the building behaves during earthquakes. The main approach of this research is to show that with proper distribution of shear strength of components, stories و and the whole building, using nonlinear analysis, it is possible to provide a situation that minimizes the building damages in strong earthquakes. Moreover, it is shown that selecting the type of analysis will play an important role in determining the optimal strength distribution. To achieve such a pattern, a frame with a special moment frame system was used as the main model, which was initially designed by linear static analysis, then the optimal strength distribution pattern of the frame was estimated with proper accuracy by repetitive nonlinear dynamic analysis on the building and the structure sections were determined. Then, the buildings, which were designed according to the estimated strength distribution and the code proposed distribution, were evaluated and compared using nonlinear time history analysis under a set of 22 near-fault and far-fault motions. Finally, the best analysis type in the seismic design of high ductility concrete buildings in near-fault and far-fault regions was select.

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1- Introduction

While buildings are usually designed for seismic resistance using elastic analysis, most will experience significant inelastic deformations under large earthquakes. Modern performance-based design (PBD) methods require ways to determine the realistic behavior of structures under such conditions. Enabled by advancements in computing technologies and available test data, the nonlinear analysis provides the means for calculating structural response beyond the elastic range, including strength and stiffness deterioration associated with inelastic material behavior and large displacements. As such, nonlinear analysis can play an important role in the design of new and existing buildings [1-3]. Researchers continue to look for methods that, in addition to time and cost-effectiveness and accuracy of solutions, can provide the main earthquake parameters. One method for solving this problem is to use nonlinear analysis in the seismic design of buildings.

2- Methodology

In the present study, a new methodology has been presented to provide seismic design considerations of low-rise reinforced concrete (RC) special moment frame. One of the innovations of this research is the use of a new methodology to select basic building characteristics using nonlinear dynamic analysis. For this purpose, a regular multistory RC frame building was designed using both the proposed and conventional methods. The two methods were assessed using dynamic analysis.

The first building was designed with linear static analysis (LSA). The second building was designed with nonlinear dynamic analysis (NDA). The dimensions of the structural components designed with LSA by the Iranian Seismic Code (IS 2800-14) [4] and NDA by chapter 16 of FEMA P-1050-1[5] are reported in "Table 1" and "Table 2".

Table 1 Design results of LSA

Building	Story	Beam		Column			
						Reinforcement	
		b (cm)	*h (cm)*	*b (cm)*	*h (cm)*	Number of bars	Bar size
	1	40	40	45	45	16	16
LSAB	2	40	40	45	45	16	16
	3	35	35	40	40	8	16
	4	35	35	40	40	8	16

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Table 2 Design results of NDA

Building	Story	Beam		Column			
						Reinforcement	
		b (cm)	h (cm)	b (cm)	h (cm)	Number of bars	Bar size
NDAB	1	40	40	50	50	8	20
	2	40	40	50	50	8	20
	3	35	35	45	45	8	18
	4	35	35	45	45	8	18

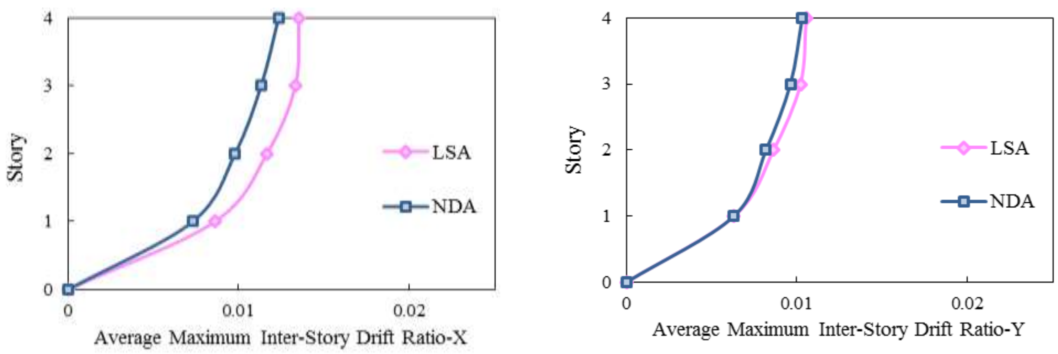
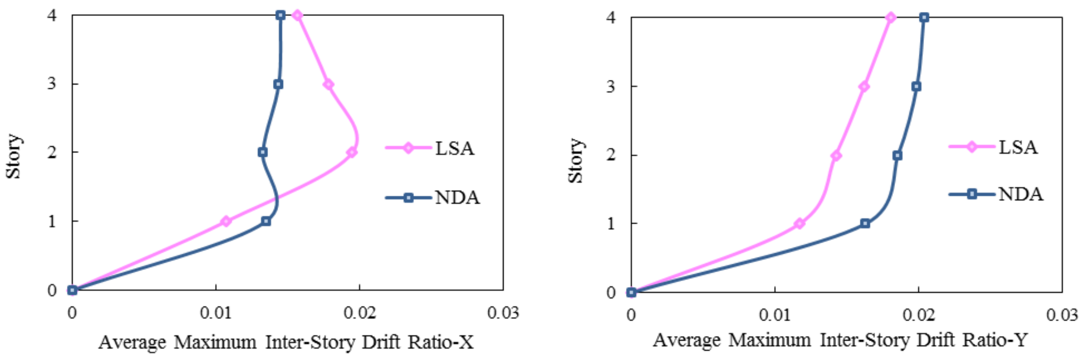


Fig. 1. Average maximum inter-story drift ratios of NDA under far-fault ground motions (a) X direction; (b) Y direction



(a) (b)

Fig. 2. Average maximum inter-story drift ratios of NDA under near-fault ground motions (a) X direction; (b) Y direction

3- Results and Discussion

Fig. 1 shows the average maximum inter-story drift ratios for the LSA building and NDA building under the eleven far-fault records in both the X and Y directions. It was observed that the average maximum inter-story drift ratios in the NDA building on almost all stories in the X and Y directions were lower than for the LSA building.

Fig. 2 shows the average maximum inter-story drift ratios for the LSA building and NDA building under the eleven near-fault records in both the X and Y directions. In the X-direction, the first story of the LSA building, and the second, third and fourth stories of the NDA building recorded the smallest average maximum inter-story drift ratios. In the Y direction, all stories of the LSA building had the lowest average maximum inter-story drift ratios compared to the NDA building.

4- Conclusions

- In regions under far-fault ground motions, the maximum inter-story drift ratios in the NDA building compared to the LSA building in the X direction decreased an average of 13% and, in the Y direction, decreased an average of 4%.
- In regions under near-fault ground motions, the average maximum inter-story drift ratios in the NDA building compared to the LSA building in the X-direction on the first story increased an average of 26% and on the second, third, and fourth stories decreased an average of 20%. In the Y direction, the values for all stories increased an average of 25%.
- The nonlinear dynamic procedure was the most suitable approach for the seismic design of RC buildings with special flexural frames in regions under far-fault ground motions.

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