nehrp SeismicWaves
How the National Earthquake Hazards Reduction Program Is Advancing Earthquake Safety
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Linking Critical Technologies for Pre- and Post-Earthquake Loss Estimation

NEHRP's ShakeMap-HAZUS Demonstration Projects

A Dilemma Waiting to Happen

A severe earthquake has just occurred and reliable information about damage and injuries is not yet available . . . Decisions—about what resources to mobilize and where to deploy them—must start to be made now, before they can be confirmed by information verified on the ground.

Fortunately, an innovative tool is becoming available that can help responders cope with such situations. It is the product of an ongoing effort, begun several years ago by the Federal Emergency Management Agency (FEMA) in cooperation with the U.S. Geological Survey (USGS) and others, to bring the cutting-edge benefits of integrated ShakeMap and HAZUS technology to seismically active areas.

Two Tools Meant for Each Other

ShakeMap, which charts the location and severity of earthquake ground shaking, and HAZUS, which estimates the losses that such shaking can produce, were created as independent, highly flexible tools. USGS began developing ShakeMap in the 1990s to transform the data generated by its growing, nationwide network of monitoring stations into a near-real-time response tool. Within minutes of damaging earthquakes, ShakeMap systems generate data and maps showing the geographic distribution and intensity of the ground motions experienced. This information can be used to inform response personnel and the media about the scope of the event, and to guide emergency-response and damage-assessment efforts.

HAZUS is short for Hazards U.S. Multi-Hazard or HAZUS-MH, a FEMA-developed and GIS-based software system built around sophisticated risk-assessment methodologies designed to estimate potential losses from earthquakes, floods, and hurricane winds. FEMA has continually improved the HAZUS earthquake model, issuing a series of upgrades in recent years. The model can now generate various estimates of damage (e.g., casualties, displaced households, outages) and loss (e.g., repair and replacement costs, value of lost wages and building contents) relating to affected populations, to commercial, industrial, and residential structures, and to transportation and utility lifelines.

By the middle of this decade, realistic earthquake scenarios, which describe the ground motions and damaging effects that large earthquakes would likely produce in particular regions, had developed into a popular vehicle for response planning. It was in this context that ShakeMap, which projected the ground shaking for scenarios, began to be used alongside HAZUS, which estimated the aggregate losses used to measure resource requirements for response, recovery, and loss mitigation.

Mapping Earthquake Losses

In a 2005 upgrade, FEMA calibrated HAZUS specifically for ShakeMap input, enabling the system to generate more accurate loss estimations. FEMA then funded two multiyear demonstration projects to further link ShakeMap data on ground shaking with HAZUS data on the people, property, and infrastructure at risk. The intent was to enable communities to identify areas where damage is expected to be more extensive and where there is greater potential for injuries and loss of life.

FEMA recognized that incorporating ShakeMap data into HAZUS loss modeling could provide this capability, yielding information that would be of value both before and after earthquakes. In the immediate aftermath of damaging earthquakes, this information could enable responders to guide resources to where they are most likely to be needed, even before needs are verified on the ground. And when developed for earthquake scenarios, such information could be used in response and recovery planning to help government, utilities, and others project amounts and locations of resource needs; stimulate seismic-risk awareness and preparedness among the public; and identify vulnerabilities in the built environment that can be reduced through mitigation efforts such as strengthening buildings and lifelines.

Model Approach for Areas at Risk

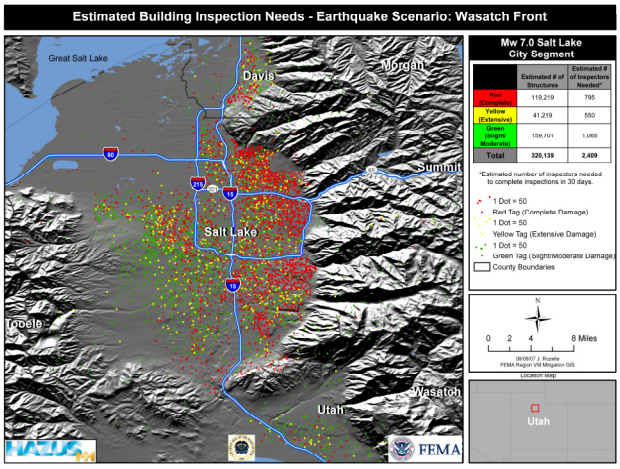
The two demonstration projects were initiated in the states of Washington and Utah, where high levels of seismic activity are juxtaposed with highly populated areas. In Washington, the project targeted the Seattle metropolitan area, where more than 3 million people live near the Cascadia Subduction Zone and other faults. In Utah, the project focused on the Wasatch Front region,

a 125-mile-long urban corridor extending north and south from Salt Lake City, where most of the state's population lives along the Intermountain Seismic Belt. To bring state-of-the-art ShakeMap-HAZUS integration to these areas, the projects have employed a common approach:

- Establish working group—Each project has been planned and managed by a broadly inclusive working group. These groups have brought together scientists and emergency-management personnel responsible for developing and using earthquake monitoring and planning information at state and local levels, as well as ShakeMap and HAZUS experts from USGS and FEMA.
- Optimize both tools—ShakeMap systems were already operating in both states, but their output has been enhanced by incorporating the latest region-specific data on soil and geologic conditions. Similarly, existing HAZUS capabilities have been strengthened by incorporating the best available data on local building inventories and lifelines, and by enabling HAZUS to estimate damage and losses over smaller geographic areas.
- Develop rapid connectivity—Dedicated and integrated ShakeMap-HAZUS systems are being installed to provide near-real-time loss-mapping capabilities for state and local emergency management agencies, for police, fire, and medical personnel, and for lifeline and utility operators.
- Produce planning resources—In both projects, the enhanced ShakeMap-HAZUS systems have been used to generate detailed sets of earthquake scenario risk maps. These show the geographic distribution of damage and losses likely to be found following the types of moderate to large earthquakes that could occur in these two areas.

Having an Impact

Strengthened, region-specific ShakeMap-HAZUS capabilities are having an impact in Utah and Washington. State and local officials are integrating the scenario risk maps into their earthquake planning activities, recognizing their value for targeting mitigation efforts, for stimulating awareness and preparedness in areas at risk, for estimating resources needed for response and recovery, and for designing response and recovery operations.



Risk map from Utah project showing the expected distribution of buildings with complete (red), extensive (yellow), and moderate (green) damage in Salt Lake City following a magnitude 7.0 scenario earthquake. Each dot represents 50 buildings. Courtesy of FEMA.

The maps helped persuade the Utah State Legislature to pass a resolution in 2008 calling on the Utah Seismic Safety Commission to inventory the state's public unreinforced-masonry buildings (URMs) and recommend how to mitigate their risks. In analyzing the losses likely from a large earthquake on the Wasatch Fault, ShakeMap-HAZUS systems found that 80 percent of severe casualties would be caused by damage to URMs.

The ShakeMap-HAZUS capabilities have also begun to stimulate the development of new, innovative planning information. In 2008, for example, researchers at the University of Utah, in collaboration with FEMA, supplemented these capabilities to map the return on investment (reductions in losses) expected from structural mitigation of single-family homes in a neighborhood of Salt Lake City affected by a scenario earthquake.[1]

These and other promising results have recently led FEMA to initiate a third ShakeMap-HAZUS demonstration focusing on the Reno to Carson City urban corridor in Nevada. All three projects demonstrate the efficacy of the collaboration facilitated by NEHRP, which encompasses not only the agencies participating in NEHRP at the federal level, but also their state and local partners.

[1] See the Sugar House Earthquake Loss Estimation Project at http://code.google.com/p/sugarhouse-earthquake-loss-estimation/.