International Conference on Civil Engineering, Architecture and Urban Management in Iran
Tehran University
August-2018

Reliability of the maximum displacement ratio in nonlinear static procedure for near-fault sites

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Abstract

The nonlinear static procedure (NSP) has become a popular approach among practitioners for preforming performance based seismic design (PBSD) of buildings. However, researches show that this method can yield unconservative estimations of system responses. It indicates that, even though NSP has been accepted by seismic standards such as ASCE 41-17 as an alternative to the rigorous nonlinear dynamic procedure (NDP), it should be used with caution. In this paper, the accuracy of the maximum displacement ratio coefficient, which is a modification factor in ASCE 41-17 nonlinear static procedure, is evaluated for near-fault zones. This coefficient is meant to relate expected maximum inelastic displacements to displacements calculated for linear elastic response. In order to investigate the accuracy of this coefficient, ten near-fault earthquake records with forward directivity are considered. By performing nonlinear time-history analyses (NTHAs) on SDOF systems with various strength ratios, true values for this coefficient are evaluated. Comparison of NTHA-based results with those obtained from ASCE 41-17 formulations show that ASCE 41-17 formulation is not reliable for near-fault sites.

Key words: Nonlinear static procedure, Performance based seismic design, Near-fault sites, Pushover analysis

1. Introduction

In comparison to classical elastic approaches, performance based seismic design of buildings results in more realistic designs in which inelastic behavior of the building can be directly considered. Furthermore, effects of earthquake characteristics can also be automatically incorporated by adopting NTHAs. However, due to the complex and resource-intensive nature of NTHA-based approaches, NSP is more desirable for practitioners. The idea of NSP is that an equivalent single-degree-of-freedom (SDOF) system can be used to approximate displacement demands of the multi-degree-of-freedom (MDOF) system.

The advent of PBSD in building guidelines and standards can be traced back to the project started by Federal Emergency Management Agency (FEMA) in 1984 to address the risk posed by seismically unsafe existing buildings. After thirteen years of extensive effort, FEMA 273 [1] was the most significant outcome of the project. FEMA 273 [1] provided quantified thresholds for acceptance criteria of Operational (OP), Immediate Occupancy (IO), Life Safety (LS) and Collapse Prevention (CP) performance levels. The fundamental