Book Review

"Seismic Hazard and Risk Analysis" by Jack W Baker, Brendon A Bradley and Peter J Stafford (2021), Cambridge University Press,

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Julian J Bommer

Department of Civil & Environmental Engineering

Imperial College London

Skempton Building

South Kensington campus London

SW7 2AZ, U.K.

Tel: +44-7787-351-004

Email: j.bommer@imperial.ac.uk

Declaration of Competing Interests

The author and Dr Peter Stafford are both affiliated to Imperial College London and have collaborated extensively in both research and consultancy. This relationship has had no bearing on my evaluation of the book.

“Seismic Hazard and Risk Analysis” by J.W. Baker, B.A. Bradley & P.J. Stafford

Seismology is a wonderfully broad field that encompasses many disciplines, contributing to the understanding of earthquakes and unveiling the secrets of the Earth’s interior (and even the interiors of other planets). There are several ways in which seismology contributes to a better world, notable among which is the discrimination between the signals generated by earthquakes and explosions that makes possible the maintenance of treaties banning tests of atomic weapons. Early warning systems, another example of applied seismology, have the potential to save lives and reduce the impact of major earthquakes. But there can be little doubt that the most effective and consistent benefits that the science of seismology brings to society are through the long-term implementation of seismic risk mitigation measures that protect lives and livelihoods against the effects of earthquakes. The most important mitigation measures are related to the earthquake-resistant design of new buildings and infrastructure and the design of strengthening interventions in existing structures. In a world of limited resources subject to competing demands, cost-effective risk mitigation strategies must necessarily begin with quantitative assessment of seismic risk. For any seismologist or Earth scientist wishing to obtain a greater understanding of how their discipline contributes to this critical first step in the process of earthquake risk mitigation, *Seismic Hazard and Risk Analysis* provides an excellent overview. This new textbook by Jack Baker, Brendon Bradley and Peter Stafford will provide both insight and inspiration to seismologists whose work contributes the vital information on earthquake genesis and characteristics that underpins all seismic hazard and risk analysis.

The quantitative assessment of both the hazard and risk posed by earthquakes is fundamental to the effective mitigation of seismic risk yet there is little in the way of guidance on the basic concepts and

procedures involved in the practice of these disciplines. This full-length textbook devoted exclusively to the subjects of seismic hazard and risk analysis fills a very important gap in the technical literature. In making this statement, I do not wish to underestimate the importance of two previous contributions to the literature in this area, both of great value. Leon Reiter's 1990 book *Earthquake Hazard Analysis: Issues and Insights* (ISBN 0-231-06534-5) remains a very interesting and readable introduction the subject, despite its vintage, but provides little detailed technical guidance in terms of how to perform seismic hazard and risk calculations. Robin McGuire's 2004 monograph (ISBN 978-0-943198-01-9), also entitled *Seismic Hazard and Risk Analysis*, did provide such details, albeit in a very condensed format. The new book by Baker, Bradley, and Stafford provides a clear and complete text on the subject, reflecting important advances made in recent years, that will very likely become the standard reference on seismic hazard analysis in coming years.

The authors of this valuable new tome are all accomplished professors and their experience in teaching these subjects is apparent in the structure and organization of the book, each chapter beginning with an opening statement and a list of learning objectives. Each chapter also concludes with some expertly designed exercises, which serve to illustrate the practical application of concepts presented in the chapter and to bring to life the lessons learnt through connection to the stated learning objectives. For readers wishing to go deeper than these simple exercises, a companion web site has been created by the authors from which example data sets and supplementary material can be accessed to perform the more complex calculations described in the book. Throughout the text, concepts are illustrated through calculations related to the 1989 Loma Prieta earthquake in northern California and the ground motions generated in the San Francisco Bay Area, which also serves to create links between the chapters. This textbook will be a gift to anyone teaching courses related to probabilistic seismic hazard analysis (PSHA) and every student

following a course on this subject should ensure that they acquire a copy. The authors have generated only original figures throughout the book, cleverly crafted in perfectly legible grayscale that has reduced the retail price of the book, hopefully making it affordable to all students of geophysics, seismology, geology, and civil engineering. I can assure any student who has an interest in seismic hazard and risk analysis that the purchase of this book will be a worthwhile investment—and its value will persist longer after graduation.

While written primarily as a didactic textbook, *Seismic Hazard and Risk Analysis* will also be of great value to practitioners, especially Earth scientists and engineers who may become involved in seismic hazard and risk assessments. The book will be equally valuable for those who are more likely to end-users of such assessments, including engineers commissioning consultants to undertake site-specific seismic hazard analyses for major infrastructure projects and those involved in incorporating the outputs of such analyses into design specifications. Regulators, urban planners, architects, insurers, and reinsurers working in seismically active regions will also find this book to be a very valuable resource.

The book is organized into four broad sections, in addition to two very useful appendices that provide information on probability concepts and on the statistical tools used for model calibration. The book begins with an introduction that provides basic definitions of hazard and risk analyses as well as explaining how the outputs of such analyses are used. The Introduction also explains the basics of deterministic and probabilistic approaches to seismic hazard and risk assessment, highlighting the benefits of the latter, which the authors clearly favor: the probabilistic approach is the main focus of the book. The Introduction also includes a discussion of the primordially important topic of uncertainty in seismic hazard and risk analyses.

The second section of the book focuses on Hazard Inputs, the first two chapters describing the definition of seismic source characterization models in terms of the sources of possible future earthquakes and their recurrence characteristics. Sources of diffuse seismicity and sources directly based on geological faults are both included, with clear guidance on the definition of fault rupture scenarios both on fault sources and within area source zones (which are required for consistency with the distance metrics used in modern ground-motion models). The following two chapters describe models for the prediction of ground motions, starting with an overview of the various parameters used to characterize earthquake ground motions and the derivation of empirical models to predict values of these parameters for different earthquake scenarios. The final chapter is devoted to physics-based simulations of complete waveforms based on full finite-fault rupture models, also covering the simplified version of such approaches based on point-source stochastic simulations.

The third section of the book addresses the integration of the seismic source characterization and ground motion characterization models in Hazard Calculations. While this section provides clear explanations of the fundamentals of performing PSHA calculations and interpreting the outputs, it also presents some of the more advanced variations, including vector PSHA in which the joint occurrence of two ground-motion parameters is analyzed. There is also a chapter entirely devoted to non-ergodic hazard analysis, which is a topic at the forefront of modern PSHA practice that addresses the large influence exerted on the results by the aleatory variability associated with ground-motion predictions. The variability is intended to represent the variability in ground motions at a specific location over time due to earthquakes but is generally represented by the variability in ground motions over multiple sites due to earthquakes generated in various sources, referred to as the ergodic assumption. The chapter presents clear guidance on the

identification and separation of ergodic components from both ground motion and source characterization models.

The fourth and final section addresses Risk Analysis, extending the modeling of seismic hazard to quantifying the impact of earthquake shaking on the built environment, both for a single site and for spatially distributed exposure. The section concludes with an extremely useful discussion of the options for validating seismic hazard and risk assessments, or more accurately how models or model elements can be validated through observational data. At the same time, the book provides much needed warnings regarding the pitfalls that can be encountered through the wholesale rejection of probabilistic hazard and risk analyses using observations from a single event.

Through this outstanding book, the emphasis is on concepts and procedures, with specific models being invoked only for illustration purposes. Consequently, the book will remain relevant and current for many years to come as the state-of-the-art in these fields continues to evolve, while enabling interested individuals to follow the latest developments by facilitating a solid grounding in the fundamentals.

The current state of practice in seismic hazard and risk analysis is very varied, with the lower part of the distribution being worryingly poor, often due to basic misunderstandings or misconceptions. The root cause of such misconceptions must surely, in part, be related to the lack of clear instructions on the how and why of earthquake hazard and risk assessments. I sincerely hope that the tremendous contribution that Baker, Bradley, and Stafford have made through writing their outstanding book on *Seismic Hazard and Risk Analysis* will be widely disseminated and studied, since it will be a powerful device to improve the state of practice in these fields.

Data and Resources

The author based his review on the final version of the manuscript for the Baker-Bradley-Stafford book, provided by Dr Peter Stafford. Reference was also made to the author's own hard copies of the books by Leon Reiter and Robin McGuire.