

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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Seismic Loss Estimation For Efficient Decision Making:

Handbook of Seismic Risk Analysis and Management of Civil Infrastructure Systems S Tesfamariam, K Goda, 2013-04-30 Earthquakes represent a major risk to buildings bridges and other civil infrastructure systems causing catastrophic loss to modern society Handbook of seismic risk analysis and management of civil infrastructure systems reviews the state of the art in the seismic risk analysis and management of civil infrastructure systems Part one reviews research in the quantification of uncertainties in ground motion and seismic hazard assessment Part two discusses methodologies in seismic risk analysis and management whilst parts three and four cover the application of seismic risk assessment to buildings bridges pipelines and other civil infrastructure systems Part five also discusses methods for quantifying dependency between different infrastructure systems The final part of the book considers ways of assessing financial and other losses from earthquake damage as well as setting insurance rates Handbook of seismic risk analysis and management of civil infrastructure systems is an invaluable guide for professionals requiring understanding of the impact of earthquakes on buildings and lifelines and the seismic risk assessment and management of buildings bridges and transportation It also provides a comprehensive overview of seismic risk analysis for researchers and engineers within these fields This important handbook reviews the wealth of recent research in the area of seismic hazard analysis in modern earthquake design code provisions and practices Examines research into the analysis of ground motion and seismic hazard assessment seismic risk hazard methodologies Addresses the assessment of seismic risks to buildings bridges water supply systems and other aspects of civil infrastructure Soil-Foundation-Structure Interaction Rolando P. Orense, Nawawi Chouw, Michael J. Pender, 2010-07-20 Soil Foundation Structure Interaction contains selected papers presented at the International Workshop on Soil Foundation Structure Interaction held in Auckland New Zealand from 26-27 November 2009 The workshop was the venue for an international exchange of ideas disseminating information about experiments numerical models and practical en **Advances in Civil Engineering Materials** Elham Maghsoudi Nia, Mokhtar Awang, 2024-07-05 This book showcases the latest research in civil engineering and architectural materials with a specific focus on the following key areas circularity energy retrofitting building materials structural advancements and transportation innovations The research findings and advancements presented in this book are a part of the 7th International Conference on Architecture and Civil Engineering ICACE 2023 held on 15 November 2023 at the Everly Hotel Putrajaya Malaysia This conference serves as a prominent platform for researchers professionals and industry experts to exchange knowledge and ideas in order to advance the fields of civil engineering and architecture **M.J. Nigel Priestley Symposium** Mervyn J. Kowalsky, Sri Sritharan, 2008 **Life-Cycle Civil Engineering: Innovation, Theory and Practice** Airon Chen, Xin Ruan, Dan M. Frangopol, 2021-02-26 Life Cycle Civil Engineering Innovation Theory and Practice contains the lectures and papers presented at IALCCE2020 the Seventh International Symposium on Life Cycle Civil Engineering held in Shanghai China

October 27 30 2020 It consists of a book of extended abstracts and a multimedia device containing the full papers of 230 contributions including the Fazlur R Khan lecture eight keynote lectures and 221 technical papers from all over the world All major aspects of life cycle engineering are addressed with special emphasis on life cycle design assessment maintenance and management of structures and infrastructure systems under various deterioration mechanisms due to various environmental hazards It is expected that the proceedings of IALCCE2020 will serve as a valuable reference to anyone interested in life cycle of civil infrastructure systems including students researchers engineers and practitioners from all areas of engineering and industry

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Life-Cycle of Engineering Systems: Emphasis on Sustainable Civil Infrastructure Jaap Bakker, Dan M. Frangopol, Klaas Breugel, 2016-11-18 This volume contains the papers presented at IALCCE2016 the fifth International Symposium on Life Cycle Civil Engineering IALCCE2016 to be held in Delft The Netherlands October 16 19 2016 It consists of a book of extended abstracts and a DVD with full papers including the Fazlur R Khan lecture keynote lectures and technical papers from all over the world All major aspects of life cycle engineering are addressed with special focus on structural damage processes life cycle design inspection monitoring assessment maintenance and rehabilitation life cycle cost of structures and infrastructures life cycle performance of special structures and life cycle oriented computational tools The aim of the editors is to provide a valuable source for anyone interested in life cycle of civil infrastructure systems including students researchers and practitioners from all areas of engineering and industry

Maintenance, Safety, Risk, Management and Life-Cycle Performance of Bridges Nigel Powers, Dan M. Frangopol, Riadh Al-Mahaidi, Colin Caprani, 2018-07-04 Maintenance Safety Risk Management and Life Cycle Performance of Bridges contains lectures and papers presented at the Ninth International Conference on Bridge Maintenance Safety and Management IABMAS 2018 held in Melbourne Australia 9 13 July 2018 This volume consists of a book of extended abstracts and a USB card containing the full papers of 393 contributions presented at IABMAS 2018 including the T Y Lin Lecture 10 Keynote Lectures and 382 technical papers from 40 countries The contributions presented at IABMAS 2018 deal with the state of the art as well as emerging concepts and innovative applications related to the main aspects of bridge maintenance safety risk management and life cycle performance Major topics include new design methods bridge codes heavy vehicle and load models bridge management systems prediction of future traffic models service life prediction residual service life sustainability and life cycle assessments maintenance strategies bridge diagnostics health monitoring non destructive testing field testing safety and serviceability assessment and evaluation damage identification deterioration modelling repair and retrofitting strategies bridge reliability fatigue and corrosion extreme loads advanced experimental simulations and advanced computer simulations among others This volume provides both an up to date overview of the field of bridge engineering and significant contributions to the process of more rational decision making on bridge maintenance safety risk management and life cycle performance of bridges for the purpose of enhancing the welfare of society The Editors hope that these Proceedings will serve as a valuable reference to all concerned with bridge structure and infrastructure systems including students researchers and engineers from all areas of bridge engineering

Interpretable Machine Learning for the Analysis, Design, Assessment, and Informed Decision Making for Civil Infrastructure M. Z. Naser, 2023-10-18 The past few years have demonstrated how civil infrastructure continues to

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Life-Cycle of Structures and Infrastructure Systems Fabio Biondini, Dan M. Frangopol, 2023-06-28 Life Cycle of Structures and Infrastructure Systems collects the lectures and papers presented at IALCCE 2023 The Eighth International Symposium on Life Cycle Civil Engineering held at Politecnico di Milano Milan Italy 26 July 2023 This Open Access Book contains the full papers of 514 contributions including the Fazlur R Khan Plenary Lecture nine Keynote Lectures and 504 technical papers from 45 countries The papers cover recent advances and cutting edge research in the field of life cycle civil engineering including emerging concepts and innovative applications related to life cycle design assessment inspection monitoring repair maintenance rehabilitation and management of structures and infrastructure systems under uncertainty Major topics covered include life cycle safety reliability risk resilience and sustainability life cycle damaging processes life cycle design and assessment life cycle inspection and monitoring life cycle maintenance and management life cycle performance of special structures life cycle cost of structures and infrastructure systems and life cycle oriented computational tools among others This Open Access Book provides an up to date overview of the field of life cycle civil engineering and significant contributions to the process of making more rational decisions to

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Proceedings of the 2nd U.S.-Japan Workshop on Urban Earthquake Hazards Reduction, Held at Tokai University, Shimizu, Japan, July 27-29, 1988 ,1989 Seismological Research Letters ,2000 *Proceedings International Association for Earthquake Engineering*,1989 **LESSLOSS** Gian Michele Calvi,Rui Pinho,2004

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