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EVALUATION OF STRENGTH REDUCTION FACTOR FOR NEAR-FAULT AND FAR-FAULT GROUND MOTIONS

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To create an economic design, the design philosophy in seismic regulation codes allows buildings to be designed for seismic forces less than that which occurs at the site. Reduction in forces, which results in inelastic deformations, is achieved by a coefficient called the strength reduction factor. Therefore, it is important to study the parameters that influence this coefficient.

The strength reduction factor is described by the ratio of the elastic strength demand to the inelastic strength demand as follows:

$$R_\mu = \frac{f_y(\mu = 1)}{f_y(\mu = \mu_i)} = \frac{f_o}{f_y} = \frac{u_o}{u_y} \qquad (1)$$

in which f_y (μ = 1) is the lateral yielding strength required to maintain the system elastic under the effect of a specified ground motion and f_y (μ = μ_i) is the lateral yielding required to maintain the displacement ductility demand less than or equal to a predetermined target ductility ratio, under the same ground motion (Miranda, 1993).

The effect of near-field ground motion records with filing step effect and without pulse on the strength reduction factor, R_μ, has not been studied in the preceding investigations. Therefore, a comprehensive study was carried out to demonstrate the effect of four categories of seismic ground motion records on the strength reduction factor in this paper. The first category consists of 18 near-fault records with filing step effect and the other three groups, individually contain 20 ground motion records including the near-fault records with forward directivity effect, the near-fault records without pulse (NON-pulse records) and the far-fault ground motion records. All records, selected from the PEER database, correspond to site classes C and D based on the site classification of NEHRP 2003. The effect of the period of vibration, ductility level and of cyclic deterioration considered by the modified Ibarra-Medina-Krawinkler (the modified IMK) deterioration model on the strength reduction factor was studied.

To perform linear and nonlinear analyses, a single degree of freedom system model was considered as applied in other researches such as Norouzi & Poursha (2018) and Adam (2008). In this survey, in order to determine appropriate analytical time steps, a sensitivity analysis was used to examine the variation of R_μ with the period. Therefore, 1324 time steps were selected over the period range of 0.02 to 50 sec. Moreover, ductility demand ratios of 2, 4 and 6 were considered to evaluate the effect of ductility level on the strength reduction factor. Besides, the damping ratio was assumed to be 5%.

The results show that difference of the R_μ for the near-fault earthquakes without pulse is negligible in comparison to the for those far-fault ground motions for all ductility demand ratios. When ductility factor is 1.5, difference in the value of R_{μ} records that contain pulses is insignificant relative to far-fault ground motions. With the increase in ductility, over the period range of 0.2 to 4 sec, the strength reduction factor for pulse-like records decreases by up to 20% to 50% in comparison with both far-fault and non-pulse ground motion records. Generally, the results indicate that the existing equations for R_{μ}, based on far-fault ground motions, cannot be directly applied to pulse-type near-fault earthquake records, especially for those with filing step effect that makes the design unsafe.

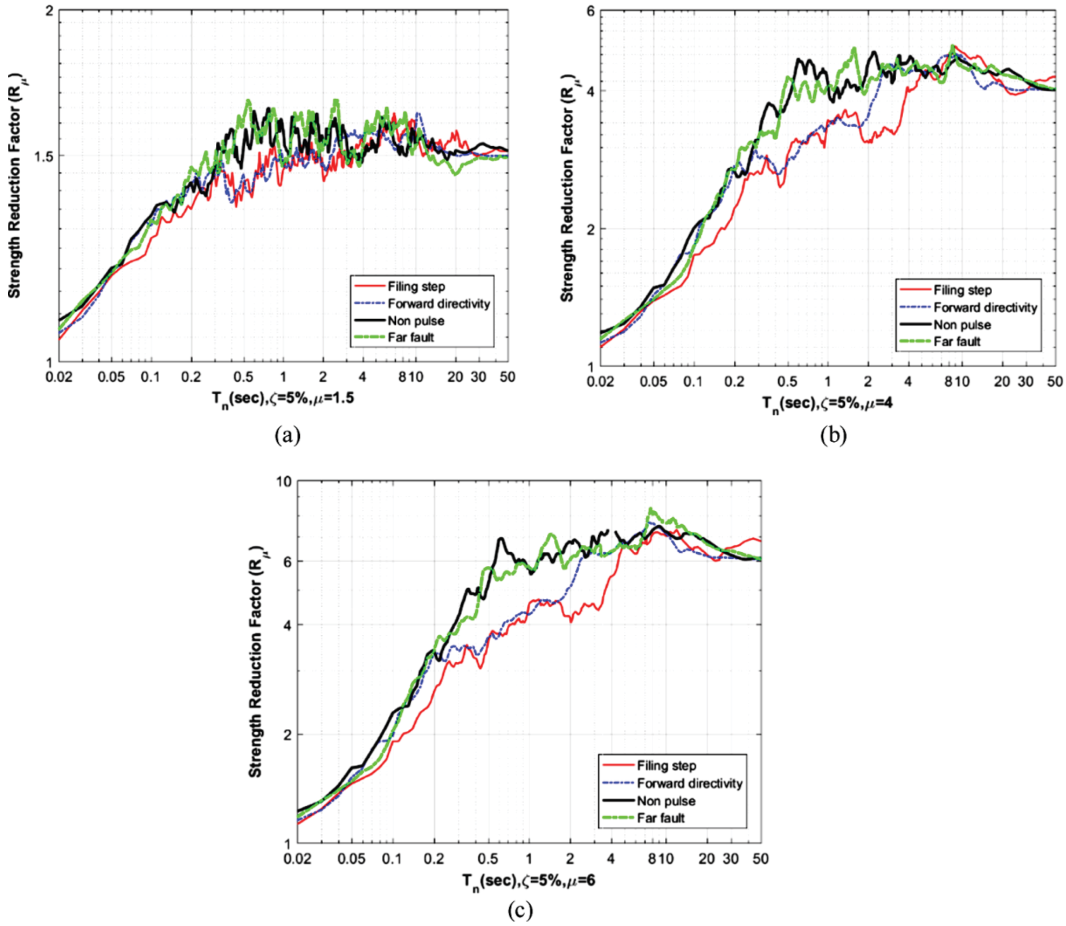

Figure 1. Strength reduction factor for SDOF systems under the effect of four categories of seismic records: a) μ = 1.5, b) μ = 4, c) μ = 6.

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