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NUMERICAL STUDY ON 2D REINFORCED CONCRETE FRAMES WITH NONDUCTILE COLUMNS USING IDA APPROACH

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In recent decades, reliable seismic design of reinforced concrete (RC) structures has been of interest in both practical engineering calculations and research studies. That requires adequate information regarding the ultimate capacities of structural components to withstand the demands (i.e., columns, beams, joints, etc.). Several experimental and numerical studies have been carried out to predict the maximum lateral ductility and strength of RC columns with non-seismic detailing due to the crucial role of this type of primary structural element during earthquakes. Those resulted in developing some criteria as well as numerical models (Elwood and Moehle, 2005; Azadi and Allahvirdizadeh, 2019). The latter can be utilized in numerical simulations of RC structures either based on 1D structural elements or 3D continuum elements (Azadi and KhanMohammadi, 2018; Azadi et al., 2018). This work employs the former sort of elements for developing the numerical models since it is computationally much cheaper than another approach. The numerical models consist of nine 2D ten-story three-bay RC frames, which consider the impacts of various values for transverse reinforcement ratio (3 cases) and initial axial load ratio (3 cases) on the nonlinear seismic response of existing columns and consequently the global behavior of frames. In this regard, the columns and beams are modeled utilizing nonlinear beam-column elements. Moreover, zero-length elements defined by the uniaxial limit state material proposed by Elwood and Moehle (2005), which enhanced and extended to time history analysis by Azadi (2007), are located at the top of columns to predict the occurrence of shear and axial failure in columns. The performance of the modeling approach to capture the nonlinear behavior of such structures is already demonstrated in (Farahmand et al., 2015). The geometry details, mechanical properties of concrete and reinforcing steel, and the initial axial load ratios used for developing the numerical models are presented in Table 1. The height of columns and length of beams are 320 and 500 cm, respectively.

Table 1. Geometry details of the frames and mechanical properties of materials.

Story No.	Element Type	b (cm)	h (cm)	d (cm)	s (cm)	ρ_l (%)	P/Ag.f'c	fy (MPa)	f'c (MPa)
1 to 3	Beam	50	55	50	N/A	2.06	N/A		
	Column	55	55	50	15-25	2.13	0.12-0.25		
4 to 6	Beam	45	50	45	N/A	2.19	N/A	300	20
	Column	50	50	45	15-25	2.26	0.12-0.25		
7 to 10	Beam	40	45	40	N/A	2.01	N/A		
	Column	45	45	40	15-25	2.43	0.12-0.25		

In Table 1, *b*, *h* and *d* are the width, height and the effective height of the column section, respectively, and *s* is the spacing of stirrups, ρ_l is the longitudinal reinforcement ratio, *P/Ag.f'c* is the initial axial load ratio, *fy* is the yield stress of both transverse and longitudinal rebars and *f'c* is the compressive strength of concrete. The seismic collapse capacity of the RC frame was achieved by performing Incremental Dynamic Analyses (IDAs) using developed algorithm according to (Kazemi et al., 2018a; 2019). For this purpose, the gravity load including dead load plus 20% of the live load is uniformly distributed over the beams. Figure 1 illustrates the results of the IDAs, conducted through 48 pulse-like records according to (Kazemi et al., 2018b). The median as well as 16% and 84% percentile of 48 IDAs curves are denoted as dashed-red and solid-blue lines, respectively. It can be followed that the median collapse capacity of the 10-story model characterized by the spacing of stirrups equals to 15 cm and the initial axial load ratio of 0.12 is 0.61 g. The collapse capacity for the 16% and 84% percentile of the IDAs curves is observed as 0.43 g and 0.86 g, respectively. Meanwhile, the results showed that the stirrups spacing and initial axial load ratio significantly influence the amount of the median collapse capacity, and the optimal values are recommended for design purpose.

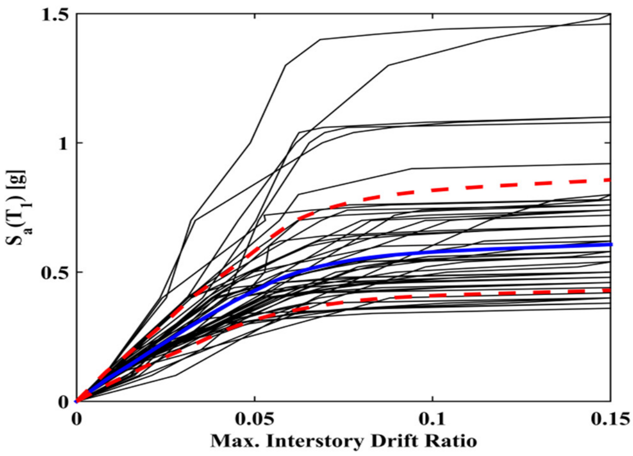

Figure 1. IDA curves for the 10-story model with S =15cm and P/Ag.f'c = 0.12 with the median, 16% and 84% percentile of the 48 IDAs curves denoted by solid-blue and dashed-red curves.

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