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Technologies of Earthquake Early Warning Systems: Prediction and Prevention

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Abstract: Destructive shaking movements triggered by earthquakes can cause significant losses such as human sacrifice, house damage and property loss. Sichuan earthquake of 2008, happened in southwestern China, caused over 69,000 death and 374,176 injured [1]. It is not just the earthquake itself that is deadly, the subsequent debris flows and plagues deprived more lives. For instance, outbreaks of the Plague of Justinian occur months or even up to a year after high-magnitude earthquakes. Large earthquakes initiate chains of surface and underground processes that last much longer than the brief moments of strong shaking [2]. Earthquake induced geohazards, including landslides in mountainous regions, floods from temporary lakes, plague after major rainfalls, remain a significant threat [2]. Even extreme geohazard like volcanic eruption can be triggered by earthquakes. An apparent question is raised: 'what if we can predict shaking with previous seconds of warning once an earthquake rupture begins?'. Earthquake early warning (EEW) system shows us the answer, using seismic knowledge and the technology of monitoring systems to alert devices when shaking waves generated by an earthquake appeared (USGS, 2012). Accurate prediction of earthquake can give people more time to prepare for shaking and the geohazard events it triggers. Governments should provide more resources to EEW to reduce earthquake damage to people and property, especially in poor countries where the education about disaster prevention is immature.

Keywords: Earthquake; Induced Geohazards; EEWs; Reduce Damage

1. Research Background: Basic idea of earthquake early warnings

Earthquake early warning is the rapid detection of earthquakes, real-time assessment of the shaking hazard, and notification of people in the area of shaking (Berkeley Seismology Lab). The philosophy of early warning is to give people enough time to evacuate from the danger zone. This time period is referred to as 'the golden time' [3]. When an earthquake occurs, two different waves are generated, P waves and S waves with a speed of 0.5 to 3 miles per second. Seismic waves release energy moves through Earth's crust and cause the shaking we feel at the affected area. After non-damaging P-waves are detected by sensors, the damaging S-waves arrive. This delay between the arrival of P waves and S waves gives us a chance to forecast the shaking intensity at locations away from the epicenter within seconds to minutes. The accurate amount of time it can give us depends on many factors: your distance away from the epicenter, the degree of the earthquake and the delay between P and S waves. The notification obtained by earthquake observation network and seismic intensity meters provides residents with earthquake early warnings.

Earthquake early warnings can benefit many social groups in wealthy countries. Japan, we know, is a country full of earthquakes. So how do the Japanese reduce losses through earthquake early warnings? There is an example of JMA (Japan Meteorological Agency) which provides an earthquake observation network comprised of about 200 seismographs and 600 seismic intensity meters (JMA, 2012). It is not enough for Japan to build its comprehensive early warning system. It also collects data from over 3600 seismic intensity meters managed by local governments and NIED (National research institute for earth science and disaster prevention). In contrast, the early warning system in poor countries appears to be inadequate. They do not have enough budget to invest in these projects, and the constraints brought by high-tech are not satisfied. The optimization of the technology required by EEWs can improve this situation by reducing costs and lowering certain

conditions. Also, the education is immature in those countries which means people may not know how to respond correctly when they receive the warnings.

2. Advantages of people-centered technologies for EEWs

Early warning systems for earthquakes need to have not only a sound scientific and technical basis, but also a strong focus on the people exposed to risk [4]. To be effective, there should be a system to incorporate all relevant factors (techniques, scientific theories, people themselves) together when creating a feasible prediction model. Early warning, meaning the provision of information on an emerging dangerous situation where that information can effectively reduce the risks involved [4]. According to Basher (2006), the interacting elements needed by an early warning system are risk knowledge, monitoring and warning service, dissemination and communication, response capability [4]. The first part, namely risk knowledge, includes not only the mechanism of relevant hazards, but also the vulnerabilities of people and society to these hazards. People need to know what exact type of population (including residence, lifestyle, occupation, etc.) is affected most by various type of seismic hazards. Monitoring and warning service are the technical capacity to show precursor and forecasting of earthquakes. Next portion is about dissemination of possible warnings and prior preparedness to those risks. This people-centered technology can somehow improve the basic understandings of the upcoming hazards. Scientists will make the To-Do list and use proper way to disseminate.

3. Advantages of using ocean bottom seismometers

Another prominent improvement of technology in tracking earthquakes is the land-sea experiment to deploy ocean bottom seismometers. According to UW news (2017), the National Science Foundation is funding the largest marine seismic-monitoring effort along the Alaska Peninsula. This technology is also used to forecast the potential earthquakes in British Columbia which is located on the Pacific Ring of Fire. This region is famous for thousands of annually recorded earthquakes, many occurring near the Cascadia Subduction Zone (convergent boundaries between Juan de Fuca and North American tectonic plates). Ocean bottom seismometers (OBSs) instrumentation provides us a method to effectively predict megathrust earthquakes caused by above type of geological settings. About 71 percent of earth's surface is covered by water, thus making it impossible to investigate the whole earth's movement simply by land stations. The first OBSs were laid on the seafloor by US researchers in 1937 [5]. Then, a brand-new system was developed in 1939 which incorporated timers with OBSs and seismic sources dropped to the bottom separately. Another essential need for this project is to work together at all levels, from local to international [6]. This leads to a hypothesis: what if the poor countries can keep up with the footsteps of those developed countries and participate in those group they build. Although this action might not be smooth sailing, but the result is worth trying.

4. Counter arguments and rebuttal about recovery policies

Although we list many advantages in previous sections, others may still think recovery policies can work more efficiently in mitigating earthquake damage. Those who hold this idea basically focus on the limitation and challenges of early warning systems. The golden time is restricted by many other factors, like communication method, delay time and population, etc. A concept called the failure of early warning administrative chain appears. This is a particular issue that a large number of social-based agencies (local earthquake administration, local community, local management committee) involved in the branched component of the early warning chain [3]. The mechanism of early warning dissemination is like an interlocking chain. Any problem at any stage will affect the efficiency and final result of hazard prevention.

In addition, people may not have appropriate experience or knowledge to deal with the signal passed by the early warning system. People may be in a hurry and take the elevator when an earthquake occurs; people may hide under easily collapsed walls; people may push each other while walking downstairs and cause additional casualties. Without knowing how to respond, people can easily fall into panic and cause unexpected harm. Faced with the above arguments, one can only say that it is still a long way to complete the entire prediction and prevention system.

Although the early warning system cannot avoid various losses caused by earthquake disasters, there will be

no reduced loss if we do nothing.

Conclusion

The government should undoubtedly and strongly support the construction of EEWs which provide people with golden time to respond to possible geohazards. This ten of seconds or even a few minutes will greatly reduce the loss caused by the disaster. Many of these factors (communication methods, detecting technologies, etc.) will work better if they can rely on the power of government. Only with the support of the government, the earthquake monitoring network can be refined, and earthquake early warnings can be effective, just like the developed countries have done.

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