Long-period pulse and static displacement of the 2016 Kumamoto earthquake based on the comparison with prediction equations

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During the 2016 Kumamoto earthquake static displacement of 160 cm and long-period velocity-pulse with a period of 3 s are observed at Nishihara village strong motion station. We estimate static displacements and long-period pulses from strong motion records in the near fault region and compare them with previous prediction equations. In addition, we examine the relation between the observed data and rupture distance or the other parameters to aim for the improvement or development of the prediction equations.

Firstly, we derive velocity and displacement time history from acceleration time history of K-NET, KiK-net, JMA-95 type and local government strong motion records based on the method by Zahradnik and Plesinger (2005). Then we estimated the static displacement Dp, the period of velocity-pulse Tp and the PGV for the maximum Dp direction (Fling-P). The fault model by Ozawa et al. (2016) is used to compare with the previous equations.

Tp at 7 stations including Nishihara village stations are ranging from 2.4 to 3.3 s among 8 stations with |Rx| < 15km and Tp at the other station is 5.5 s. Tp at stations with 15km< |Rx| <30km are ranging from 5 to 10 s and become longer as the distance is longer. It is found that one bell-shape pulse is observed in the extremely near fault region but two pulses overlap and resultantly Tp become longer in the relatively far fault region. Tp predicted by Kamai et al.(2014) and Burks and Baker(2016) is 5.5 s and 3.9 s, respectively. We interpret that Tp is predicted longer than Tp observed in the stations with |Rx|<15km since these previous equations of Tp are modeled by only Mw. The equation by Kamai et al. was developed using only simulation data and the equation by Burks and Baker was developed using simulation data and historical records. Records at 37 stations with 50km
PGV of Fling-P component at Nishihara village is 277 cm/s. This is larger than the average plus the standard deviation of PGV equation by Si and Midorikawa (1999). The PGV ratios of Fling-P component to the orthogonal component are 2 or 2.5 times at three stations with Rrup <1km and become smaller to unity as Rrup is longer.

Kamai et al. and Burks and Baker developed Dp equations modeled by Mw and Rrup using the almost same data used for Tp equations. Dabaghi and Kiureghian (2014) showed a Dp equation modeled by Mw, Rx, fault width and depth of top fault by combining the equations by Dreger et al.(2011) and Abrahamson(2002). Predicted Dp by these equations are 80 to 90 cm at the distance of near 0 km. Dp observed at Nishihara village with the distance of near 0 km is 160 cm. However, Dp observed at the other stations with the distance of near 0 km are smaller than 80 cm and so the average of Dp observed at near 0 km is not so underestimated by the previous equations. When x/L, that it, ratio of the distance along the strike direction from the fault edge, is smaller, the observed Dp becomes smaller. Biasi et al.(2013) developed a rupture shape model for slip distribution using x/L as a parameter from point measurements of rupture displacement of 22 strike-slip ruptures. The rupture shape investigated after the Kumamoto earthquake (Shirahama et al.,2016) is consistent to Biasi et al.. The parameter x/L would be an explanatory variable to improve the Dp equation.

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Keywords: The 2016 Kumamoto earthquake, Long-period pulse, Static displacement, Prediction equation, Strong motion record, Peak ground velocity