Site amplification from coda waves in northeastern Honshu, Japan

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Introduction

Quantitative understanding of seismic amplification in near ground surface is important for the prediction of strong ground motion on the surface. The purpose of this study is to estimate site amplification factors in northeastern Honshu, Japan, where strong motions were recorded in 2008 Iwate-Miyagi Nairiku earthquake (M_{JMA}7.2) and an earthquake occurred in Northern Iwate on 24th July/2008 (M_{JMA}6.8).

We estimated site amplification factors in various frequency bands by using coda-normalization method (e.g. Phillips and Aki 1986). Coda waves that are the tail portion of a seismogram depend on source and site but are independent of path [Aki and Chouet 1975]. By using this distinguishing feature of coda waves, the coda normalization method can estimate site amplification factor without estimating the complexity of the path effects.

Data and Method

We used acceleration seismograms of local earthquakes observed at KiK-net stations (National Research Institute for Earth Science and Disaster Prevention [NIED]) in northeastern Honshu, Japan. The coda normalization method supposes uniform spatial distribution of coda wave energy. In order to satisfy this condition in many seismograms as possible, the event with short hypocentral distance is suitable for the analysis. The local events whose hypocentral distance is smaller than 100 km was used in this study.

Using bandpass-filtered (1-2Hz, 2-4Hz, 4-8Hz, 8-16Hz) seismograms obtained from KiK-net surface data, we made three-component root-mean-square envelopes. We estimated the site amplification factors from the coda waves of which the lapse time is from 70 s to 80 s. The spectral amplitude of coda wave A_{ij} is proportional to the product of source spectrum S_i and site amplification factor R_j. We decomposed source spectrum S_i and site amplification factor R_j from the coda amplitudes A_{ij} of many earthquakes with an inversion analysis. In order to obtain the stable solution, we assumed the average amplification factor over the stations is one.

Result

In low frequency band (1-2Hz), site amplification factors are small in Kitakami mountains (0.4-0.6 times from the average). On the other hand, site amplification factors are large in Sendai plain and Kitakami basin (about 3.5 times from the average). The site amplification factor in low-frequency band decreases with increasing the geological age. In high frequency band (8-16Hz), site amplification factors are small in backarc side and large in forearc side. It is not related to the geological age. A very large site amplification factor was obtained in 4 - 8 Hz band at IWTH02 (5.0 times from the average), where the largest PGA of all stations (1019gal) was observed in Northern Iwate earthquake.

Finally, we corrected PGA in each frequency band (1-2Hz, 2-4Hz, 4-8Hz, 8-16Hz) for 2008 Iwate-Miyagi Nairiku earthquake by using the estimated site amplification factors. Deviation of PGA attenuation became smaller than before the correction for all the frequency bands. For example, standard deviation from an attenuation relationship changed from 0.77 to 0.56 by the correction in 4 - 8 Hz band. This supports the reliability of our estimated site-amplification factors. We expect that seismic intensity and PGA in broad-band seismograms of scenario earthquakes are precisely evaluated by using the frequency-dependent site amplification factors estimated in this study.

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