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SEISMIC ASSESSMENT OF BASE-ISOLATED BUILDINGS UNDER THE EFFECT OF NEAR-FAULT EARTHQUAKES

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Base isolation is a *seismic* energy dissipating technique that reduces the seismic responses of a structure e.g. floor accelerations and story drifts (Hoseini Vaez et al., 2012). This might be an economical practical method to decrease non-structural damages under earthquakes (Mayes and Naeim, 2001). In addition, because of short distance between the fracture (source of wave) and reception place in near-field earthquakes, higher frequencies are not damped. So, the time history of their accelerations has a higher frequency content.

The effects of the fling-step and forward directivity (see Figure 1) are recognised as the main characteristics of near-field earthquakes (Kalkan and Kunnath, 2006). The base isolation is able to reduce the response of a structure and minimize damages to the structure by creating a discerepancy between the natural frequency of a structure and the main frequency of an earthquake. A strong near-field ground motion, which is distinguished by a large amplitude and long period pulse, tends to make a large displacement in the isolator. To prevent such a large displacement in the isolators, a greater size is needed that is more expensive that economical profits will be doubtful.

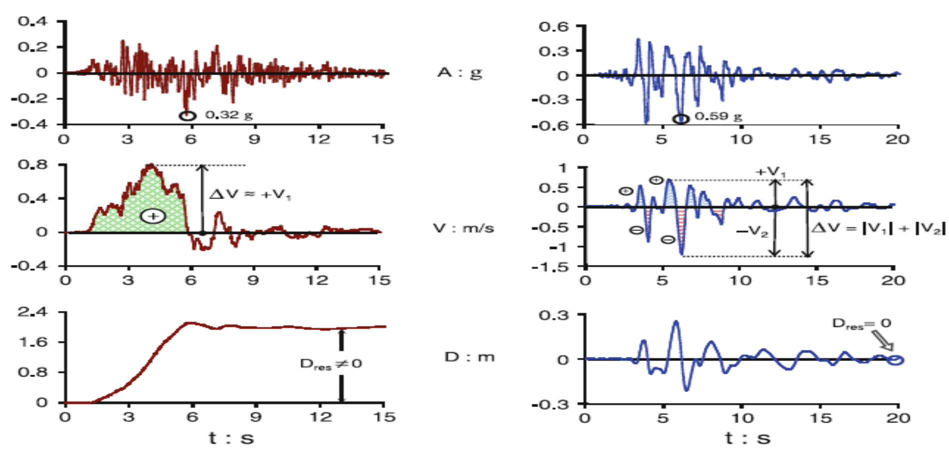

Figure 1. Schematic explanation of the 'fling-step' and 'forward-directivity' phenomena as reflected in two characteristic records: the fling affected Sakarya motion (*left*) and the directivity affected Jensen Filtration Plant record (*right*) (Garini and Gazetas, 2013)

Because of destructive effects of earthquakes on building structures located in the near-field area, this investigation attempts to study the seismic behavior of base-isolated building frames under the effect of near-field earthquakes using pushover analyses. For this purpose, two steel moment frame structures including low- and medium-rise (3 and 9-story) frames with 4 bays are isolated using lead-rubber base isolation system considering three levels of stiffness i.e. Hard (H), Normal (N) and Soft (S) isolators. The lead–rubber bearings (LRBs) are designed to cover a wide range of base isolator periods. Normal isolators are designed with trial and error method with an appropriate assumption for (K_1/K_2) and (Q), which K_1/K_2 and Q are the ratio of elastic stiffness to postyield stiffness and the characteristic strength, respectively. Table 1 shows the characteristics of normal base-isolation system. Hard and soft isolators are defined by significant increase and decrease in stiffness of the normal isolator without any change in the main characteristics of isolator (K_1/K_2 & Q). The effect of near-fault characteristics on the seismic behavior of different base-isolated structures are studied using pushover analyses. For this pupose, approximate pushover analyses with two different lateral load distributions are implemented for each set of ground motions described later. Also, to account for the effect of higher modes in the case of medium-rise isolated building, modal pushover analysis (MPA) is implemented. To evluate the accuracy of pushover analyses, nonlinear time history analyses (NLTHAs) are conducted using different sets of near-field ground motions with forward directivity, fling step and non-pulse characteristics. Furthermore, the NLTHAs are carried out using far-field ground motion records. Then, the results obtained by pushover analyses are correspondingly compared with those of nonlinear time history analyses.

Table 1. Characteristics of normal base-isolation

Fram	K_{eff} (kg/m)	β_{eff} (%)	T_{eff} (s)	K_1 (kg/m)	F_y (kg)	K_1/K_2	D_D (m)	D_y (m)	Q
3 St	127100	0.1701	1.3223	587866.5	5761	6.5	0.1323	0.0098	4850
9 St	89000	0.2314	2.4984	541690	8612	10	0.2225	0.0159	7750

The results show that story drifts of base-isolated structures subjected to near-field earthquakes with pulse are significantly greater than those from near-field earthquakes without pulse and far-field ones. However, story drifts decrease in base-isolated structures compared to the fixed-base structures, but the effect of near-field earthquakes on isolators displacement is not negligible. Also the results indicate that the seismic responses obtained by pushover analyses are accurate enogh in the case of base-isolated building frames with hard isolator but the results may deteriorate in the case of base-isolated building frames with soft and normal isolators.

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