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Improvement of Ground Motion Prediction Equation Utilizing Aftershock Records of the 2011 Tohoku Earthquake

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1. Introduction

Since the Kobe Earthquake in 1995, dense seismic observation has been deployed all over Japan. Ground motion prediction equations based on the records observed have been proposed, for an intensity measure such as acceleration response spectra. Though it is desirable that site-specific correction should be made, an single coefficient is usually used all over Japan partly because of insufficient number of records at each station, partly because of purpose of prediction applicable for all sites with some explanatory parameters regarding site conditions. Effect from earthquake source mechanism such as fault type should also be considered. Moreover, the uncertainty regarding wave propagation path should be taken into consideration for further improvement of ground motion prediction.

On 11 March 2011, the 2011 off the Pacific coast of Tohoku Earthquake occurred. Thousands of aftershocks occurred within half a year, and ample strong motion records were observed. Since lots of records from thousands of aftershocks occurred in quite wide sub-duction zones of an epicentral region of the main shock, taken at hundreds of KNET stations in Tohoku region are available in the present, these ample records must be fully utilized for studying effects of site, path and source mechanisms on the ground motion prediction.

In this paper, we correct an existing ground motion prediction equation in order to construct site (or area) specific ground motion prediction model at the Tohoku area, using the aftershock records (inter-plate earthquakes). Two corrections are made; one is the correction associated with site characteristics, and the other is the correction associated with the hypocenter location. The ordinary correction procedure based on statistical minimization of residual is applied for PGA (peak ground acceleration), PGV (peak ground velocity) or Sa (acceleration response spectrum). Then, the standard deviation of residuals is compared both for aftershocks and for past large earthquakes (hereafter, called test earthquakes) occurred in the same rupture zone of 2011 Tohoku Earthquake.

2. Results

2.1. PGA and PGV

For aftershocks, both two corrections, i.e. correction for site characteristics and for hypocenter location, improve the prediction accuracy, and the standard deviations decrease. Correction on hypocenter location reduces the standard deviation more than correction on site characteristics does. For test earthquakes, on the other hand, the standard deviation of the case with corrections tends to increase slightly. From this result, it is concluded that it seems to be difficult to apply the correction terms derived from the aftershock records directly to the past earthquakes.

2.2. Acceleration response spectrum

For aftershocks, the standard deviations become small at all periods both for site correction and the hypocenter location correction. For test earthquakes, the standard deviation increases for the shorter period. It is considered because this may come from the effect of the nonlinearity of the subsurface ground. The standard deviations of PGA and PGV are also larger even after site correction made in section 2.1, which may come from the same reason. Standard deviation after hypocenter location correction slightly decreases, though it is not as drastically as that for aftershocks. The possible reasons would be inaccuracy in hypocenter correction term based on spatial interpolation.

3. Summary

The correction terms calculated from the observed aftershock records of the 2011 off the Pacific coast of Tohoku Earthquake improve the accuracy of ground motion prediction to some extent for the past strong ground motions. The future work is to improve the accuracy in the short period. It is required that the number of aftershock records increases, effect of the nonlinearity of the subsurface ground is confirmed and the correction regarding hypocenter locations is reexamined.

Keywords: Ground motion prediction equation, aftershock records, site-correction