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Fundamental analysis on quantification of aftershock ground motion hazard

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The Aftershocks of the recent giant earthquakes have caused severe societal consequences in terms of fatalities and casualties, and business interruption. For example, in the 2011 Christchurch earthquake and the 2011 Van earthquake, destruction of buildings due to aftershocks caused a number of casualties. Intermittent aftershocks of the 2004 Chuetsu earthquake affected business continuity. As to the Tohoku earthquake in 2011, the influence of aftershocks was widespread, including, e.g. landslides, tsunamis, fires, power failures, and the closure of railroads and highways. Aftershocks also affect decisions on evacuation, recovery, and business continuity activities. The aftershock hazard is the prime point to be considered for rational decision-making process in the post-mainshock environment. Quantitative analysis of aftershock hazard is required to improve rational decision-making capability in the post-mainshock environment, especially for the expected Tokai Tonankai and Nankai earthquakes.

The focus of our research is two-fold: (1) to clarify a probability distribution which can be applied to seismic intensities of aftershock by analyzing the 2011 Tohoku earthquake data and (2)to propose a framework to evaluate a probability model at each site. The aftershock ground motion records that were collected from Kyoshin Network (K-NET) for 142 days from March 11, 2011 were used in our research. A total of 62 observation stations located in Iwate, Miyagi, and Fukushima are selected. Peak Ground Velocity (PGV) is adopted as an index of seismic intensity. The data analysis employing probability paper plot and statistical goodness-of-fit test confirmed that the distributions of aftershock intensity agreed with Type II extreme value distribution (Frechet distribution). Then, a method to evaluate parameters of the aftershock probability distribution was discussed and suggested that the parameters can be evaluated from the main shock intensity at each station. The proposed method is considered useful to evaluate aftershock hazard immediately after mainshock.

Our research is, however, based on aftershock hazard for five months, and do not consider the fact that aftershocks decrease with increasing elapsed time from the occurrence of the mainshock. Integrating a time dependent factor (i.e., the modified Omori law) is considered as a future issue to be tackled. Clarifying periodic features of aftershock by analyzing response spectrum and analyzing aftershocks of other giant earthquakes are also considered future tasks.

Keywords: seismic hazard analysis, aftershock, probabilistic method, the 2011 Tohoku earthquake