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Seismic reliability and sensitivity assessment of Soil-Structure-Foundation Systems

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Abstract

An increasingly important objective for the structural reliability community is the incorporation of advanced reliability methods into current engineering practice. One initiative to address this objective is the development of nonlinear finite element reliability methods. Such methods comprise a combination of static and dynamic nonlinear finite element analysis and reliability algorithms, such as FORM, SORM and simulation. In this article after a brief review of reliability theories we will discuss on capabilities of reliability analysis softwares such as Opensees. This article consists of implementation of analytical tools for stochastic ground motion modeling, finite element response sensitivity analysis, and reliability analysis in order to propagate basic sources of uncertainty related to earthquake loading and material (structural and soil) properties through nonlinear seismic response analysis of SFSI systems.

Keywords: reliability, sensitivity, soil, structure, foundation

1. INTRODUCTION

Until recent years, structural reliability was not routinely analyzed or quantified in the design process. Reliability was accounted for tacitly by the factor-of-safety approach to design in most of the engineering codes (ATC [1], Eurocode [2], FEMA [3],[4]). Also practical guidelines and the lessons learned in the past decades helped the analysts to improve the reliability of structural systems. The structural designer/analyst often did not perform formal risk analyses on newly designed structures. The complications that reduce the ability to quantify the reliability reside in the stochastic nature of design inputs. The primary purpose for establishing a factor-of-safety for design is somehow to ensure the system reliability. In the field of structural reliability, the performance of a structure is evaluated with respect to a prescribed set of limit states that define admissible and inadmissible system behavior. If the response of a structure violates one or more limit states, its performance is deemed unacceptable. This fact suggests that future design and design processes might benefit greatly by focusing on the reliability targets rather than the factors-of safety. Many attempts have been made for loss estimation after an earthquake (HAZUS [5], Miranda et al. [6], Rojahn et al. [7]) and also fragility curves have been developed to estimate the probability of failure of different systems as a function of the system characteristics and the frequency content of the ground motions (Krawinkler and Ibarra [8]). The present paper focuses on the application of system reliability to steel structures, based on storey drifts, which is one of the most sensitive EDPs that causes significant damage to structures, and hence might be quite important in loss estimation. First and second order reliability methods (FORM, SORM) are used to quantify the probability of failure of the system and a sensitivity analysis is performed to identify the importance of the parameters that are used as threshold values for storey drifts. In the next paragraphs, the basic assumptions, theoretical background and applications are documented. Following the used framework, the formidable task of assessing probabilistically potential structural damage states is broken down into four sub-tasks according to the total probability theorem of applied probability theory. These four sub-tasks are (1) Probabilistic Seismic Hazard Analysis, (2) Probabilistic Seismic Demand Hazard Analysis, (3) Probabilistic Seismic Capacity Analysis also called Fragility Analysis, and (4) Seismic Reliability Analysis.

2. Probabilistic Seismic Hazard Analysis for a specific site in Tabriz (PSHA)

In the hazard analysis, one considers the seismic environment (nearby faults, their magnitude-frequency recurrence rates, mechanism, site distance, site conditions, etc.) and evaluates the seismic hazard at the