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inside: quarterly report

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Movers and Shakers

Seismologists create an early warning system to alert Californians before an earthquake occurs.

Earthquakes are unlike hurricanes or floods because they can't be predicted. But what if there was warning system to alert residents that the ground would start shaking in 10 to 15 seconds? Although this doesn't sound like very much time, it would provide the opportunity for:

- people to move out of a hazardous environment;
- technology to go into safe mode or save an important document;
- elevators to stop at the next floor and open their doors;
- trains to decelerate; and
- alarms to sound in operating rooms so doctors can put down potentially dangerous tools.

In only 15 seconds, people would have the opportunity to improve their safety and prevent data loss. This is what seismologists and the U.S. Geological Survey (USGS) are trying to provide California residents — a publicly available early warning earthquake system.

"The idea is that you detect the beginnings of the earthquake, and then you rapidly assess the magnitude that earthquake poses, and provide a warning to people before the shaking starts," said Richard Allen, seismology professor at the University of California (UC), Berkeley. "We're talking about very short periods of time — a few seconds to a few tens of seconds."

The combination of new technologies and expanded understanding about earthquakes is letting seismologists move closer to issuing public alerts before people feel the first tremor. "There's a recognized need for more rapid earthquake information, particularly in our digital age," said David Oppenheimer, a seismologist for the USGS. "There are certain applications that could be used with earthquake early warning to mitigate the impacts of an earthquake. That's our mission."

SYNOPSIS
Seismologists test a network of sensors designed to warn California residents a few seconds before an earthquake strikes.

AGENCY
U.S. Geological Survey; Swiss Seismological Institute; Southern California Earthquake Center; and University of California, Berkeley.

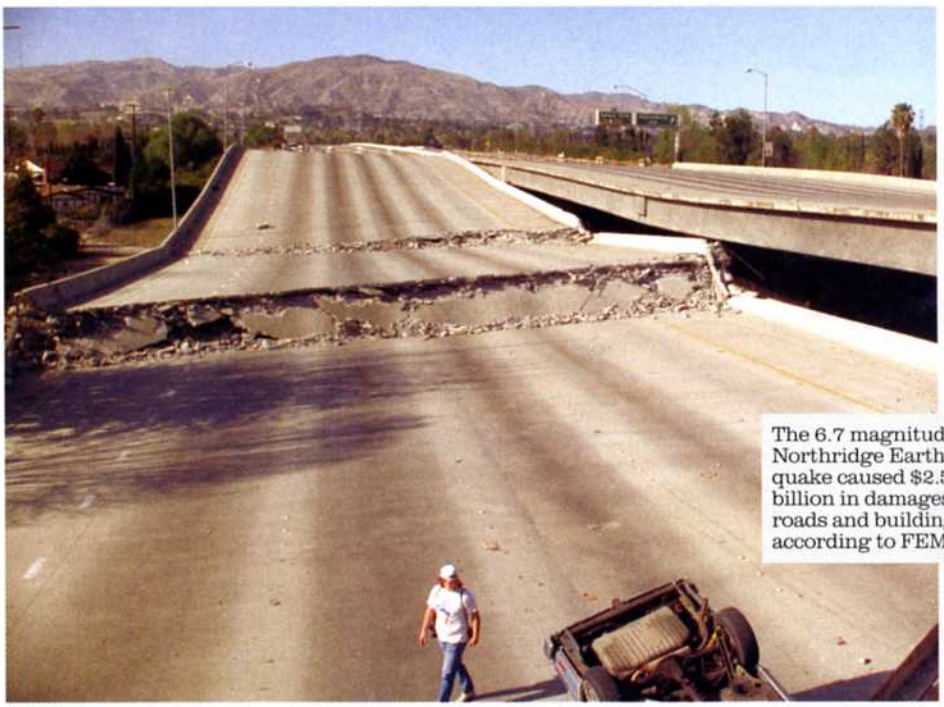


PHOTO COURTESY OF FEMA

The 6.7 magnitude Northridge Earthquake caused $2.5 billion in damages to roads and buildings, according to FEMA.

Proof of Concept

Earthquake early warning isn't a new idea. On Oct. 1, 2007, the Japan Meteorological Agency launched the most advanced early warning system to date, which provides alerts through media outlets and Internet applications when an earthquake is detected. Systems also have been established in Mexico City, Turkey, Taiwan and Romania, Allen said.

10-15 SECONDS
The amount of time the early warning system would give residents to prepare for an earthquake.

Early warning systems detect primary waves, the first tremors of an earthquake that travel at about 1 to 5 mph in the Earth's crust, according to the Nevada Seismological Lab at the University of Nevada. The damage comes from the next round of waves, called shear or secondary waves, which can topple buildings and cause the damage associated with large temblors. These "s-waves" move more slowly than their predecessors, which provides a window of time in which the public could be alerted. The time between the two sets of waves is fairly constant, which lets seismologists estimate when the ground will begin shaking in a given area.

In August 2006, the USGS funded a $900,000 project to take the algorithms that various groups had developed for earthquake prediction and get them running on real-time seismic systems. The effort is a collaboration among the USGS, Swiss Seismological Institute, Southern California Earthquake Center and UC Berkeley. Seismologists monitored the

performance of three algorithms that are running statewide in California, according to Allen. He said the algorithms constantly detect earthquakes and accurately predicted the two largest quakes during the three-year test period. They were magnitude 5.4 earthquakes, one in the San Francisco Bay Area and one in the Los Angeles region.

The initial test period proved the concept was technically feasible. In August 2009, phase two began as another three-year project funded by the USGS for $1.2 million. "The goal of this three-year project is to develop a prototype warning system that actually provides warning to a small group of users, maybe 10 institutional users," Allen said. "So we're currently in the process of taking the best from each of these three algorithms and combining them into a single algorithm that will form this prototype."

When completed, the pilot system, called the California Integrated Seismic Network ShakeAlert System, will send a warning to the test user group comprising emergency response groups, utilities and transportation agencies.

Going Underground

The early warning system consists of seismic networks that are distributed throughout California. The instruments are buried approximately 3 to 7 feet underground. "They're all across the state, they're very sensitive to ground vibrations, they easily detect earthquakes on the other side of the planet," Allen said. "So when there's an earthquake close by, they easily detect it and send that signal to us for processing."

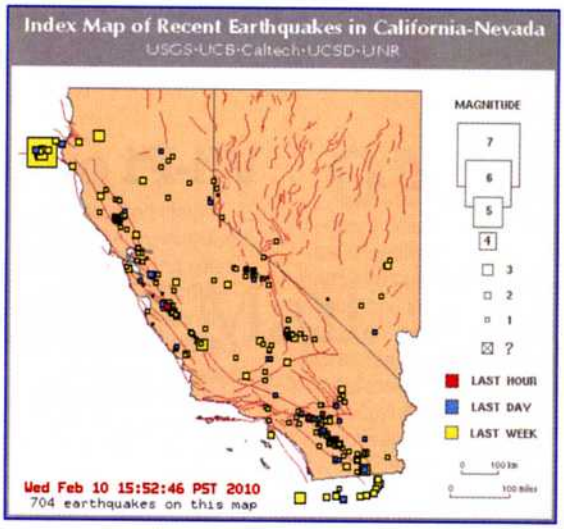
He estimated that there are more than 3,000 seismic instruments located in California. But only about 400 of those are sophisticated enough to work with the early warning system. Allen said the system becomes better as more seismic stations are connected to the network. California needs about 100 additional stations to fully utilize the system and provide warnings to all communities.

"The more seismic stations you have, the faster you can detect the earthquake because you will have a seismic station closer to the epicenter," Allen said. "And the faster you have multiple stations detecting the earthquake, the system becomes more accurate and more robust."

Most seismic stations are located near San Francisco and Los Angeles, leaving gaps in other areas of the state. Adding seismic stations would increase the number of earthquake warnings residents would get.

Cost is the major barrier to implementing a publicly available early warning system. Allen estimated that it would take $80 million to install additional seismic stations, create a control center and run the entire operation for five years.

Another challenge is that California cities have been built directly above where earthquakes happen. By contrast, Japan and Mexico have subduction zones that are located offshore, so they can deploy seismometers along the coastline, Allen said. This allows warnings to be publicized with more advance notice than earthquakes that originate on the mainland. "In our case we need to detect that earthquake as soon as the p-waves, the first energy coming from the earthquake, reach the surface," he said. "That's why our system has to be as rapid as possible."



704 The number of earthquakes that occurred on Feb. 10, 2010, according to a real-time map available on usgs.gov.

Digital Age

The USGS is funding the seismology part of the project, Oppenheimer said, to produce a system that's reliable, accurate and optimally has no false alarms. The next step hasn't been taken yet, which will develop the delivery mechanisms that will alert the public and automate precautions to keep people safe, like decelerating Bay Area Rapid Transit trains.

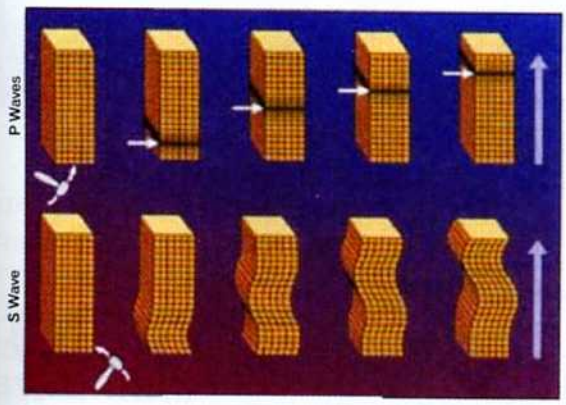
"The prototype period will be over in 2013. At that point, we'll probably start talking about delivery mechanisms," Oppenheimer said. "Some of it will definitely go over the Internet. It could be wireless, but we'd have to think about that."

Oppenheimer said the alerts couldn't be delivered via text message because it takes most people too long to find their cell phone, open it and press the buttons to view the message. Something may have to be developed that causes portable devices to enunciate the alert.

Another option could be something like Japan's Internet-based warning application. The application pops up a message on a computer screen once it receives the alert and counts down to when the shaking is forecasted.

But even the best warning system can't prevent earthquake damage. "It's important to remember that earthquake mitigation really revolves around improving our infrastructure," Oppenheimer said, "and this shouldn't be looked at as a solution to at-risk structures that we live in." GT

Body Waves



EARTHQUAKE ABCs

A **P wave**, or compressional wave, is a seismic body wave that shakes the ground back and forth in the same direction and the opposite direction as the direction the wave is moving.

An **S wave**, or shear wave, is a seismic body wave that shakes the ground back and forth perpendicular to the direction the wave is moving.

SOURCE: U.S. GEOLOGICAL SURVEY