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Study on the Green's function of a surface layer for weak and strong shocks

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1. Introduction
Green's function obtained by using borehole array recordings, G_1, is an apparent Green's function because the borehole recordings contain the down-going waves from the free surface and the upper layers. Tanaka and Kinoshita (2009) proposed a method to estimate true Green's function, G_0, using the apparent Green's function. In this study, we applied this method to the strong and weak motion data recorded at the IWTH25 site to study the motion-dependent characteristics of Green's function.

2. Method and Data
Kinoshita (1999) showed that the real part of $1/2G_0$is given by $1/G_1$for perfectly elastic medium. Since $1/2G_0$is a minimum-phase function, the imaginary part is uniquely determined from the real part using Hilbert transform. Thus we first estimated $G_1$by using maximum likelihood method and then estimated $G_0$from the estimated G_1. The data used in this study are obtained at the IWTH25 site (KiK-net). As the strong motion data, we used the seismograms recorded for the 2008 Iwate-Miyagi Inland Earthquake. Borehole array recordings with the maximum acceleration of more than 10gals obtained for the earthquakes that occurred before this event and aftershock recordings were used for the study of weak motion. The seismograms were converted to transverse component data and then converted to velocity data. In the weak motion study, $G_0$was estimated by using the velocity data of 10.24 seconds from the onset of direct S wave. In the strong motion study, $G_0$was estimated by using borehole array data of a duration of 13.8 seconds just after the point at which the difference of permanent displacements is fixed.

3. Results
This study yielded the following results:
(1) In the data window in which the deformation of surface layer is progressing, i.e., the relative displacement of surface and borehole depth is dynamically developing, the response of surface layer may be non-liner. This means that the Green's functions are not defined in this window. After this data window, the response of surface layer shows small amplitude response; the pole frequencies of Green's function are stable in a low frequency region and the Q values at the pole frequencies decrease. In this study, we used this data window for the strong motion study.
(2) Pole frequencies in the predominant frequency range of 1-8Hz moved, as a whole, toward low frequencies in the strong motion as compared with the pole frequencies obtained in the weak motion. This fact reveals that the weakness of surface layer's rigidity progresses toward rather deep depth in spite of hard lock site.
(3) In the coda part after the data window used for the strong motion study, the poles of Green's

function have recovered gradually. However the pole frequencies obtained using aftershock data have not recovered to the positions of pole frequency estimated using the data recorded for the events before the Iwate-Miyagi Inland Earthquake, although the difference of pole positions is insignificant.

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