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Detailed Seismic Risk Analysis of Buildings Using Structural Reliability Methods

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Abstract

This paper presents probabilistic models and methods for detailed seismic risk analysis of structures using structural reliability methods. This approach to risk analysis is an alternative to those that employ the theorem of total probability and conditional probability distributions. Detailed risk analysis entails probabilistic quantification of responses, the ensuing damage of individual structural and nonstructural components, and the resulting economic and social losses. Such an analysis requires a library of probabilistic models for hazards, responses, damage, repair cost, downtime, and casualty with a specific format as presented in this paper. Two analysis options are proposed: one that is based on sampling and another that is based on the first-order reliability method. Furthermore, this paper puts forward importance and sensitivity measures that identify the most important sources of uncertainty and the most important design decisions considering multiple sources of hazard. The developments are showcased by a comprehensive application to a four-story building in Tehran, Iran. The primary results are the loss exceedance probabilities and their disaggregation into direct and indirect economic losses and social loss. The application provides insights into the most vulnerable components, the most influential seismic sources, the most important sources of uncertainty, and the most influential design decisions.

Keywords: Seismic risk; Reliability method; Probabilistic model; Sensitivity analysis; Economic loss; Social loss.

1 Introduction

This paper employs a library of predictive models in conjunction with structural reliability methods for detailed seismic risk analysis of structures. Risk analysis with structural reliability