# Simulation of dynamic and static displacements in the source area of the 2008 Iwate-Miyagi Nairiku earthquake

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Ground displacements as well as strong accelerations at large earthquakes could cause severe damages and disruptions to civil structures located near the source faults. At recent inland earthquakes such as the 1999 Chi-Chi, 1999 Kocaeli, 2008 Wenchuan, and 2016 Kumamoto earthquakes, infrastructures such as dams, roads, tunnels, bridges, and pipelines were damaged by significant amounts of coseismic displacements and inclinations associated with fault rupture (e.g., Lee et al., 2002; Pamuk et al., 2005; Shirahama et al., 2016; Yang and Mavroeidis, 2018). In techtonically active areas, predictions and quantitative evaluations of such near-fault displacement including dynamic component would be significantly important for seismic hazard and engineering design. In this study, we evaluated the displacements based on the waveform simulation at the IWTH25 station that recorded the peak amplitude of more than 100 cm in the vertical component at the 2008 Iwate-Miyagi Nairiku earthquake (Aoi and Morikawa, 2009; Matsu’ ura and Kase, 2010; Fukuyama, 2015). We employed the 3D finite-difference method (Nakamura et al., 2012) with fine grids and the reciprocity theorem for an efficient modeling. We produced stochastic slip distribution models that are generated from the finite-fault source inversion results of the 2008 earthquake (Suzuki et al., 2010) based on the slip probability density function by Murphy et al. (2016) for our simulation. The seismic moment of each generated model is equal to the reference one.

Our simulation results show that the static amplitude, which is the mean amplitude in the tail part of the waveform, for 100 models for the rupture velocity Vr=1.6 km/s is 120±24 cm at the IWTH25 borehole station. The amplitude highly correlates with slip amounts in deep parts on the fault plane around the hypocenter, which corresponds to the location below the station and is consistent with the possible source location of 4g accelerations observed at the IWTH25 ground station imaged by Suzuki et al. (2010), while less sensitive to ones in the shallower parts with the largest slip in the reference source model. Our simulation results by using other stochastic slip distributions that were generated from another kinematic model of Asano and Iwata (2011) also demonstrate high and low correlations in the deep and shallow parts, respectively. Our results also show the peak amplitude of 132±26 cm in the waveform, indicating that the ratio of the peak to the static component at IWTH25 is 1.1. Because a sequence of overlapping of waves associated with Mo rate contributes to the amplification of pulse components at a station, the ratio is approximately proportional to the peak amplitude of the source time function in the entire fault. The parameter tests for the rupture velocity of 1.6 to 2.6 km/s result in a small but positive variation of the ratio of 1.1 to 1.2. At a surface station above the upper edge of the fault, about 7 km southeast of IWTH25, the amplitudes of the peak and static component for source models for Vr=1.6 km/s are 70±40 cm and 39±25 cm, respectively, and the ratio shows a large variation of 1.9 to 2.8 with Vr=1.6 to 2.6 km/s, indicating that the dynamic component is more dominant in the waveform than that at IWTH25 and very sensitive to the rupture velocity because of effects of the forward directivity, which cannot be evaluated from the static analyses. Our approach based on the 3D simulation for stochastic models is useful to quantitatively evaluate displacements including their variations due to uncertainties of source models and to constrain the occurrence condition and cause of large displacements.

 

Keywords: Iwate-Miyagi Nairiku earthquake, fault displacement, stochastic slip distribution, reciprocity theorem, finite-difference method