

Dynamic source modeling under stress distribution derived from geological and geomorphological data

*Yuko Kase¹, Haruko Sekiguchi²

1. Geological Survey of Japan, AIST, 2. Disaster Prevention Research Institute, Kyoto Univ.

Strong ground motion prediction needs realistic earthquake scenarios with characteristics of earthquakes occurring on source faults. We have proposed methods for constructing source models with realistic locations of asperities and rupture propagation by numerical simulations of dynamic rupture under constraints derived from geological and geographical data for the Uemachi fault system (Sekiguchi et al., 2003; Sekiguchi et al., 2005; Kase and Sekiguchi, 2013). Here we assume that variations of earthquakes occurring repeatedly on a certain fault are limited, but not to only one characteristic earthquake. We apply our method to possible sources of earthquake occurring on the Uemachi fault zone using 3-D geometry of the fault plane and average uplift rate distribution along the fault trace, and calculate ground motion distributions.

We adopt a shape of the fault plane by Kimura et al. (2012) that is estimated from the flexure structure of the sedimentary layer in the hanging wall. We estimate the loading stress distribution on that fault plane using the uplift rate distribution evaluated from the gap of sedimentary layers across the fault trace identified from 2 m digital elevation model data by Kondo et al. (2015). We add small-scale heterogeneity based on the k^{-1} stress drop distribution model (e.g., Andrews, 1980) on to the loading stress distribution. We assume that the regional stress distribution on the fault is equal to a stress distribution just after an earthquake, and calculate a distribution of the dynamic coefficient of friction. We also assume the static coefficient of friction, adding a constant to the dynamic coefficient of friction. Therefore, a rupture spontaneously initiates from the area where the initial shear stress is larger than the initial static frictional stress. The source processes are simulated by a finite-difference method (Kase, 2010), which calculate the spontaneous rupture propagation on the fault plane under the constraints of the stress distribution model and the slip-weakening constitutive law (e.g., Andrews, 1976).

We convert the slip distribution on the fault whose uplift is matched with the observed value in the northern part of the Uemachi fault zone into the stress change distribution, using Okada (1992), and then calculate plural rupture scenarios changing random numbers to generate small-scale heterogeneity of stress distribution. We observe that there is a portion in the central part of the Uemachi fault zone that decelerates the rupture propagation, probably because of the three-dimensional shape of the fault surface and the heterogeneous stress distribution. The rupture process depends on the small-scale heterogeneity of the loading stress distribution model. Two types of hypocenter locations and two types of rupture areas are typically obtained: ruptures initiate in the northern or southern part of the fault, and they propagate on the whole fault plane or only half of the fault. In the case of events that ruptured the whole fault plane, the final slip distribution suggests two asperities in the northern and southern parts, which are likely due to the two-peak distribution of the uplift rate.

We also model earthquake cycle, accumulating stress on the fault to the residual stress just after an event. The hypocenter locations are stable, which are observed in the northern or southern part. In most of the cycles, two types of events which rupture only the northern or southern half of the fault occur by turns. The events rupturing the whole fault occur only occasionally.

Keywords: dynamic rupture, Uemachi fault zone, ground motion prediction, geomorphology, geology