

SEISMIC LOSS ESTIMATION FOR EFFICIENT DECISION MAKING

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SUMMARY

In order to incorporate seismic risk of facilities into a decision making framework, procedures are needed to quantify such risk for stakeholders. Seismic loss estimation methods combine seismic hazard, structural response, damage fragility, and damage consequences to allow quantification of seismic risk. This paper presents a loss estimation methodology which provides various measures of seismic risk for a specific facility. The methodology is component-based and can therefore distinguish between different structural configurations or different facility contents and is consistent with state-of-the-art loss assessment procedures. Loss is measured in the forms of direct structural and non-structural repair costs, and although not considered in the example, business disruption and occupant injuries can also be considered. This framework has been packaged in a computer code available for future dissemination in the public domain so that users need only to have a basic understanding of the methodology and the input data that is required. Discussion is given to the flexibility of the framework in terms of the rigour which can be employed at each of the main steps in the procedure. Via a case study of a high-rise office building, the use of the methodology in decision-making is illustrated. Methodological requirements and further research directions are discussed. →

INTRODUCTION

Current seismic design codes provide guidelines for the design and detailing of structures with the primary goal of preventing global collapse during strong ground motion shaking. Observations from worldwide earthquakes in the past two decades have illustrated that with few exceptions, structures designed to these state-of-practice guidelines are sufficient for providing life safety with a high degree of confidence. However, these events illustrated the severe economic consequences resulting from earthquakes in highly developed regions of society. These economic consequences can be primarily attributed to: (i) direct economic losses associated with repairing damage within a structure; (ii) direct losses associated with injuries and casualties; and (iii) indirect losses associated with the loss of income due to business disruption. These three forms of losses (damage, death and downtime) are known as the '3D's'. Some examples from the United States include the 1994 Northridge (\$17-26 billion), and 1989 Loma Prieta (\$11 billion) earthquakes [1]. In response to these observed losses it has become apparent that seismic design of structures should consider all of these potential consequences and their likelihood of occurrence.

Quantification of seismic risk is a difficult task which is subject to inherent variability. Although it can be roughly forecasted, it is not known when and where future significant fault ruptures will occur. Even when an earthquake occurs at a particular location, due to the complex rupture mechanism, process of seismic wave propagation and site effects, the intensity, frequency content and duration of ground motions at

a particular site are also uncertain. These uncertainties in the ground motions affecting a given site cause corresponding uncertainty in the level of structural response, and associated damage in the structure. Finally, the cost to repair a damaged structure is also uncertain and depends on available resources and demand. In order to rigorously assess the seismic risk of a structure all of the above uncertainties should be accounted for. Thus it becomes necessary that the problem of seismic risk is cast into a probabilistic framework which can propagate such uncertainties in each of the input variables and give a probabilistic output useful for decision making processes.

These aforementioned uncertainties result from either inherent randomness in a process, or uncertainty due to the limited knowledge and application of engineering models. These two different types of uncertainty are referred to as aleatory randomness and epistemic uncertainty, respectively. An example of aleatory randomness would be the variation in the level of ground motion observed at a site due to different ground motions resulting from the same rupture magnitude and source-to-site distance, while epistemic uncertainty would result from which ground motion prediction equation is used to estimate the level of ground motion at the site. As aleatory randomness is deemed as an inherent property of complex phenomena, it cannot be reduced; epistemic uncertainty being knowledge-based can be reduced if better knowledge of the phenomena is acquired. As these two different uncertainties are related to different aspects of the considered problem they deserve separate treatment within a decision making process.

This paper presents a discussion of the use of seismic loss estimation for decision making at various stages of design

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