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Influence of earthquake record truncation on fragility curves of RC frames with different damage indices

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ABSTRACT

Probabilistic seismic analysis of structures with incremental dynamic analysis (IDA) is a widely used method to offer comprehensive evaluation of the seismic performance of structures. Although IDA is a powerful computer-intensive method, it is really a time-consuming procedure. Accordingly, in this study, for coping with this problem, significant motion duration is used instead of total motion duration. This truncation can significantly reduce the computational effort and time. In order to determine the influence of truncation, fragility curves and their mean annual frequencies (MAF) in each limit state are used with two different damage indices, namely modified Park & Ang and maximum inter-story drift, for different RC frames. Although truncation can produce larger errors in fragility curves of high-rise structures and different structures with energy-based or combination indices because of their greater dependence on record duration, this study has shown that it causes negligible errors in fragility curves of mid-rise structures with deformation-based indices.

1. Introduction

Engineers have been seeking more accurate modeling and investigating of structures under earthquake excitations, and modeling software is constantly developing. Thereby, nowadays, nonlinear modeling and analysis of structures are not really difficult. Incremental dynamic analysis is one of the most powerful analyses, which is used for investigating seismic performance of structures. Although this is a widely applicable method and it can present a lot of precise information about structures, it is really time-consuming, and state-of-the-art computers are needed for investigation of massive structures. All researchers have been seeking efficient methods and software by which they can increase the speed of analyses; thereby, they can obtain more precise outputs during less spending of time.

IDA has been used by several researchers for different studies. For example, Mander et al. [1] used it for seismic risk assessment of bridges; Pinho et al. [2] used it to evaluate the accuracy of static pushover methods on twelve bridges, and Goulet et al. [3] relied on IDA to estimate seismic losses for a reinforced concrete frame structure.

Inasmuch as IDA is a widely used method for assessing structural performance in recent decades, many researchers have been trying to improve the performance of IDA, and they have presented efficient methods, such as IM selection [4] progressive IDA for first-mode dominated structures [5], use of a trilinear idealization model of IDA for RC structures [6], and implementation of IDA in parallel [7]. As mentioned above, although IDA is really a widely applicable method, it is time-consuming; hence, in this study, strong motion duration is used instead of total motion duration.

Although the effect of ground motion duration on liquefaction and slope stability is recognized, its influence on structural response and fragility curves is a debatable topic. Some researchers, such as Ruiz-Garcia [8], Iervolino [9], Raghunandan and Liel [10], have studied on the influence of motion duration, and they indicated that the longer duration record proves more damage to the structure than shorter duration record because the longer duration ground motion imposes high energy demands on the structure. In this regard, most of them considered two different ground motions, whereas in this research one set of ground motion with different motion duration is considered.

2. Model and ground motion record selection

Three different types of intermediate moment RC frame systems, which have 5, 10, 20 stories (Fig. 1) were modeled for considering whether maximum response of structure occurs in strong motion duration or not. These frames are assumed to be located in

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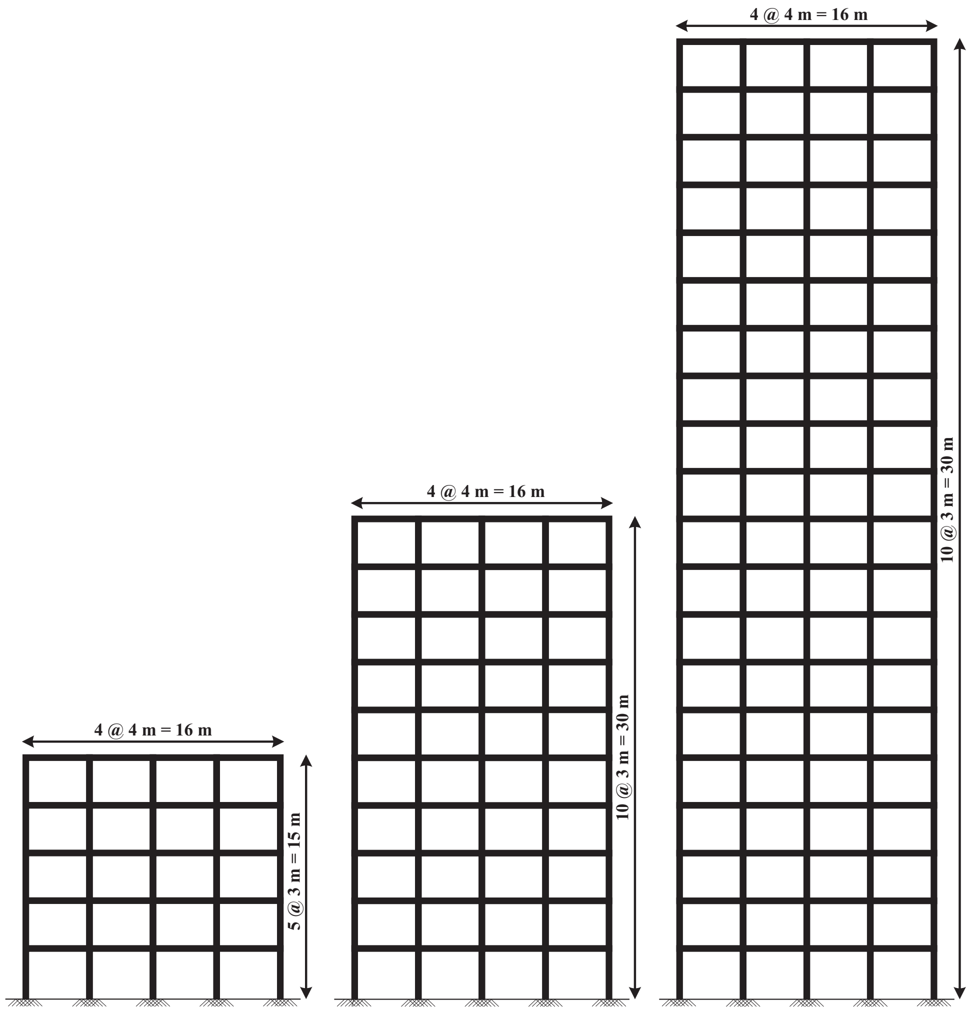

Fig. 1. View of studied frames.

Table 1
The suite of twenty ground motion records used.

Earthquake name	Station name	Magnitude (Ms)	Component (deg.)	PGA (cm/s^2)
Imperial Valley, 1979	El Centro, Parachute Test Facility	6.8	315	200.2
San Fernando, 1971	Pasadena, CIT Athenaeum	6.5	90	107.9
San Fernando, 1972	Pearblossom Pump	6.5	21	133.4
Landers, 1992	Yermo, Fire Station	7.5	0	167.8
Loma Prieta, 1989	APEEL 7, Pulgas	7.1	0	153
Loma Prieta, 1990	Gilroy #6, San YsidroMicrowavw Site	7.1	90	166.9
Loma Prieta, 1990	Saratoga, Aloha Ave	7.1	0	494.5
Loma Prieta, 1990	Gilroy, Gavilon College PhysSchBldg	7.1	67	349.1
Loma Prieta, 1990	Santa Cruz, University of California	7.1	360	433.1
Loma Prieta, 1990	San Francisco, Dimond Heights	7.1	90	110.8
Loma Prieta, 1990	Fremont, Mission San Jose	7.1	0	121.6
Loma Prieta, 1990	Monterey, City Hall	7.1	0	71.6
Loma Prieta, 1990	Yerba Buena Island	7.1	90	66.7
Loma Prieta, 1990	Anderson Dam, Downstream	7.1	270	239.4
Morgan Hill, 1984	Gilroy, Gavilon College PhysSciBldge	6.1	67	95
Morgan Hill, 1984	Gilroy #6, San YsidroMicrowavw Site	6.1	90	280.4
Palmsprings, 1986	Fun Valley	6	45	129
Northridge, 1994	Littlerock, Brainard Canyon	6.8	90	70.6
Northridge, 1994	Castaic, Old Ridge Route	6.8	360	504.2
Northridge, 1994	Lake Hughes #1, Fire station #78	6.8	0	84.9

the seismicity zone II of the 4 zones system specified by Iranian standard 2800 [11] and are therefore designed respectively for seismic base shears of 12%, 8.5%, 6% of their seismic weights. The first periods of 5, 10 and 20 story frames are 0.48, 0.96 and 1.56 s respectively.

The analyses of the buildings are conducted using the finite element software SeismoStruct [12], which is capable of calculating the large displacement behavior of space frames under static or dynamic loading, taking into account both geometric nonlinearities and material inelasticity. The spread of material