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Applicability of seismometers JU-215 to shallow-structure explorations using miniature microtremor arrays (<1m)

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We have so far shown the possibility to analyze the dispersion characteristics of Rayleigh waves with wavelengths longer than 100 m by observing vertical-component microtremors using a circular array with radius less than 1 m if we are provided with high-performance (low-noise) seismometers (e.g., Cho et al., 2008). A microtremor/strong-motion observation kit JU-215, which was co-developed by the NIED and Hakusan Co. (Senna et al., 2006, 2008), consists of low-noise accelerometers, JA40GA04, manufactured by Japan Aviation Electronics Industry, Ltd (Kunugi et al., 2006) and a recording system with a wide dynamic range 135 dB, DATAMARK LS700XT, manufactured by Hakusan Co. The applicability of JU-215 to the exploration method described above was examined based on observed data in this study.

More concretely, we conducted circular-array observations at 21 sites in and around the Tsukuba city during October to November, 2011. The arrays had radius either 40 cm or 60 cm consisting of six kits of JU-215. We adopted a drawing software, Adobe Illustrator, to draw a real-size array and placed the seismometers directly on the hardcopy in situ (Photo 1). We installed three arrays on earthen roads and eighteen arrays on blacktop roads. The observation durations were 30 minutes with a time interval of 0.01 s. We analyzed the phase velocities of Rayleigh waves by applying either the CCA method (Centerless Circular Array Method; Cho et al., 2004, 2006) or noise-compensated CCA method (Tada et al., 2007) to the vertical-component waveforms. We used a software, microtremor analysis codes BIDO that has been released on the internet via url http://staff.aist.go.jp/ikuo-chou/bidodl.html.

As a result, the upper limit of the wavelength range analyzable was 160 m at the maximum and about 100 m on average. This means that the maximum wavelengths relative to the array radius get a few hundred at the maximum and 170 on average. The SN ratios that were separately analyzed in this study took values about 10,000 in the frequency ranges between 2 to 10 Hz for most sites, being consistent with the analyzable wavelength ranges when we consider the relationship between SN ratios and the maximum wavelengths analyzable by the CCA method (Cho et al., 2006). The SN ratios for the arrays with radii less than 1 m can almost be considered to indicate those for the recording system, validating the high performance of JU-215. The observation kit JU-215 might able to apply a circular array of four points: one at the center point and three around the circumference, instead of six points. The examination will be done in the future.

We extracted from the analysis results the phase velocities corresponding to the wavelength 40 m regarding them to be AVS30 following Konno and Kataoka (2000). They ranged between 140 to 280 m/s being comparatively well consistent with those deduced from the geomorphologic data (Matsuoka et al., 2005). By adopting miniature-array analyses described here we are able to obtain phase velocities of Rayleigh waves in the frequency ranges from 2-3 Hz to several tens of Hertz, which can be used for more detailed explorations of either shallower or deeper potions of substructures.

Senna, S., S. Adachi, H. Ando, T. Arai, K. Iisawa, H. Fujiwara: Development of microtremor survey observation system, Program of the 115 SEGJ (Society of explortion geophysics of Japan) Conference, 120-122, 2006.

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