ESTIMATING THE DURATION EFFECTS IN STRUCTURAL RESPONSES BY A NEW ENERGY-CYCLE BASED PARAMETER

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While the duration of the earthquakes essentially plays an important role in the dynamic analysis of the structures in which degrading behaviors are expected to be encountered during the motion (Hancock and Bommer, 2007), the approaches taken to reflect its incorporation are somewhat inadequate compared to its immense influence on the structural response (Samanta and Pandey, 2018). In this study, a new approach is proposed to determine the number of nonlinear cycles as a duration measure. Moreover, a parameter based on both hysteretic energy and number of nonlinear cycles is likewise suggested to precisely reflect the shaking characteristics of the motion.

One approach for calculating the number of nonlinear cycles is to count cycles directly regardless of the associated hysteretic energy dissipated within these cycles. The main disadvantage of this method is that it ignores the influence of hysteretic energy of the cycles in the counting procedure. In order to improve the deficiencies of the aforementioned method, the hysteretic energy is adjusted and normalized by strength level, the maximum displacement under earthquake motion and yield displacement of the system as expressed in Equation 1.

$$N_{eq} = \frac{E_H}{F_y\left(x_{max} - x_y\right)} \tag{1}$$

A parameter, as expressed in Equation 2, is also proposed in this study to take account of the influence of strong-motion duration. It is generally believed that motion duration is a secondary parameter, and therefore, it is rather pointless to investigate its influence regardless of the intensity and the frequency content of the motions.

$$\beta = \frac{E_H}{F_y \delta_y N_{eq}^{\alpha}} \tag{2}$$

where Eh represents hysteretic energy, which is imposed on the structure through motions; N_{eq} is designated as the nonlinear number of cycles; F_y stands for the strength level; δ_y is the yield displacement, and α is assigned as a constant value which should be obtained to establish a strong correlation between motion duration and responses in the structures. Using a parametric study, an optimum value of α equal to 0.5 has found to the most appropriate value for this factor.

In this study, nonlinear time history analysis is employed to record factors that are related to the employed damage measures as well as the one pertinent to the proposed parameter, the β. Subsequently, the proposed method is applied to several considered RC MRFs in order to check the influence of motion duration on structural responses. For diminishing the influence of the intensity and the frequency content of motions on the results, the far-field acceleration spectra of FEMA P-695 are matched to a reference code spectrum using a wavelet procedure offered by Hancock et al. (2006).

To investigate the influence of each motion-duration parameter on structural damage measures, correlations between structural demands and duration measures (including β) are observed and compared. For a 6-story frame, the Park-Ang response measure is plotted against the motion durations obtained from bracketed duration definition with a threshold of 0.05 g and the parameter (β) proposed in this study as illustrated in Figures 1 and 2. Correlation of Park-Ang damage with the β parameter is more remarkable than the bracketed duration.

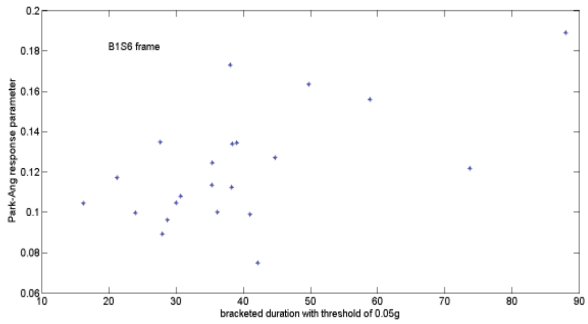

Figure 1. Variation of response parameter Park-Ang versus the bracketed duration with a threshold of 0.05 g for a 6-story frame.

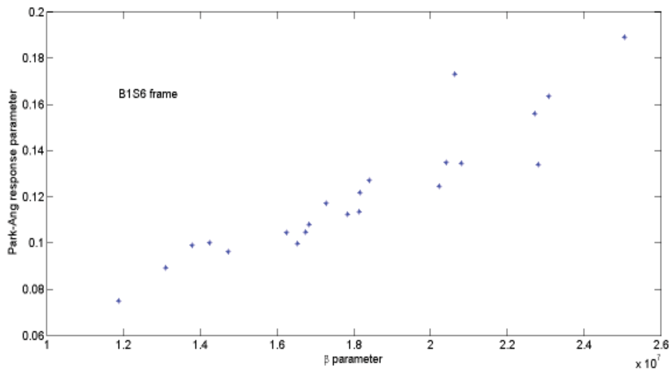

Figure 2. Variation of response parameter Park-Ang with the β as a duration measure for a 6-story frame.

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