Seismic Performance Evaluation of RC Building through Static Non Linear Pushover Analysis and Comparison by Changing the Size of Rectangular Column

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Abstract— While studying the performance based seismic design the prediction of inelastic seismic responses and the evaluation of seismic performance of a building structure are very important subjects. The seismic performances of reinforced concrete buildings are evaluated by nonlinear static pushover analysis in this research. A finite element model that can accurately simulate nonlinear behaviour of building is formulated by considering several important effects. Both global response such as system ductility demand and local response such as inter-story drift are investigated in this research. A numerical example is performed on a 9-story reinforced concrete building has been simulated. The performances have also been compared by changing the different sizes of the rectangular columns. Finally, the global and local responses obtained from the modal pushover analysis are compared with those obtained from the nonlinear dynamic analysis of MDOF system.

Key words: Seismic Evaluation, Pushover Analysis, Reinforced-Concrete Buildings

I. Introduction

The earthquake resistant design of structures requires that structures should sustain, safely, any ground motions of an intensity that might occur during their construction or in their normal use. However ground motions are unique in the effects they have on structural responses. The most accurate analysis procedure for structures subjected to strong ground motions is the Push over analysis. Pushover analysis is based on the assumption that structures oscillate predominantly in the first mode or in the lower modes of vibration during a seismic event.

Presently, there are two methods for investigating inelastic seismic performance. One is the nonlinear time history analysis and another is nonlinear static analysis called "pushover analysis". The nonlinear time history analysis can be divided into two methods. One is based on the dynamic response of an equivalent single degree of freedom system derived from a multi degree of freedom (MDOF) system [1]. The other is based on the equivalent response directly obtained from the nonlinear dynamic response of a MDOF system [2]. The static pushover analysis can also be divided into two methods. One is based on the first-mode pushover analysis [3-4]. The other is based on the modal pushover analysis (MPA) where higher mode effects are taken into account [5-6]. In this study, the seismic performances of 9-story reinforced-concrete building are evaluated and compared by the nonlinear static pushover analysis and nonlinear dynamic analysis.

A. Modal Pushover Procedure:

The equation of motion for a symmetric-plan multi-storey building subjected to earthquake ground motion acceleration üg (t) are the same as those for external forces, known as the effective earthquake forces [7].

$$P_{eff}(t) = -mi\ddot{u}_g(t) \quad (1)$$

Where, m is the mass matrix and i is a vector with all elements equal to unity. Defined by s = mi, the spatial (height-wise) distribution of forces can be expanded into its modal components Sn.

$$S = \sum_{n=1}^{N} S_n$$

$$S_n = \Gamma_n m \phi_n \quad (2)$$

Where ϕ_n is the nth mode and $\Gamma_n = \phi_n^T mi / \phi_m^T m \phi_n$

In the MPA procedure, the peak response of the building to P_(e ff,n) (t)= 〖-s〗_n ü_g (t), the nth mode component of effective forces, is determined by a nonlinear static or pushover analysis. The peak demands due to these modal components of forces are then combined by an appropriate modal combination rule. The steps are summarized as a series used to estimate the peak inelastic response of higher modes of vibration [6].

II. Problem Formulation

S.No	Content	Description
1	Type Of Structure	Multi Story High Raised Frame (Moment Resisting Frame)
2	Seismic Zone	5
3	Zone Factor	0.36
4	Number Of Storey	G+9
5	Floor Height	3.00m
6	Base Floor Height	3.3m
7	Wall Thickness	External-230mm Internal- 115mm
8	Materials	Concrete (M25for Beams) And (M30for Columns) Reinforcement Fe500
9	Size Of Column(Rectangular)	
	Set 1	450*600mm
	Set 2	500*600mm
	Set 3	550*600mm
10	Size Of The Beam In All Floors And Roof	450*600
11	Depth Of Slab	125mm
12	Specific Weight Of Rcc	25kn/M3
13	Type Of Soil	Medium

Table 1: Preliminary assumed data for G+9 RCC framed building

III. OBJECTIVES

In this study the seismic behavior of a frame building has been analyzed by using push over analysis. The seismic performance evaluation of the building has been carried out by changing the sizes of the columns Static type of pushover analysis is to be used in this research work where the loads consist of permanent gravity loads and incremental horizontal forces at each storey level. Capacity curves (base shear versus story total drift) obtained from static pushover analysis using commercially available software called Etabs 2015 are used for the calculation of some seismic demand parameters.

The dimensions of the buildings have been kept constant and only the column sizes have been changed. Three different combinations of the rectangular column dimensions are taken and the non linear response of each is evaluated by using the pushover analysis. The buildings are designed for the gravity and seismic loadings as per IS 456: 2000 and IS 1893: 2002.

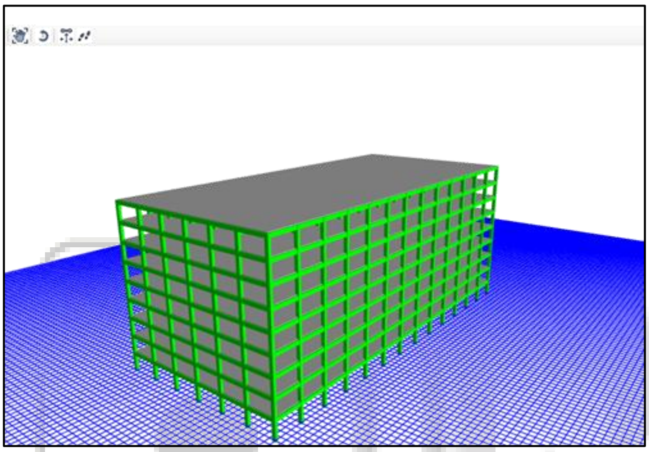

Fig. 1: 3D figure of the building frame to be analyzed using different combinations of columns.

IV. RESULTS

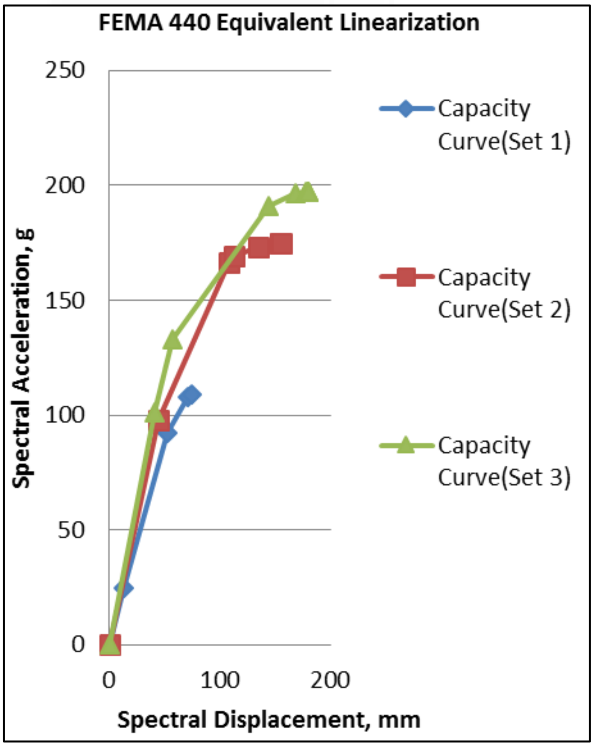

Fig. 2: Capacity Curves for the three cases of buildings

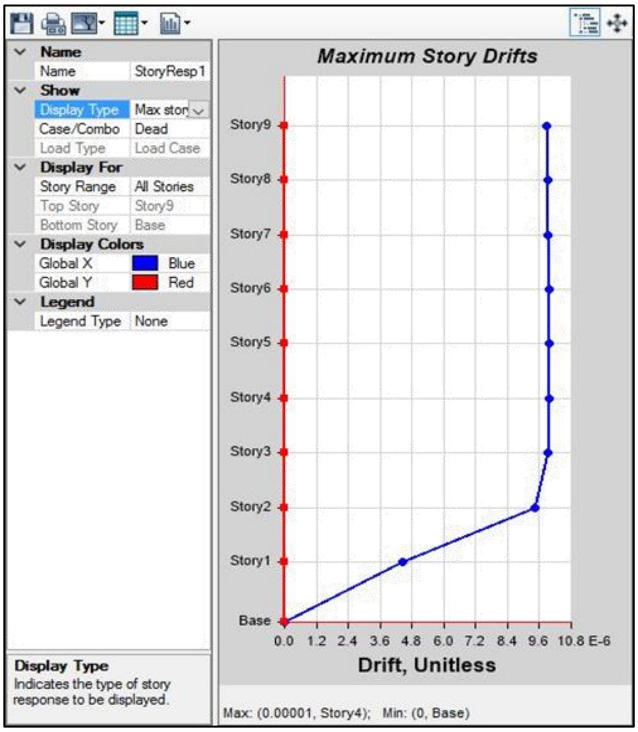

Fig. 3: Maximum story drift for the first case of building.

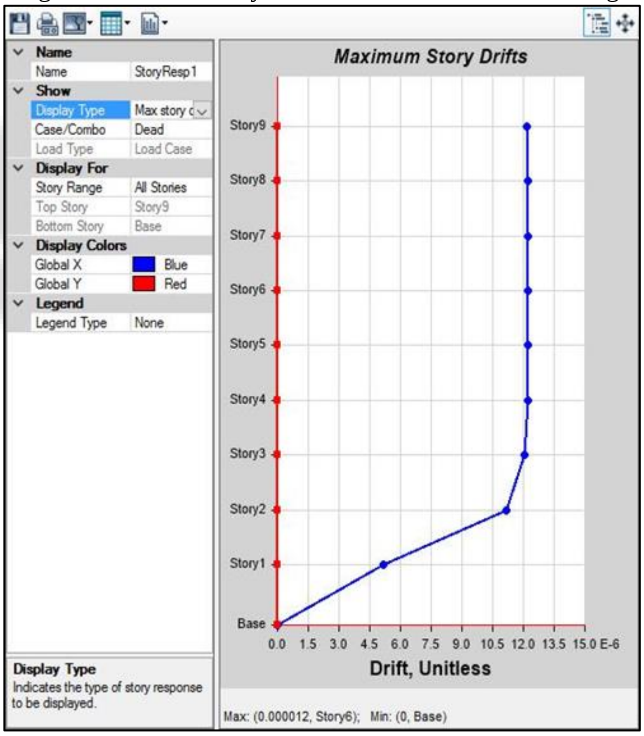

Fig. 4: Maximum story drift for the second case of building.

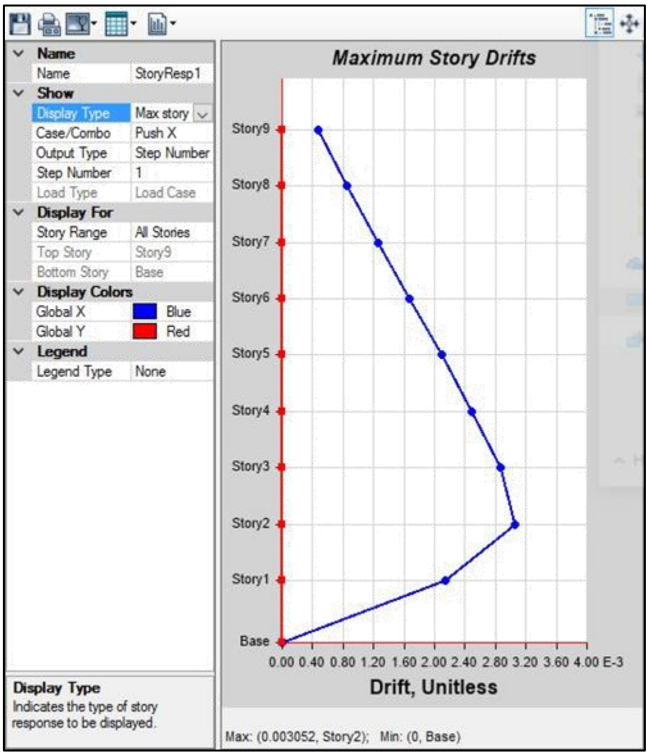

Fig. 5: Maximum story drift for the third case of building.

V. CONCLUSION

In this study the seismic behavior of a frame building has been analyzed by using push over analysis. The seismic performance evaluation of the building has been carried out by changing the sizes of the columns Static type of pushover analysis is to be used in this research work where the loads consist of permanent gravity loads and incremental horizontal forces at each storey level. Capacity curves (base shear versus story total drift) obtained from static pushover analysis using commercially available software called Etabs 2015 are used for the calculation of some seismic demand parameters.

By observing the story drift pattern it can be seen that the lease drift can be observer from the third case i.e the second story shows a maximum drift of 3 whereas the other cases show a minimum story drift of 9.7 and 12.

Also, the capacity spectrum of the third case shows a better capacity spectrum than the other two. Thus, it can be concluded that case three shows better seismic performance than the other two.

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