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A method of real-time prediction of main ground motions using vertical motions for the Earthquake Early Warning System

Susumu Kurahashi[1*], Kojiro Irikura[1]

[1]Aichi Institute of Technology

The Earthquake Early Warning system (EEW system) by JMA was successfully operated during the 2011 off the Pacific Coast or Tohoku Earthquake (the Tohoku Earthquake, Mw9.0). The estimated seismic intensity by the EEW system was in good agreement with the observed ones near the hypocenter of the mainshock (for example Miyagi and Fukushima Prefecture). However, in the Kanto region far away from the hypocenter, the estimated seismic intensity was clearly underestimated in comparison with the observed one. It is caused to the fact that the attenuation-distance relationships of PGV and PGA for such great earthquake are well expressed as a function of not epicentral distance but the shortest distance from site to source fault.

So far, we have found that the attenuation-distance relationships of both horizontal and vertical PGAs tend to have a certain level of saturation near the source faults during large inland earthquakes. Based on the above results, we proposed a method of providing the information about the rupture extension before the arrival of the main motions from large earthquakes to calculate seismic intensity in wide areas using this information (Kurahashi et al, 2010). The seismic intensity in further regions is calculated using the rupture extension and the attenuation-distance relationships. We found that vertical PGAs at stations near the source fault of the Tohoku earthquake have a certain level of saturation, although the saturation levels are changeable due to site effects.

Hoshiba (2012) proposed that the method of the ground motions prediction method using real time monitoring. This method can predict the S wave motions at an optional station using the S wave motions at a near station by a method based on Kirchhoff Fresnel integral method. Irikura and Kurahashi (2013) proposed the method of calculating S wave motions from P wave motions based on Hoshiba (2012). In order to calculate the S wave motions accurately using the above-mentioned P wave motions, we need to estimate frequency-dependent site effects. In order to calculate the site effect correction by real time, it is necessary to estimate the site effects by IIR filter.

In this study, we propose a method of calculating instantaneously the seismic intensity and the S wave motions using the vertical motions.

The IIR filter as a method to the site effect is estimated using the Hoshiba (2012) method. The procedure is as follows,

1) The frequency-dependent site effect is obtained by removing the source spectra and propagation-path effect from the observed records. The source spectra are obtained by the omega-squared model with seismic moment and corner frequency. Therefore, the site effect means amplification of ground motions between bedrock and Earth surface.

2) The frequency parameter of the IIR filter is decided considering the site effect as a target.

Keywords: real-time information, vertical acceleration, predicted S wave motions