

Earthquake hazards prediction

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ABSTRACT

Countries and areas in Asia and Oceania have suffered from large earthquake and tsunami disasters. The 2005 Kashmir earthquake occurring in northern Pakistan flattened almost all houses and structures due to strong shaking in towns near the source areas, killing more than 80,000 people. The 2004 Aceh earthquake occurring north-west off the Sumatra Island generated catastrophic tsunamis that hit coastal areas in the Indian Ocean as well as Indonesia where more than 200,000 people were killed. Those earthquakes taught us the importance of earthquake hazard prediction as well as warning systems for tsunami. In Japan, we experienced more than 6,400 dead or missing and 100,000 totally collapsed buildings during the 1995 Kobe earthquake, which are the greatest damage in Japan since the great Kanto earthquake of 1923.

One of the lessons from the 1995 Kobe earthquake we learned is the importance of evaluating strong ground motions from future earthquakes to mitigate earthquake damage in urbanized areas surrounded by active faults and located close to subduction-zone earthquakes. The basic policy of preparation for earthquake hazards in Japan was defined as the 1999 fundamental mission statement governing earthquake research over the next ten years as “The promotion of earthquake research – comprehensive basic policies for the promotion of seismic research through the observation, measurement, and survey of earthquakes –”, established by the Headquarters for Earthquake Research Promotion (Director: Ministry of Education, Culture, Sports, Science, and Technology). It proposed developments of making seismic hazard maps by promoting the survey of active faults, long-term evaluation of occurrence potentials and prediction of strong ground motion.

The Earthquake Research Committee under the Headquarter started to make the seismic hazard maps from two different approaches, probabilistic and deterministic. The probabilistic seismic hazard map is shown as the predicted likelihood of a ground motion level such as PGA, PGV, and seismic intensity occurring in a given area within a set period of time. It provides important information for land planning, design standards of structures and people’s enlightening as to seismic risks. The deterministic seismic hazard map is shown as the distribution of the ground motion level predicted for a specific earthquake fault. The strong ground motions at specific sites near the source fault should be estimated as time histories as

well as shaking levels. The ground motion time histories are effectively used for nonlinear dynamic analysis of structures, which are needed to design earthquake-resistant buildings, bridges, lifelines, and so on, in particular to secure seismic safety of critical structures such as and nuclear power plants.

To obtain the ground motion time histories (waveforms) from individual specific earthquakes, we have developed a new methodology, “recipe of strong motion prediction”. This recipe give source modeling for specific earthquakes based on source characteristics from the waveform inversion using strong motion data. Main features of the source model are characterized by three kinds of parameters, which we call: outer, inner, and extra fault parameters. The outer fault parameters are to outline the overall pictures of the target earthquakes such as entire source area and seismic moment. The inner fault parameters are parameters characterizing stress heterogeneity inside the fault area. The extra fault parameters are considered to complete the source model such as the starting point and propagation pattern of the rupture. The validity and applicability of the procedures for characterizing the earthquake sources for strong ground prediction are examined in comparison with the observed records and broad-band simulated motions for recent earthquakes such as the 1995 Kobe and the 2003 Tokachi-Oki earthquakes. In future directions, prediction of strong ground motions are encouraged to constrain fault parameters physically taking into account the source dynamics as well as empirically from past earthquakes.