Detection method of P-to-S converted waves from seismic bedrock using all-pass function deconvolved from receiver function

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Introduction : It is important for theoretical strong motion prediction to estimate S-wave velocity structure of sediments on the seismic bedrock with S-wave velocity of about 3 km/s. The time difference between P-waves and P-to-S converted waves from the seismic bedrock (PS-P time) is one of good information to construct the S-wave velocity structure. In this study a method to accurately estimate the PS-P time is proposed and applied to theoretical waves and strong motion records observed at two KiK-net stations (Satoh, 2005).

Methodology : Receiver function derived by Fourier inverse analysis of a complex Fourier spectral ratio (R/V) of radial to vertical components for P-wave has been used to estimate S-wave velocity structures of crust and mantle using far-field long-period P-waves (e.g., Langston, 1979). Kobayashi et al. (1998) applied this method to short-period strong motion records in order to estimate PS-P time using P-to-S converted waves from the seismic bedrock. Here I call the receiver function as the original RF. In my study, the R/V is deconvolved to minimum-phase-shift function and all-pass function by Izumi et al.'s method (1988, 1989). Receiver function derived by Fourier inverse analysis of the all-pass function (all-pass RF) is newly introduced to estimate the PS-P time.

Data : Strong motion records observed at two KiK-net stations (GIFH09 and AICH04) by September in 2003 are used. The hypocentral distances are from 50 km and 200 km. The P and S-wave velocity structures on the seismic bedrock are surveyed by PS logging by NIED. The seismic bedrock exists at depths of 700 m and 400 m at GIFH09 and AICH04, respectively.

Results : Firstly, it is shown by numerical experiments using theoretical waves that Fourier phase spectrum of all-path function is nearly linear phase and that the all-pass PF has a clear peak at the time which corresponds to the theoretical PS-P time. On the other hand, Fourier phase spectrum of R/V is not linear phase and the original RF has several peaks.

Then the validity of all-pass RF for the estimation of PS-P time is shown by using the observed records. The upper figures compare the original RFs and the all-pass RFs, both of which are filtered between 1 to 5 Hz, for five earthquakes. Every original RF has several peaks. Every all-pass RF has a clear peak at the time, which corresponds to the theoretical PS-P time of about 0.5 sec. The RFs stacking of all RFs are shown in the lower figures. After stacking, the time with the maximum peak in both the original RF and the all-pass RF correspond to the theoretical PS-P time. However, the stacking original RF has two clear peaks, while the stacking all-pass RF has only one clear peak. The percentage of wrong estimations decrease from 16 % to 0 % at GIFH09 and 37 % to 10 % at AICH04 by using the all-pass RF for each earthquake. When the records whose peak ground accelerations of P-waves are larger than 1 cm/s/s are selected, correct PS-P time is estimated from every all-pass RF even at AICH04.

Conclusions : It is shown that the PS-P time is well estimated from an all-pass RF without stacking of RFs of many records. Therefore the proposed method is applicable even if few records are available.

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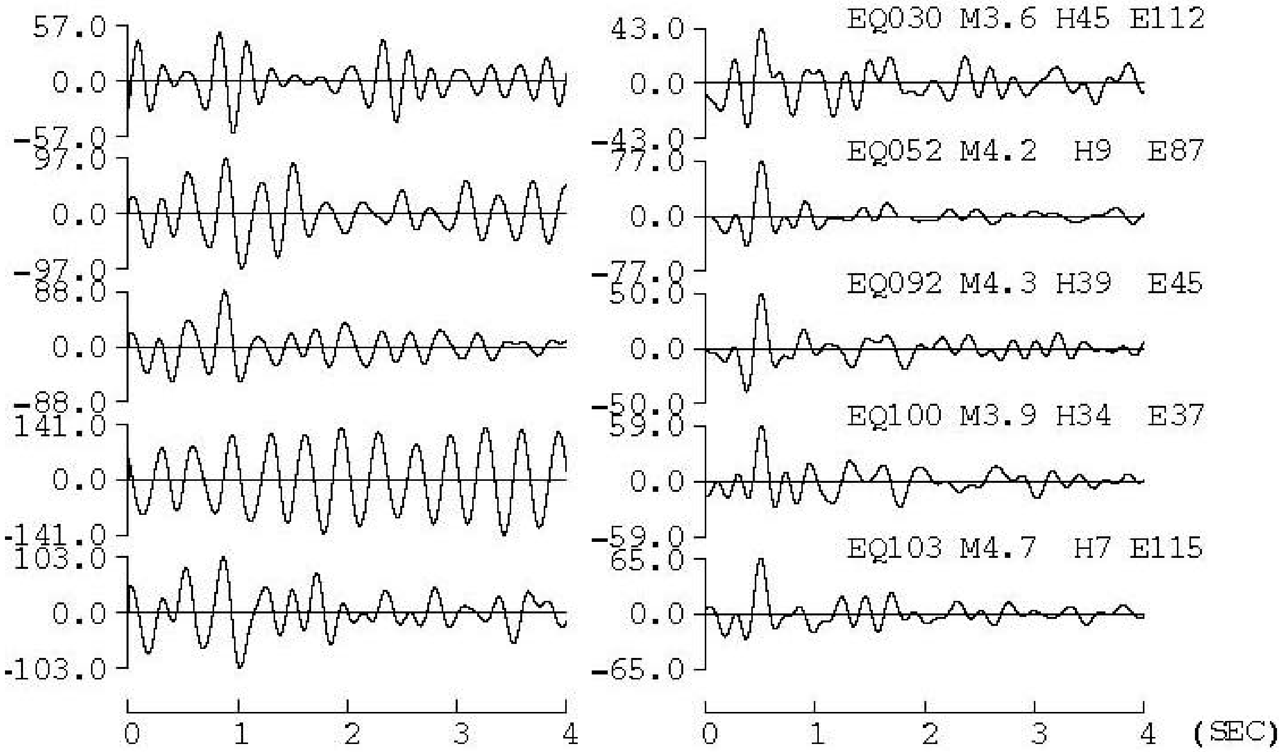
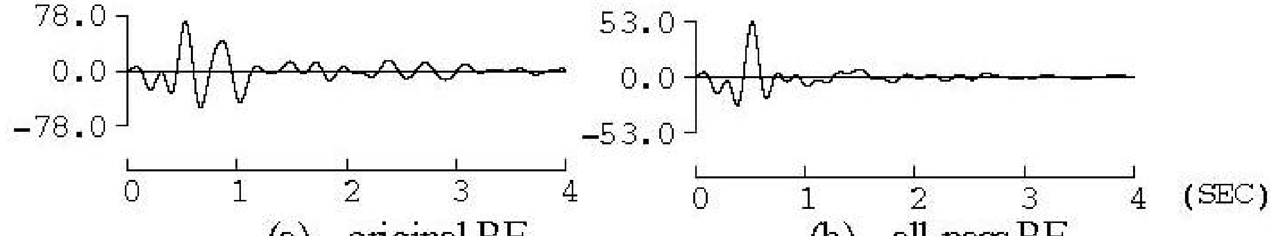


(a) original RF　　(b) all-pass RF

AICH04 での RF の例（1～5Hz のフィルター波）



(a) original RF　　(b) all-pass RF

AICH04 での全データの RF のスタッキング結果