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Synthesis of high-frequency ground motion based on information extracted from low-frequency ground motion

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1. Introduction

Broad-band ground motion computation of a scenario earthquake is generally based on the hybrid method that is the combination of deterministic approach in lower-frequency band and stochastic approach in higher-frequency band.

In the hybrid method, the low- and high-frequency (LF and HF, respectively) wave fields are generated through two different methods that are completely independent of each other, and are combined at the matching frequency. However, LF and HF wave fields are essentially not independent as long as they are from the same event. In this study, we focus on the relation among acceleration envelopes at different frequency bands, and attempt to synthesize HF ground motion using the information extracted from LF ground motion, aiming to propose a new method for broad-band ground motion prediction.

2. Method

Our study area is Kanto area. We use KiK-net borehole acceleration data and compute RMS envelope at four frequency bands: i) 0.5-1.0 Hz, ii) 1.0-2.0 Hz, iii) 2.0-4.0 Hz, iv) 4.0-8.0 Hz. Taking the ratio of the envelopes of adjacent bands, we find that the envelope ratios have stable shapes at each site. We use the envelope ratios as the empirical envelope-ratio characteristics to be combined with low-frequency envelope and random phase to synthesize HF ground motion. We have applied the method to M5-class earthquakes that occurred in the vicinity of Kanto area and successfully reproduced the observed HF ground motion (2011 SSJ Fall Meeting).

3. Toward ground motion prediction of M7-class earthquakes

We examine the application of the method for ground motion synthesis of M7-class earthquakes by analyzing interplate and intraslab earthquakes that occurred in the off Ibaraki prefecture region (M_{JMA} from 5.1 to 7.0) and northern Miyagi prefecture region (M_{JMA} from 4.5 to 7.0), respectively.

For the interplate earthquakes, the LF envelopes are rich in later-phases while HF envelopes show rapid attenuation that follows the S-wave strong motion part. The rates of attenuation of the envelope ratios show dependency on seismic moment; HF ground motion of a M7-class earthquake shows greater attenuation with respect to LF ground motion relative to M5-class earthquakes. It reflects long-period ground motion generated in both the source process and the propagation path, which is characteristic of large interplate earthquakes. Such dependency on seismic moment is not seen in the intraslab earthquakes. Magnitude-dependent envelope ratios should be modeled in order to be applied to M7-class ground motion prediction.

Keywords: broad-band ground motion prediction