

HAZUS-MH Flood Loss Estimation Methodology. I: Overview and Flood Hazard Characterization

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Abstract: Part I of this two-part paper provides an overview of the HAZUS-MH Flood Model and a discussion of its capabilities for characterizing riverine and coastal flooding hazard. Included is a discussion of the Flood Information Tool, which permits rapid analysis of a wide variety of stream discharge data and topographic mapping to determine flood-frequencies over entire floodplains. Part II reports on the damage and loss estimation capability of the Flood Model, which includes a library of more than 900 damage curves for use in estimating damage to various types of buildings and infrastructure. Based on estimated property damage, the model estimates shelter needs and direct and indirect economic losses arising from floods. Analyses for the benefits of flood warning, levees, structural elevation, and flood mapping remedies are examples of analyses that can be performed with the Flood Model.

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Introduction

HAZUS-MH is the most recent evolution of a family of natural hazards loss estimation software whose development began in the early 1990s. The purpose of HAZUS and natural hazards loss estimation software in general is to quantify the human, property, financial, and social impacts of natural hazards such as earthquake, wind, and flood, under existing conditions and given any of numerous possible mitigation measures. Quantification of losses under existing conditions is valuable for understanding and communicating the relative importance of natural hazards risks and the various factors (such as location, land use zoning, construction quality, etc.) contributing to that risk. Similarly, analysis of the beneficial impacts of mitigation measures (such as relocation, improved land use and planning, structural modifications, warning, etc.) permits informed decision making and efficient allocation of scarce resources. The first release of HAZUS, in 1997, was for analysis of earthquake effects. This paper discusses, in two parts, the development and technical details of the HAZUS Flood Model.

Flood Model Development

Development of the HAZUS Flood Model took place in two phases that began in 1997 with the appointment of an advisory committee to provide technical oversight and guidance. Phase I consisted of a comprehensive review of existing flood loss estimation studies, models, and data (EQE 1998). Based on that review, a concept for a methodology was developed as represented in Fig. 1 (EQE 1999a). The concept was evaluated through proof-of-concept testing performed in six communities in regions representing various flooding conditions (EQE 1999b). The findings from the proof-of-concept testing were that:

- Discharge frequencies can be determined for all river reaches in the United States where digital elevation models (DEM) and regional regression relations are available;
- Flood depths can be determined for all river reaches in the United States where DEM and Q3 data is available. Fig. 2 is an example of the accuracy achievable using the recommended methodology and available DEM and Q3 data;
- Base flood elevations (BFEs) along coastal shore-perpendicular transects can be estimated and provide reasonable results;
- Applying U.S. Census and Dunn & Bradstreet data at the census block level provides a resolution suitable for flood loss estimation;
- Depth-damage functions for buildings developed by the Federal Insurance Administration (termed "credibility-weighted" functions) are suitable for flood loss estimation, since they are based on the best available damage data and represent more than 20 years of losses. Additionally, depth-damage functions developed by the U.S. Army Corps of Engineers (USACE) are also suitable in selected instances, for a wide variety of building types in various regions;
- Depth-damage functions for lifelines such as water, electric power, roads, and railroads can be developed using a combination of historical data, component based modeling, and expert opinion; and

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HAZUS Market Characterization Study, 2002 **HAZUS Market Characterization Study**, 2002 **Hazard market characterization study**, 2002 **Hazard Market Characterization Study**, 2002 Flood and Coastal Erosion Risk Management Edmund Penning-Rowsell, Sally Priest, Dennis Parker, Joe Morris, Sylvia Tunstall, Christophe Viavattene, John Chatterton, Damon Owen, 2014-01-03 A new Multi Coloured Manual This book is a successor to and replacement for the highly respected manual and handbook on the benefits of flood and coastal risk management produced by the Flood Hazard Research Centre at Middlesex University UK with support from Defra and the Environment Agency It builds upon a previous book known as the multi coloured manual 2005 which itself was a synthesis of the blue 1977 red 1987 and yellow manuals 1992 As such it expands and updates this work to provide a manual of assessment techniques of flood risk management benefits indirect benefits and coastal erosion risk management benefits It has three key aims First it provides methods and data which can be used for the practical assessment of schemes and policies Secondly it describes new research to update the data and improve techniques Thirdly it explains the limitations and complications of Benefit Cost Analysis to guide decision making on investment in river and coastal risk management schemes The Economic Impacts of Terrorist Attacks James Elliott Moore, 2007-01-01 These papers enhance our understanding of numerous aspects of the terrorism problem Andrew Haughwout Papers in Regional Science The Economic Impact of Terrorist Attacks exposes the reader to a healthy sampling of the current approaches that researchers have taken in addressing a challenging set of economic problems Jared C Carbone Journal of Regional Science Knowledgeably compiled and expertly co edited by the team of Harry W Richardson Peter Gordon and James E Moore II The Economic Impacts of Terrorist Attacks is a groundbreaking study of the extensive damage done to the American economy as a result of terrorism with a particular focus on the attacks in 2001 very highly recommended to students of politics economics and the present war on terrorism The Midwest Book Review Focussing on the economics of terrorism in the post 9 11 world this book brings together original research based on the collaborative efforts of leading economists and planners The authoritative and expert contributors use a variety of methodological approaches and apply them to different types of terrorist attacks on airports highways seaports electric power infrastructure for example They also draw analogies between man made and natural disasters The results suggest that these issues are extremely complex and that the economic costs of some types of attack are huge but that increased understanding and estimation can be used to justify resource investments in prevention mitigation and response A primary aim of the book is to contribute to developing more cost effective anti terrorist policies Scholars and researchers in the fields of transportation public sector economics urban planning disaster prevention mitigation and management and engineers will find The Economic Impacts of Terrorist Attacks a major contribution to a new and rapidly expanding research area *Seismic Resilience Assessment of Hospital Infrastructure* Qingxue Shang, Tao Wang, Jichao Li, Mohammad Noori, 2024-03-14 Healthcare facilities or hospital

systems are classified as some of the most critical infrastructure systems when responding to natural disasters Seismic Resilience Assessment of Hospital Infrastructure systematically presents a suite of novel techniques developed by the authors and their team for seismic resilience assessment of hospital infrastructure with particular emphasis on seismic tests and fragility models of hospital equipment resilience assessment of single hospital buildings and emergency departments and post earthquake functionality of urban hospital infrastructures Features Presents a state of the art review on hospital resilience Develops seismic fragility model database for hospital equipment based on shaking table tests Provides a road map for effective and efficient methods necessary for assessing and improving seismic resilience of hospital systems and other critical engineering systems Expertly summarizes outcomes of many important research projects sponsored by various research agencies including the National Natural Science Foundation of China

Modeling Spatial and Economic Impacts of Disasters Yasuhide Okuyama, Stephanie E. Chang, 2013-06-29 This volume is dedicated to the memory of Barclay G Jones Professor of City and Regional Planning and Regional Science at Cornell University Over a decade ago Barclay took on a fledgling area of study economic modeling of disasters and nurtured its early development He served as the social science program director at the National Center for Earthquake Engineering Research NCEER a university consortium sponsored by the National Science Foundation and the Federal Emergency Management Agency of the United States In this capacity Barclay shepherded and attracted a number of regional scientists to the study of disasters He organized a conference held in the ill fated World Trade Center in September 1995 on The Economic Consequences of Earthquakes Preparing for the Unexpected He persistently advocated the importance of social science research in an establishment dominated by less than sympathetic natural scientists and engineers In 1993 Barclay organized the first of a series of sessions on Measuring Regional Economic Effects of Unscheduled Events at the North American Meetings of the Regional Science Association International RSAI This unusual nomenclature brought attention to the challenge that disasters largely unanticipated often sudden and always disorderly pose to the regional science modeling tradition The sessions provided an annual forum for a growing coalition of researchers where previously the literature had been fragmentary scattered and episodic Since Barclay s unexpected passing in 1997 we have continued this effort in his tradition

Hydrological Hazard: Analysis and Prevention Tommaso Caloiero, 2018-11-26 This book is a printed edition of the Special Issue Hydrological Hazard Analysis and Prevention that was published in Geosciences

Earthquake Spectra, 1999 *Earthquake Engineering Frontiers in the New Millennium* Y.X. Hu, 2017-11-22 This volume comprises papers presented at the China US Millennium Symposium on Earthquake Engineering held in Beijing China on November 8 11 2000 This conference provides a forum for advancing the field of earthquake engineering through multi lateral cooperation

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 *RiskScape Volcano - a Volcanic Hazard*

Risk Assessment Model for RiskScape Grant D. Kaye, 2008 **Seismic Design of Steel Structures** Victor Gioncu, Federico Mazzolani, 2013-11-20 Providing real world applications for different structural types and seismic characteristics Seismic Design of Steel Structures combines knowledge of seismic behavior of steel structures with the principles of earthquake engineering This book focuses on seismic design and concentrates specifically on seismic resistant steel structures Drawing on experience from the Northridge to the Tohoku earthquakes it combines understanding of the seismic behavior of steel structures with the principles of earthquake engineering The book focuses on the global as well as local behavior of steel structures and their effective seismic resistant design It recognises different types of earthquakes takes into account the especial danger of fire after earthquake and proposes new bracing and connecting systems for new seismic resistant steel structures and also for upgrading existing reinforced concrete structures Includes the results of the extensive use of the DUCTROCT M computer program which is used for the evaluation of the seismic available ductility both monotonic and cyclic for different types of earthquakes Demonstrates good design principles by highlighting the behavior of seismic resistant steel structures in many applications from around the world Provides a methodological approach making a clear distinction between strong and low to moderate seismic regions This book serves as a reference for structural engineers involved in seismic design as well as researchers and graduate students of seismic structural analysis and design

National Earthquake Resilience National Research Council, Division on Earth and Life Studies, Board on Earth Sciences and Resources, Committee on Seismology and Geodynamics, Committee on National Earthquake Resilience—"Research, Implementation, and Outreach, 2011-09-09 The United States will certainly be subject to damaging

earthquakes in the future Some of these earthquakes will occur in highly populated and vulnerable areas Coping with moderate earthquakes is not a reliable indicator of preparedness for a major earthquake in a populated area The recent disastrous magnitude 9 earthquake that struck northern Japan demonstrates the threat that earthquakes pose Moreover the cascading nature of impacts the earthquake causing a tsunami cutting electrical power supplies and stopping the pumps needed to cool nuclear reactors demonstrates the potential complexity of an earthquake disaster Such compound disasters can strike any earthquake prone populated area National Earthquake Resilience presents a roadmap for increasing our national resilience to earthquakes The National Earthquake Hazards Reduction Program NEHRP is the multi agency program mandated by Congress to undertake activities to reduce the effects of future earthquakes in the United States The National Institute of Standards and Technology NIST the lead NEHRP agency commissioned the National Research Council NRC to develop a roadmap for earthquake hazard and risk reduction in the United States that would be based on the goals and objectives for achieving national earthquake resilience described in the 2008 NEHRP Strategic Plan National Earthquake Resilience does this by assessing the activities and costs that would be required for the nation to achieve earthquake resilience in 20 years National Earthquake Resilience interprets resilience broadly to incorporate engineering science physical social economic behavioral and institutional governing dimensions Resilience encompasses both pre disaster preparedness activities and post disaster response In combination these will enhance the robustness of communities in all earthquake vulnerable regions of our nation so that they can function adequately following damaging earthquakes While National Earthquake Resilience is written primarily for the NEHRP it also speaks to a broader audience of policy makers earth scientists and emergency managers

Mapping the Zone National Research Council, Water Science and Technology Board, Board on Earth Sciences and Resources/Mapping Science Committee, Committee on FEMA Flood Maps, 2009-06-15 Federal Emergency Management Agency FEMA Flood Insurance Rate Maps portray the height and extent to which flooding is expected to occur and they form the basis for setting flood insurance premiums and regulating development in the floodplain As such they are an important tool for individuals businesses communities and government agencies to understand and deal with flood hazard and flood risk Improving map accuracy is therefore not an academic question better maps help everyone Making and maintaining an accurate flood map is neither simple nor inexpensive Even after an investment of more than 1 billion to take flood maps into the digital world only 21 percent of the population has maps that meet or exceed national flood hazard data quality thresholds Even when floodplains are mapped with high accuracy land development and natural changes to the landscape or hydrologic systems create the need for continuous map maintenance and updates Mapping the Zone examines the factors that affect flood map accuracy assesses the benefits and costs of more accurate flood maps and recommends ways to improve flood mapping communication and management of flood related data

Earthquake Engineering Halil Sezen, 2012-08-08 Recent major earthquakes around the world have shown the vulnerability of

infrastructure and the need for research to better understand the nature of seismic events and their effects on structures As a result earthquake engineering research has been expanding as more and more data become available from a large array of seismic instruments large scale experiments and numerical simulations The first part of this book presents results from some of the current seismic research work including three dimensional wave propagation in different soil media seismic loss assessment probabilistic hazard analysis geotechnical problems including soil structure interaction The second part of the book focuses on the seismic behavior of structures including historical and monumental structures bridge embankments and different types of bridges and bearings **Natural Hazards** Burrell E. Montz, Graham A. Tobin, Ronald R.

Hagelman, 2017-04-21 What can we learn from the spatial patterns of disasters What human and structural factors need to be addressed to explain hazard vulnerability As populations grow and the climate warms how can natural hazards be mitigated Thoroughly revised and updated and now with a more global perspective the second edition of this accessible text provides an integrated framework for understanding and managing natural hazards Numerous case studies from around the world illustrate the complexities of extreme geophysical events and highlight their physical social political and economic dimensions The text identifies essential principles for tackling the fundamental causes of differential vulnerabilities that perpetuate human distress and for promoting recovery and resilience New to This Edition New frameworks for understanding human resilience and adaptive capacity in recovery dynamics of risk and uncertainty and more Chapter on spatial and temporal aspects of hazards Discussions of cutting edge topics such as chronic disasters controversies in international aid and how hazards affect regions differentially Many new case studies including Hurricanes Katrina and Charley Superstorm Sandy the 2011 Japan tsunami Ecuador's chronic volcanic hazard and others Reflects 20 years of research advances across the physical and social sciences development trends new technologies and ongoing global climate change

Statistical Seismology David Vere-Jones, Yehuda Ben-Zion, Ramón Zúñiga, 2005-07-19 Statistical Seismology aims to bridge the gap between physics based and statistics based models This volume provides a combination of reviews methodological studies and applications which point to promising efforts in this field The volume will be useful to students and professional researchers alike who are interested in using stochastic modeling for probing the nature of earthquake phenomena as well as an essential ingredient for earthquake forecasting **Theory and Practice in Policy Analysis** M.

Granger Morgan, 2017-10-12 Many books instruct readers on how to use the tools of policy analysis This book is different Its primary focus is on helping readers to look critically at the strengths limitations and the underlying assumptions analysts make when they use standard tools or problem framings Using examples many of which involve issues in science and technology the book exposes readers to some of the critical issues of taste professional responsibility ethics and values that are associated with policy analysis and research Topics covered include policy problems formulated in terms of utility maximization such as benefit cost decision and multi attribute analysis issues in the valuation of intangibles uncertainty in

policy analysis selected topics in risk analysis and communication limitations and alternatives to the paradigm of utility maximization issues in behavioral decision theory issues related to organizations and multiple agents and selected topics in policy advice and policy analysis for government

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