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EFFECT OF MULTIPLE LOW INTENSITY EARTHQUAKES IN LOW-RISE REINFORCED CONCRETE BUILDINGS

Ali NASIRI
M.Sc. Graduate, Science and Research Branch of IAU, Tehran, Iran
ali.nasiri@srbiau.ac.ir

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The basic approach for seismic design of structures utilizes a single loading scenario and a single performance criterion; usually life-safety (DiSarno, 2013); while structures, built in seismic areas, are often affected by earthquakes with various frequency and magnitude during their lifetime. Current seismic codes specify design earthquake loads as single events and assume that all of the structures in earthquake prone regions are able to withstand frequent low intensity earthquakes that is likely to occur at their location; however, the structure may experience multiple ground accelerations including small multiple earthquakes in their lifetime. Despite the fact that low intensity earthquakes do not cause remarkable damage to the structures singly, high occurrence probability and inducing accumulated damage to the structures during their lifetime, make this types of earthquakes important. The present study investigated the nonlinear behaviour of moment resisting reinforced concrete structures under real multiple low intensity earthquakes and their effects on structure's performance level. For this purpose, a regular three-bay 4-story moment resisting RC building, having standard occupancy with different types of concrete and steel Material were modeled, considering non-degrading and degrading features of both concrete and steel reinforcements. The above building was first used in research by Tran-Gilmour (2004). In order to examine the effect of multiple low intensity earthquakes on the performance of RC structures, we employed some kind of concrete and steel reinforcement models, used in OpenSees program, to consider which concrete and steel reinforcement models can represent more realistic performance of structure. The models used in this study are shown in Table 1.

Records were selected from Fin1 station, near Bandar Abbas, Iran. This data includes earthquakes with low magnitudes (range of 3 to 5 degrees on the Richter scale) recorded since the establishment of the station in 1994 which are collected from Iran Strong Motion Network (ISMN). In order to examine the effect of the cumulative damage from low intensity earthquakes, multiple earthquakes with different number of sequences (20, 40 and 60 records) were considered. The inelastic behavior of the examined RC framed structures, which are subjected to the above-mentioned seismic sequences, is investigated. Also, by using the obtained data and comparing with the drift values given in ASCE 41-06, values that provided to illustrate the overall structural response associated with various structural performance levels.

Table 1. Models description.

Frame No.	Steel Material	Concrete Material
1	Reinforcing Steel	Concrete 01
2	Steel 01	Concrete 01
3	Reinforcing Steel	Concrete 02

Table 2. The limit states defined in this study based on the value of drift.

Element	Type	Structural Performance Levels		
		Collapse Prevention	Life Safety	Immediate Occupancy
Concrete frames	Drift	4% transient or permanent	2% transient 1% permanent	1% transient Negligible permanent

Based on the analysis results, it is shown that multiple low intensity earthquakes effects have no significant impact on the behavior of reinforced concrete structures in a lower number of sequences, but have a considerable effect in higher number of earthquakes.

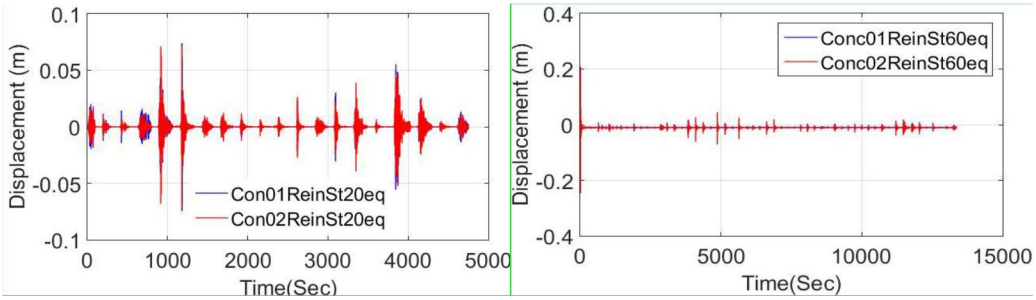

Figure 1. Roof Displacement in multiple 20 and 60 earthquakes scenario.

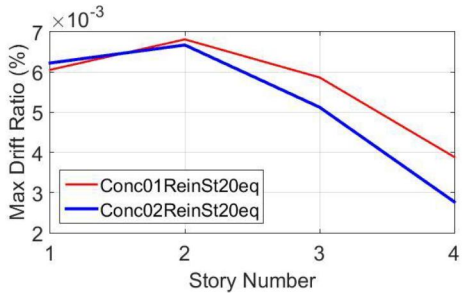

Figure 2. Maximum Drift Ratio of 4 story structures in multiple 20 earthquakes.

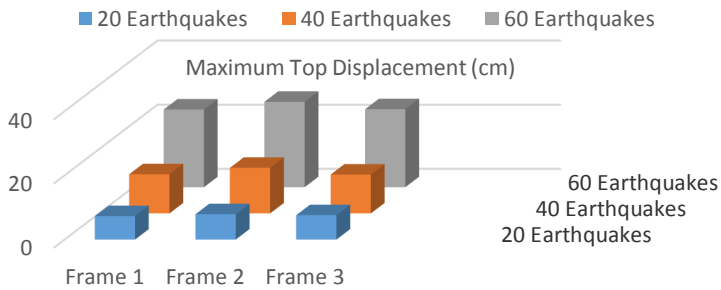

Figure 3. Maximum top displacement, comparing all frames with all earthquake cases.

Also, this research confirms that the degrading response is not accurately captured in simple models. Finally, it is recommended that future research should focus on providing detailed guidelines for assessing of the existing structures, especially the old ones, located in earthquake prone regions and affected from low intensity Earthquakes.

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