WESTERN STATES SEISMIC POLICY COUNCIL
POLICY RECOMMENDATION 10-9

Earthquake Early Warning Systems

Policy Recommendation 10-9

WSSPC supports the development of earthquake early warning systems in those states or regions with high seismic risk and a seismic network that can, or can be enhanced to, support an early warning capability.

Background

Earthquake early warning differs from earthquake prediction in that an earthquake prediction provides the time, location, magnitude and probability of occurrence of an earthquake, that is, an earthquake that is expected to occur hours, days, weeks or years in the future. In contrast, earthquake early warnings are issued as the earthquake is occurring and provide alerts to people and communities that have not yet experienced ground motion from the earthquake. Earthquake early warnings are possible because earthquakes produce differing types of waves that travel at different speeds. The faster P waves travel at about 6.5 kilometers per second and are first to arrive at seismic monitoring stations. Although they are of low amplitude and unlikely to cause damage, these P waves contain important information about the size and location of an evolving seismic sequence. Slower moving S waves (3.5 km per second) arrive after the P waves and cause more intense shaking capable of damage to buildings and infrastructure.

Based on information from the earlier arriving P waves, the expected maximum shaking can be estimated through rapid analysis and alerts can be issued to communities likely to be impacted by the earthquake. These alerts can be transmitted at the speed of light so communities that are distant from the earthquake epicenter but vulnerable to strong motion may receive a few to a few tens of seconds warning prior to the arrival of damaging S waves. Alert times vary from almost no warning in the area nearest the epicenter to 60-80 seconds in areas at some distance from the epicenter. As implied in this description, earthquake early warnings are of greatest benefit in large, though rare, major earthquakes in which regions remote from the epicenter are vulnerable to very strong ground motions from an earthquake.

A nationwide earthquake early warning system was implemented in Japan on October 1, 2007. The system is based on Japan's extensive and dense seismic and strong motion networks that were enhanced following the January 17, 1995 Hanshin-Awaji (Kobe) earthquake. Japan's earthquake early warning system has been gradually deployed and warnings are received through computers, the media and signaling devices installed in homes, critical facilities and businesses. Early warnings are used to slow or stop trains, alert drivers of motor vehicles, control elevators (to prevent people being trapped), regulate industrial processes and notify people at home or work that they should move away from hazards and protect themselves. Limited systems are in place in Mexico, Turkey, Italy and Greece and Taiwan plans to introduce a system like Japan's in the near future.

Although the United States has followed scientific and technological developments in other nations, it has not yet implemented an earthquake early warning system anywhere on U.S. soil. Currently, the U.S. Geological Survey is providing funding for the development of early warning algorithms and discussions among scientists, engineers and emergency managers on the topic have intensified over the last 2 years. A little known early experiment with earthquake early warning took place in the days and weeks following the Loma Prieta Earthquake of October 17, 1989. Within a few days after the M6.9 main shock, portable instruments were installed at three locations near the epicenter of the earthquake and early warnings of aftershocks were transmitted to search and rescue workers at the I-880 Freeway collapse, and later, to those doing demolition work on that structure (Bakun *et al.*, 1994). The system was in place for approximately six months, then dismantled.

Although earthquake early warning systems should not be advocated at the expense of hazard education, preparedness activities and programs of mitigation, earthquake early warning systems, if implemented, have the potential to save lives, reduce damage and limit down time particularly for large regional earthquakes. Those states that have urban populations and infrastructure vulnerable to major earthquakes as well as modern digital seismic and strong motion networks may consider earthquake early warning as another useful tool for addressing the earthquake hazard. Earthquakes are often described as hazards without warnings, but seismic-network-based early warning systems could provide an alert with sufficient time to implement life safety actions and rapid mitigation.

Facilitation and Communication

WSSPC recommends that its members establish state level working or study groups on earthquake early warning that include interested scientists, engineers and emergency managers. These working groups will serve in several capacities: as clearinghouses of information on this new technology and as a body of experts who are able to speak on the subject at scientific and emergency management meetings; to assess the need for seismic and strong motion network enhancement or upgrades to support earthquake early warning; to identify local areas within states where earthquake early warning system deployment is feasible or functions to which early warning will be applied; to address the broader policy issues of the organization and management of an earthquake early warning system; and, serve as advocates for earthquake early warning before legislative bodies, the media and the public.

Earthquake early warning technical prerequisites include dense station coverage, modern digital seismic and strong motion stations, real-time telemetry from stations to a central processing site and algorithms to rapidly analyze an evolving seismic sequence. High sample rate GPS and other rapid analysis technologies may also be useful. Within the working groups, earth science representatives must take the lead in assessing existing networks and recommend modifications, as necessary, to support an earthquake early warning capability. Scientists and engineers within the working groups will be essential in developing proposals to funding agencies to implement network enhancements that will facilitate the development of earthquake early warning systems. It should also be noted that enhancements to regional networks and the Advanced National Seismic System (ANSS) will yield benefits in addition to earthquake early warning capability, benefits that include more rapid and accurate source information and ShakeMaps.

Given resource limitations and considerations, choices may be required regarding where an earthquake early warning system will be deployed, including what processes or functions will be affected. In most cases, earthquake early warning systems will be deployed in areas that will potentially protect the largest number of people or in areas that include critical infrastructure. Japan introduced earthquake early warning decades ago to slow or stop high speed trains (Shinkansen) that might be derailed by strong ground motion in an earthquake.

Earthquake early warning systems involve far more than the technical capacity to issue early warnings, so working groups should provide a forum for discussions of how an early warning system will operate and be managed. Basic questions include: what agency will have lead responsibility for the system? What will be the division of labor between science agencies, seismic and strong motion network operators, emergency management organizations, private consultants and others? How will issues of legal authorities and liabilities be managed? The working groups should include both scientists and emergency managers who can speak on behalf of the technology at scientific meetings, meetings of emergency services personnel and provide clear and cogent explanations of the working of an earthquake early warning system to the media and public.

Finally, the working groups should think strategically about implementation of an earthquake early warning system by developing a long-term plan. This plan should include all of the elements discussed in this section as well as articulate a process for achieving a working earthquake early warning system. The plan may include model legislation or a proposal that includes goals, objectives and costs of implementation.

Assessment

Measures of the success of this Policy Recommendation will be (1) the number of WSSPC members that form earthquake early warning working or study groups, and (2) the number of WSSPC member states that implement earthquake early warning systems. A periodic assessment should be made to determine whether working groups have been formed and whether early warning systems have been developed or are being considered. WSSPC will post information on state efforts to implement earthquake early warning systems on the WSSPC website.

History

Policy Recommendation 10-9 was adopted unanimously by voice vote of the WSSPC members at the July 9, 2010 Annual Business Meeting in Broomfield, Colorado.

Reference Cited

W.H. Bakun, F. G. Fischer, E.G. Jensen, and J. VanSchaack, April 1994, Early Warning System for Aftershocks: *Bulletin of the Seismological Society of America*, V. 84, No. 2, p. 359-365.