Journal of Constructional Steel Research 71 (2012) 219–230

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Reliability-based assessment of deteriorating steel moment resisting frames

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ARTICLE INFO

Article history:
Received 19 May 2010
Accepted 29 July 2011
Available online 22 December 2011

Keywords:
Performance-based earthquake engineering (PBEE)
Incremental dynamic analysis (IDA)
Uncertainty
Confidence level
Mean annual frequency (MAF)

ABSTRACT

One of the objectives in performance-based earthquake engineering is to quantify the seismic reliability of a structure due to future random earthquakes at a designated site. For that purpose, two performance evaluation processes that do incorporate the effect of aleatory and epistemic uncertainties are illustrated and used in order to calculate the reliability of different height Special Moment Resisting frames through two probabilistic-based measures. These two measures are the confidence levels for satisfying the desired performance levels at given hazard levels and mean annual frequency of exceeding a specified structural capacity.
Analytical models are employed including panel zone and a comprehensive model for structural components that not only include strength and stiffness degradation in back bone curve, but also incorporate gradual deterioration of strength and stiffness under cyclic loading. Incremental dynamic analysis is then utilized to assess the structural dynamic behavior of the frames and to generate required data for performance based evaluations. This research is intended to contribute to the progress in improvement of the performance knowledge on seismic design and evaluation of special steel moment resisting frame structures.
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1. Introduction

One of the objectives of the building code seismic provisions has been to provide ductile buildings with an ability of withstanding large inelastic deformations without considerable degradation in strength and stiffness, and without the development of instability and collapse. Special Moment Resisting frame (SMRF) buildings are among the most ductile systems contained in the building codes. SMRFs are designed for lower forces than less ductile intermediate or ordinary moment frame systems, since more ductile systems are deemed to be capable of resisting demands that are significantly larger than their elastic strength limit. To verify the mentioned capability, here we evaluate performance behavior of SMRF systems using performance-based earthquake engineering frame work.

Performance-based seismic evaluation is a process to quantify the seismic reliability for a proposed new or existing structure due to future random earthquakes. Here this quantification is represented by confidence level or the probability to satisfy the desired performance at discrete hazard levels and is also presented in annualized basis, mean annual frequency (MAF) of exceeding a specified structural limit state of interest. This paper summarizes two probabilistic formats namely, Engineering Demand Parameter (EDP)-based approach and Intensity Measure (IM)-based approach by which reliability-based assessment of performance levels of the structural systems becomes possible. The EDP-based approach is implemented in FEMA-350 [1] and is mainly based on the researches done by Cornell et al. [2]. The IM-based approach has been developed recently [3] and is used in ATC-63 [4] to quantify the collapse potential of building systems.

Reliable Performance-based seismic evaluation of SMRF necessitates a robust and detailed analytical model in which connections; panel zones, beams and columns are all modeled to simulate the behavior of real moment resisting frames as accurately as possible. Hence, in this research, a comprehensive deteriorating model that has been recently introduced for structural components and also dimensions of panel zone (i.e. depth of beam by depth of column) and its strength, stiffness, and shear distortions are considered. Analytical models of buildings are developed using the nonlinear finite element program OpenSees which has advanced capabilities for modeling and analyzing the nonlinear response of systems. Numerous examples of application and also verification of non-linear steel framed structures can be found in [5] .The moment-resisting frames are subjected to a set of suitably multiplied scaled representative ground motion records for the location of site and required data for reliability-based evaluations are extracted.

2. Design of structures

Special moment resisting frame buildings with three, five, eight and fifteen-stories – in accordance with the Iranian national code [6,7] provisions – are designed with fully restrained reduced beam section (RBS) connections. FEMA-350 [1] guideline is used to design and specify the geometry and location of RBS moment connections. It should be noted that provisions given in the Iranian national code are very similar

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doi:10.1016/j.jcsr.2011.07.019