S-wave velocity profiles estimated by surface waves at strong-motion stations along the Trans-Alaska Pipeline and at Fairbanks

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The Denali, Alaska, earthquake (M7.9) of November 3, 2002 was one of the largest earthquakes of strike-slip type in North America in almost 150 years (Eberhart-Phillips, et al., 2003). The rupture of the Denali Fault broke through the Trans-Alaska Pipeline; however, no serious damage was observed. The strong motion records at the pump stations of the Trans-Alaska Pipeline were obtained through USGS. The peak horizontal acceleration, velocity, and displacement at the nearest station PS10, 3 km from the fault, were 350 cm/s/s, 161 cm/s, and 230 cm, respectively (Ellsworth, et al., 2003). These values are not surprisingly high, especially for peak acceleration. However, even if it happened in a densely populated area, severe damage would not be kept away. In order to know the importance of site effects on strong ground motion; therefore, we investigated shallow S-wave velocity structures at 4 strong-motion stations (PS09, PS10, PS11, FA02) and a temporary station. We deployed two conventional methods of array microtremors observation and surface waves generated by a sledge-hammer hit vertically. We used portable instruments that consist of only a 6-channel data-logger of 24 bits resolution and 6 vertical moving-coil type accelerometers. The amplitudes of power spectra of microtremors among all measurement sites along the Trans-Alaska Pipeline are of order 4 less than those at ERI in Tokyo. We obtained phase velocities of Rayleigh waves included in microtremors in the frequency range of 4-20 Hz by the SPAC method with the maximum array radius of 40 m. Hammer hit generated surface waves were observed by aligning equi-spaced sensors (3, 5 m) and a few different offsets (e.g., 5, 25 m). We applied one-dimensional F-K method (MLM) for the hammer-generated surface waves and could determine the phase velocity in the frequency range of 15-40 Hz. We estimated the shallow S-wave velocity profiles by forward modeling. The phase velocities obtained by these methods were various at every measurement site even though in the same frequency range. On the other hand, S-wave velocity of 400 m/sec appears to be common for a middle layer in all estimated profiles. The S-wave velocity of bedrock is plausible 1.6km/sec or high at least for all measurement sites.

We compared the theoretical waveforms by a surface vertical source using the Discrete Wave-Number Method (Hisada, 1994) with observed ones. We used a point source of a Ricker wavelet with a central frequency of 60 Hz. The theoretical waveforms agree with observed ones for major phases and P-wave phase, whose velocities are estimated to be about 350-500m/sec by direct waves. We compared the transfer functions calculated by estimated S-wave velocity structures with the observed dominant frequencies from the foreshock (M6.7) of the Denali earthquake of October 23, 2002 at 2 sites (PS09, FA02) and confirmed that the site amplifications agree well in terms of dominant frequencies with the observations. In this study, we could obtain phase velocities in relatively wide frequency range by combining both the SPAC and one-dimensional F-K methods, which enable us to estimate shallow S-wave velocity structures with sufficient accuracy.