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Application of ET method for estimation of inelastic deformation demands of steel frames

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Abstract

The accuracy of ET method in predicting the response of steel frames in nonlinear analysis is investigated by considering a simple set of MDOF steel frames. Elastic-Perfectly-Plastic material model has been assumed. Results computed with ET method are compared with the results of nonlinear response history analyses. It is shown that in most of the frames, estimations of ET analysis for maximum interstory drift ratio are less than nonlinear response history analysis results. The dispersion of the results of nonlinear response history analysis for the frames that experience more nonlinearity is high. The consistency of the base shears obtained by two methods is acceptable.

Keywords: Nonlinear response -history analysis, Dynamic pushover, Endurance Time method, Performance-based seismic engineering.

1. INTORDUCTION

The concept of Performance Based Seismic Engineering (PBSE) is gaining increased interest among researchers and practitioners [1]. PBSE includes the concept that designs should be capable of satisfying various performance objectives, under a spectrum of design ground motions ranging from minor to severe. Due to inherent randomness in ground shaking, lack of knowledge in the precise definition of the structure's characteristics, and inability to model the actual behavior accurately, estimation of seismic performance entails significant uncertainty [2].

Quantification of seismic demands for performance assessment implies the statistical and probabilistic evaluation of Engineering Demand Parameters (EDPs) as a function of ground motion Intensity Measures (IMs), and the study of the sensitivity of these relationships to important structural and ground motion characteristics [3]. Several research efforts have focused on the evaluation of demands for both single and multiple degrees of freedom (SDOF and MDOF) systems in which displacement demands from nonlinear response history analyses have been quantified as a function of a normalized strength or ground motion intensity level [4-7].

Endurance Time method is basically a simple dynamic pushover test that tries to predict EDPs of structures at different IMs by subjecting them to some predesigned intensifying dynamic excitations. The predesigned excitation in ET method is named as acceleration function instead of accelerogram to prevent confusion with real ground motions and simulated accelerograms that are usually compatible with real ground motions. ET acceleration functions are designed in a manner that their intensity increases through time [8]. Because of the increasing demand of the ET acceleration function, structures gradually go through elastic to yielding and nonlinear inelastic phases, finally leading to global dynamic instability [8].

In this paper application of ET method in estimation of inelastic deformation demands of steel frames is explained. The concept of ET criteria is first explained and prospective methods to implement it are discussed. A set of steel moment frames with different number of stories was used in this study. This set consists of weak, standard and overestimated frames to examine the capability of ET method in differentiating dissimilar structures. Elastic-Perfectly-Plastic (EPP) material model is used for the nonlinear behavior of the models. In order to evaluate the accuracy of ET method to estimate seismic demands of steel frames, the results computed with ET method were compared to the results with nonlinear response history analyses. The procedure to find the equivalent time of other methods in ET analysis for comparison of the results is described. Mean values and dispersions of the results obtained by two methods are compared for different frames.

For frames with EPP material model which are P-Δ sensitive cases, estimations of ET analysis for maximum interstory drift ratio are less than nonlinear response history analysis results. Nonlinear response