SEISMIC COLLAPSE RISK ASSESSMENT OF A STEEL MRF CONSIDERING NEAR-FAULT DIRECTIVITY EFFECTS

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In the near-fault regions that forward-directivity effects are observed, ground motion records have high amplitude two-sided pulses at the beginning of their velocity time histories. A large velocity pulse can cause significant damages to buildings that lead to increase in the seismic collapse risk of buildings. Some research works have focused on seismic collapse assessment of structures under pulse-like near-fault ground motion records (e.g., Champion and Liel, 2012; Yakhchalian et al., 2014, 2019). This study evaluates the forward-directivity effects in near-fault region on the seismic collapse risk of a steel moment resisting frame (MRF). For this purpose, three sites located at 5, 10 and 15 km distances from the midpoint of the Imperial Valley fault line were considered, as shown in Figure 1. A 3-story steel MRF was designed according to ASCE/SEI 7-10 (ASCE, 2010) for the site with 10 km distance from the midpoint of the fault considered. Then, the structure was modeled in OpenSees (McKenna et al., 2015). Two ground motion record sets including 78 far-fault and 85 near-fault pulse-like records were used to perform incremental dynamic analyses (IDAs). In each IDA, a ground motion record is incrementally amplitude scaled until the occurrence of collapse. After performing IDAs, the IDA curves of the structure were obtained for the far- and near-fault ground motion record sets. The methodology proposed by Shahi and Baker (2011) was utilized to implement the effects of forward-directivity in conducting probabilistic seismic hazard analysis (PSHA) for the three sites considered. Seismic hazard curves obtained for the three sites are shown in Figure 2-a. Moreover, probabilities of pulse occurrence given different values of $Sa(T_1)$ for the three sites are indicated in Figure 2-b. By using this methodology, given each value of $Sa(T_1)$ the distribution of occurring different pulse periods is obtained. Typical pulse period distributions (i.e., given $Sa(T_1)=1.0g$) for the three sites are presented in Figure 2-c. In this study, to assess the seismic collapse risk of the 3-story MRF assuming each of the three sites considered, the methodology proposed by Champion and Liel (2012) was applied. According to this methodology, the collapse capacity of a structure under a near-fault record depends on the pulse period of the record. Figure 3 illustrates the collapse capacity moving average curve computed using the aforementioned

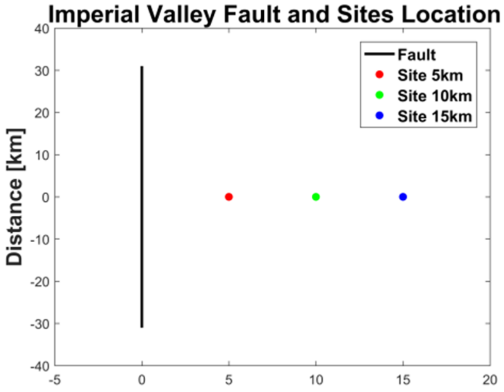

Figure 1. Near-fault sites considered in the vicinity of the Imperial Valley fault.

methodology for the 3-story MRF. It can be seen that the median collapse capacity of the structure is a function of pulse period. The green dashed-line in this figure represents the median collapse capacity of the 3-story MRF under the far-fault ground motion record set. The results of near-fault PSHA for each site were combined with the results presented in Figure 3, based on the aforementioned methodology, to obtain the collapse fragility curves of the 3-story MRF assuming the three sites of interest (see Figure 4). Table 1 presents the results of seismic collapse assessment for the 3-story MRF assuming the three sites considered for this structure. According to the results, the probabilities of collapse in 50 years assuming the sites with 5, 10 and 15 km distances from the midpoint of the fault are 3.52, 1.74 and 0.96%, respectively. It should be noted that the limit prescribed for the probability of collapse in 50 years in ASCE/SEI 7-10 is 1.0%.

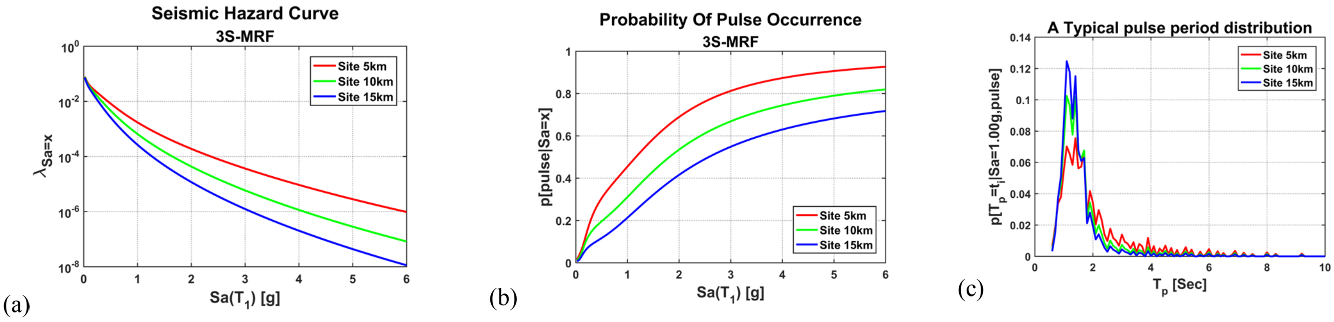

Figure 2. (a) seismic hazard curves for the three sites considered; and hazard disaggregation results including (b) probabilities of pulse occurrence given different values of $Sa(T_1=1.0\ s)$ and (c) typical pulse period distributions given $Sa(T_1) = 1.0g$ for the three sites.

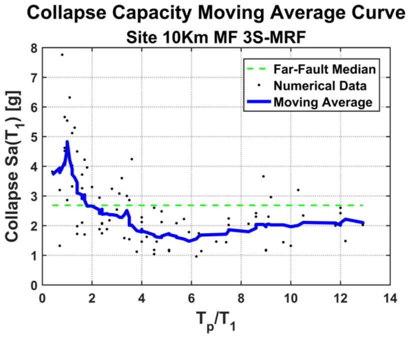

Figure 3. Collapse capacity moving average curve for the 3-story MRF.

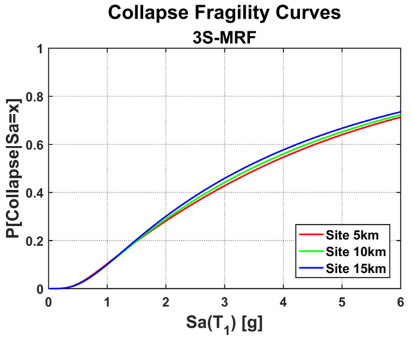

Figure 4. Collapse fragility curves for the 3-story MRF assuming the three sites considered.

Table 1. Results of seismic collapse assessment for the 3-story MRF assuming the three sites considered.

Site	Mean Annual Frequency of Collapse	P[Collapse in 50 years] (%)	P[Collapse|$Sa(T_1)= Sa_{MCE}(T_1)$] (%)
5 km	7.17E-04	3.52	21.62
10 km	3.51E-04	1.74	12.84
15 km	1.92E-04	0.96	0.97

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