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Modeling considerations for performance based seismic design of steel moment resisting frames

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Abstract

Performance based seismic design (PBSD) of buildings entails adopting nonlinear static or dynamic procedures for evaluating inelastic system responses. With the increasing level of awareness of the engineering community about seismic performance and safety of the structures, PBSD turns to be more popular in everyday design of buildings. Various models such as fiber element, finite length plastic hinge (FLPH) and concentrated plastic hinge (CPH) models can be used for this purpose. However, system responses can be sensitive to characteristics of the selected finite element model, predefined material behavior and damping characteristics. Hence, practitioners' perception regarding modeling issues has to be improved. This paper provides more insights into performing reliable nonlinear static or dynamic analyses by presenting a relatively detailed discussion on the subject and by considering a few case studies. Three steel moment resisting frames are considered to compare system responses obtained from the nonlinear dynamic procedure (NDP) and nonlinear static procedure (NSP) proposed by ASCE 41-17. All problems are solved by CPH, FLPH and fiber element models to investigate the performance of each model. It is concluded that the CPH and FLPH models are the most promising approach for being used by practitioners while fiber element models are more suitable for research-oriented purposes.

Key words: Nonlinear static procedure, Nonlinear dynamic procedure, Performance based seismic design, Distributed plasticity, Concentrated plasticity

1. Introduction

With the advent of modern computers, sophisticated inelastic analyses such as nonlinear time-history analysis (NTHA) can be carried out to obtain more accurate results for design of buildings. As it has been known and discussed by many researchers like Gong et al. [1], elastic analysis based design methods cannot yield a fully valid seismic design since the evaluation tool cannot always capture the true inelastic behavior of a structure. Elastic approaches can result in designs with excessive overstrength for some members while structural overstrength does not essentially correspond to a safer design. It means that structural components might be stronger than required although they might have insufficient ductility. NTHAs are required for identifying the patterns and states of damage, modes of failure and progressive collapse during earthquakes. However, modeling issues can significantly affect the numerical results found from NTHAs.

Plastic design of steel structures facilitates direct consideration of energy dissipation