

Recent FEMA Activities in Earthquake Risk Analysis and Mitigation

by

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ABSTRACT

The Federal Emergency Management Agency (FEMA), in collaboration with the National Institute of Building Sciences (NIBS), released the HAZUS earthquake loss estimation methodology in 1997. This methodology assists state and local emergency managers in estimating seismic risk to their jurisdictions in order to focus planning and mitigation strategies. The methodology also provides the capability to conduct post-earthquake loss estimation for emergency response, and provides a nationally consistent exposure and inventory database to compare seismic risk across multiple regions throughout the United States. HAZUS-related research and outreach activities are summarized, as well as plans for the development and release of wind and flood loss estimation modules.

KEYWORDS: earthquake modeling; geographic information systems; HAZUS; loss estimation; mitigation; Project Impact.

1. INTRODUCTION

The recent Northridge, California and Kobe, Japan earthquakes were wake up calls for the earthquake community. These events raised awareness about the

damage potential of a moderate-sized earthquake striking close to an urban center, and demonstrated that high risk could be present in areas of low seismic hazard. Many questions were raised about the earthquake problem in the United States – were seismic policies focused on regions of high risk or high hazard? Did cities like Boston or New York have a high enough risk to experience a disaster like Kobe, despite their low seismic hazard?

In the past, much of the perception of the 'earthquake problem' was based on an understanding of the *earthquake hazard* – the location of faults, geology, and the distribution of strong ground motion in space and time - instead of *earthquake risk*, which is a product of the hazard, the population and building exposure, and the vulnerability. Policy, land use, and development decisions at the Federal, state, and local level are risk-based decisions and need appropriate inputs. Areas of high earthquake risk may not always be coincident with areas of high earthquake hazard.

Detailed information is available about the earthquake hazard in different regions of the United States through the efforts of the US Geological Survey and the National Earthquake Hazards

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Reduction Program. There are few corresponding risk maps, however, that could be used for risk-based earthquake planning and mitigation. Most of the general understanding about risk is restricted to property damage, insured losses, and casualties related to specific scenario events or regional probabilistic loss studies (NRC, 1989; NIBS, 1994). Until recently, there was no nationally consistent earthquake loss estimation methodology for the United States. Without such a standardized technology, it was infeasible to compare levels of damage or losses between regions.

In support of the National Mitigation Strategy, FEMA has developed a standardized earthquake loss estimation methodology, HAZUS (Hazards United States) that uses a nationally consistent hazard, exposure, and inventory database to estimate earthquake losses throughout the United States. HAZUS provides local, state, and regional emergency management officials with the tools necessary to plan and stimulate efforts to reduce risk from earthquakes and to prepare for emergency response and recovery following an earthquake.

HAZUS is built on an integrated geographic information system (GIS) platform that rapidly produces regional profiles and estimates of earthquake loss. HAZUS is currently available in both MapInfo and ArcView versions. The methodology has been tested against the experience from several past earthquakes and against the judgment of experts, and has been judged capable of producing results that are credible for the intended purpose. Additionally, a series of pilot studies were conducted in Portland, OR and Boston, MA. Detailed descriptions of the HAZUS methodology can be

found in the HAZUS Users Manual and Technical Manuals (NIBS, 1997a,b). A series of articles in the special issue of Earthquake Spectra on Loss Estimation (Brookshire et al., 1997; Kircher et al., 1997a,b; Whitman et al., 1997) provide additional information.

Jamieson and Milheizler (1997) reviewed the development of the HAZUS methodology and provided a description of the individual modules (Potential Earth Science Hazards, Inventory, Direct Damage, Induced Damage, Direct Loss, and Indirect Loss) that comprise the HAZUS methodology.

This article summarizes research and outreach activities in the United States since the release of HAZUS in 1997 and discusses plans for the development of wind and flood loss modules.

2. CURRENT HAZUS ACTIVITIES

2.1 National Activities

2.1.1 Project Impact

FEMA's Disaster Resistant Community initiative, Project Impact, utilizes a 4-step approach to creating safer communities – forming partnerships, assessing risk, prioritizing mitigation needs, and communication with the community. Examination of the community's risk for natural disasters and identification of its vulnerabilities to those risks are essential to successful mitigation. HAZUS inventory data is being used for the analysis of several different hazards, including earthquake, flood, wind, and wildfire, to produce a Community Profile for Project Impact communities. The HAZUS loss

estimation methodology is being used to estimate earthquake losses in areas with an earthquake risk. Two Project Impact communities with significant exposure to earthquakes are Oakland, CA and Seattle, WA. The other hazards are being examined by overlaying the HAZUS inventory with hazard layers and using GIS capabilities to approximate exposure and potential losses. These multi-hazard data layers are available with HAZUS on supplemental CD-ROM's. In addition, FEMA plans to provide each Project Impact community with HAZUS software and assistance as needed to use HAZUS to conduct baseline earthquake risk analyses to facilitate mitigation planning.

2.1.2 Annualized Earthquake Loss

Since HAZUS is a standardized methodology with a nationally consistent inventory, it provides the perfect platform to assess and compare seismic risk across multiple regions throughout the continental United States. This analysis compares earthquake risk in terms of average annualized losses (AAL), which is the average loss over different return periods, normalized annually. These loss estimates help to compare the average level of risk between regions. Risk management decisions also need to account for the exposure of the region in addition to the absolute level of loss. A new index has been developed, the annualized loss ratio (ALR), which is the ratio of average annual loss to exposure. This index provides a measure of relative risk and can be used to compare risk across different geopolitical units such as census tracts, metropolitan areas, counties, or states.

2.1.3 Training

Regularly scheduled training classes have been held at contractor facilities in Menlo Park, CA and FEMA's National Emergency Training Center in Emmitsburg, MD. These classes provide 3 1/2 days of in-depth training on HAZUS and GIS. In 1997 and 1998, over 100 users have been trained in HAZUS. These users include emergency managers, planners, geologists, GIS analysts and others from 45 states, three territories, local governments, the Red Cross, the three regional earthquake consortia, and FEMA personnel.

2.1.4 Technical Support

Technical support is being provided to HAZUS users via phone, fax, and e-mail. FEMA is also developing a HAZUS homepage, which will describe current HAZUS developments and applications nationwide, and provide a network for HAZUS users. The HAZUS home page is located in the Mitigation section of the FEMA Internet site (<http://www.fema.gov>).

2.2 Regional Activities

In addition to national scale studies, HAZUS is being used by state and local officials for earthquake response and recovery planning, and to investigate mitigation alternatives. Results of an initial survey (Anagnos et al., 1998) conducted after the first release of HAZUS to state emergency managers indicated at that time that users had conducted analyses using the default inventory data included with the methodology. The survey also showed

that users are now beginning to undertake the task of refining existing inventories and collecting more detailed local data for incorporation into HAZUS to improve loss estimates.

2.2.1 Western United States

Throughout California, the HAZUS methodology is being used to estimate levels of ground motion for specific fault systems (e.g., the San Andreas Fault near Parkfield; the northern Hayward Fault near Berkley, as well as the Rodgers Creek and San Jacinto Faults). These estimates have been used to develop emergency response plans and to conduct response exercises in both northern and southern California.

FEMA Region 9 is engaged in developing a San Francisco Bay Area HAZUS users group that would enable widespread public and private sector participation. The goal of this group is to improve preparedness for the next major earthquake in the Bay area.

In the state of Washington, initial HAZUS projects in Seattle are focusing on transportation systems. Additionally, a volcano hazards database for Mt. Rainier and other Cascades volcanoes is being developed for use with the HAZUS inventory information to identify the exposure of communities to mudflows and other volcanic hazards.

Shortly after the release of HAZUS in the spring of 1997, the Portland METRO Emergency Planning Program used HAZUS analysis and maps generated by HAZUS to facilitate discussions of earthquake hazard mitigation measures at a workshop attended by

representatives of the business, utilities, and public sectors of the community.

2.2.2 Central United States

In Kentucky, Alabama, Tennessee, and Indiana efforts are underway, typically in cooperation with state university systems, to refine the existing default data and to incorporate inventory data from state and local sources.

Largely due to the efforts of the Central United States Earthquake Consortium (CUSEC), HAZUS has played a significant role in the Southwestern Indiana Disaster Recovery Business Alliance and the Southwestern Indiana Disaster Resistant Community Initiative. Both groups are working to coordinate and guide long-term planning and implementation of regional efforts to reduce vulnerability to earthquakes, floods, and other natural disasters. They are developing a HAZUS demonstration project that will emphasize training, team building, data inventory, strategy development, and program review at the community level. The Central US Earthquake Consortium is documenting this demonstration project for the benefit of other Central US communities.

2.2.3 Eastern United States

A compilation of detailed geologic information is currently underway in the New York City metropolitan area to better define seismic site response. Additionally, inventory collection programs are underway to upgrade the default HAZUS inventory data and prepare for the multi-hazard version of HAZUS. The formation of the New York City Metropolitan Area Loss Reduction Consortium in 1998 will

provide technical assistance for the development and implementation of mitigation and loss reduction strategies.

The Northeast States Emergency Consortium (NESEC) has developed an automated default Report Format to assist in developing HAZUS reports at the state, county, and community level.

Vermont has been active in mapping earthquake hazards in 'soft' soils and will use this information to develop appropriate mitigation activities in vulnerable areas.

Additional inventory collection efforts are underway in New Hampshire, where an innovative program is using Americorps volunteers to collect site-specific, all-hazards inventory data for incorporation into HAZUS.

North and South Carolina are working with HAZUS to refine the default inventory databases and are learning to use HAZUS products.

3. FUTURE HAZUS ACTIVITIES

3.1 Multi-Hazard Loss Estimation

FEMA and NIBS are currently in the process of expanding the capabilities of HAZUS to make it a multi-hazard loss estimation methodology. Flood and wind loss modules are under development and will be integrated into HAZUS in approximately two years. Flood and Wind committees were created to oversee the development of these two modules. Each is comprised of members with experience and expertise in the flood and wind fields. Dr. Joseph Minor, University of Missouri-Rolla, chairs the nine-member Wind

committee; and Mr. Douglas Plasencia, Kimley-Horn and Associates, chairs the eleven-member Flood committee.

A key element in the development of these modules is to have users provide input throughout the process. Users' Workshops are scheduled for both the Flood and Wind Modules. These will be attended by a wide variety of potential users, including emergency managers, floodplain managers, state and local representatives, and others. The outcome of these workshops will be a Users' Requirements Report that will be furnished to the development contractor to ensure that the end product meets the needs of potential users.

2.3 International Loss Estimation

The United States-Japan Common Agenda for Cooperation in the Global Perspective has identified real-time seismic information systems and earthquake loss estimation methodologies as topics for discussion at the 1st High-Level US - Japan Earthquake Policy Cooperation Forum. The creation of the Seismic Information Systems Task Committee, as part of the US-Japan Panel on Wind and Seismic Effects, is an opportunity to foster cooperation between US and Japanese researchers and policy makers. The Task Committee will provide technical support to the Common Agenda, and will act as a forum for identifying, developing, and reviewing data systems and methodologies involved with seismic information systems, earthquake loss estimation, geospatial and topographic information systems, and early seismic warning systems.

4. CONCLUSIONS

The introduction of HAZUS in the United States has sparked interest and activity in earthquake loss estimation at the Federal, state, and local level. Loss estimation also provides a unique opportunity for international collaboration and partnership. Inquiries about HAZUS and earthquake loss estimation in general from China, Japan, Latin America and Russia demonstrates the common challenges that we all face with respect to natural disasters and the willingness to work together to create safer communities for the future.

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