

Earthquake Monitoring

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Abstract: The National Institute for Occupational Safety and Health and the Stillwater Mining Company worked cooperatively with the Montana Bureau of Mines and Geology to develop a system that would collect seismic data at the Stillwater and East Boulder mines. The purpose was to obtain baseline information on the magnitude and location of mining-induced seismicity to determine if the mines needed multi-channel in-mine monitoring systems. Seismic data recorded at field sites near the mines are being telemetered via FM radio through a series of repeaters to a central recording site where the seismic signals are digitized using an Earthworm data acquisition system. The Earthworm system performs several data analysis tasks in near-real time and places raw seismic data, preliminary hypocenter locations, and magnitudes on a Website within 5 min of a seismic event. Such rapid access to seismic data allows personnel at the Stillwater Mine, Spokane Research Laboratory, and Earthquake Studies Office to evaluate seismic events quickly and respond in ways that may improve the safety of mine personnel underground. Installation of the system also broadened earthquake coverage to south-central Montana, a region previously not covered by the seismograph network.

Introduction

Close to 75 million people in 39 states face some risk from earthquakes. Earthquake hazards are greatest in the western United States, particularly in California, but also in Alaska,

Washington, Oregon, and Hawaii. Earthquake hazards are also prominent in the Rocky Mountain region and the New Madrid Seismic Zone (a portion of the central United States), as well as in portions of the eastern seaboard, particularly South Carolina. Under the National Earthquake Hazards Reduction Program (NEHRP), the federal government supports efforts to assess and monitor earthquake hazards and risk in the United States. Given the potentially huge costs associated with a large, damaging earthquake in the United States, an ongoing issue for Congress is whether the federally supported earthquake programs are appropriate for the earthquake risk.

This report discusses:

- earthquake hazards and risk in the United States,
- federal programs that support earthquake monitoring,
- the U.S. capability to detect earthquakes and issue notifications and warnings, and
- federally supported research to improve the fundamental scientific understanding of earthquakes with a goal of reducing U.S. vulnerability.

Earthquake Hazards and Risk

Portions of all 50 states and the District of Columbia are vulnerable to

earthquake hazards, although risks vary greatly across the country and within individual states. (See, for example, the box below describing the August 23, 2011, magnitude 5.8 earthquake in Virginia.) Seismic hazards are greatest in the western United States, particularly in California, Washington, Oregon, and Alaska and Hawaii. Alaska is the most earthquake-prone state, experiencing a magnitude 7 earthquake almost every year and a magnitude 8 earthquake every 14 years on average. (See box below for a description of earthquake magnitude.) Because of its low population and infrastructure density, Alaska has a relatively low risk for large economic losses from an earthquake. In contrast, California has more citizens and infrastructure at risk than any other state because of the state's frequent seismic activity combined with its large population.

Earthquake Magnitude and Intensity

Earthquake magnitude is a number that characterizes the relative size of an earthquake. It was historically reported using the *Richter* scale (magnitudes in this report are generally consistent with the Richter scale). Richter magnitude is calculated from the strongest seismic wave recorded from the earthquake, and is based on a logarithmic (base 10)

scale: for each whole number increase in the Richter scale, the ground motion increases by 10 times. The amount of energy released per whole number increase, however, goes up by a factor of 32.

Advanced National Seismic System (ANSS)

According to the USGS, "the mission of ANSS is to provide accurate and timely data and information products for seismic events, including their effects on buildings and structures, employing modern monitoring methods and technologies."³⁹ If fully implemented, ANSS would encompass more than 7,000 earthquake sensor systems covering portions of the nation that are vulnerable to earthquake hazards.⁴⁰ As envisioned, the system would consist of dense urban networks, regional networks, and backbone stations.

Detection, Notification, and Warning

Unlike other natural hazards, such as hurricanes, where predicting the location and timing of landfall is becoming increasingly accurate, the scientific understanding of earthquakes does not yet allow for precise earthquake prediction. Instead, notification and warning typically

involves communicating the location and magnitude of an earthquake as soon as possible after the event to emergency response providers and others who need the information. Some probabilistic earthquake forecasts are now available that give, for example, a 24-hour probability of earthquake aftershocks for a particular region, such as California. These forecasts are not predictions, and are currently intended to increase public awareness of the seismic hazard, improve emergency response, and increase scientific understanding of the short-term hazard.

Network for Earthquake Engineering Simulation

Through its Engineering Directorate, NSF funds the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES), a project intended to operate until 2014, aimed at understanding the effects of earthquakes on structures and materials.⁶¹ To achieve the program's goal, the NEES facilities conduct experiments and computer simulations of how buildings, bridges, utilities, coastal regions, and materials behave during an earthquake. In the first six years of operations since 2004, 160 multiyear projects have been completed or are in progress under NEES.

Conclusion

A precise relationship between earthquake mitigation measures, NEHRP and other federal earthquake-related activities, such as earthquake research, and reduced losses from an actual earthquake may never be possible. However, as more accurate seismic hazard maps evolve, as understanding of the relationship between ground motion and building safety improves, and as new tools for issuing warnings and alerts such as ShakeMap and PAGER are devised, trends denoting the effectiveness of mitigation strategies and earthquake research and other activities may emerge more clearly. Without an ability to precisely predict earthquakes, Congress is likely to face an ongoing challenge in determining the most effective federal approach to increasing the nation's resilience to low-probability but high-impact major earthquakes.

Reference

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