Investigation of the Directional Dependency Seen in the Phase Velocity Derived from Microtremors observed in Uji Campus, Kyoto University

〇Thinzar YADANAR, Yuting CHOU, Sayo NISHIYAMA, Takashi HIRAI, Masafumi MORI, Fumiaki NAGASHIMA and Shinichi MATSUSHIMA

Introduction

The purpose of the research is to investigate if the Rayleigh wave phase velocity is dependent of the wave propagation direction of microtremors and if the propagation direction is time dependent. We conducted microtremor observations in Uji Campus and calculated the Rayleigh wave phase velocity by using the Spatial Autocorrelation (SPAC) method and the frequency-wavenumber (f-k) method. The SPAC method averages the SPAC coefficient for all azimuth so it cannot consider the difference of phase velocity according to direction of the wave propagation. On the other hand, the f-k method can estimate both phase velocity and the wave propagation direction of microtremors (Luo et. al., 2016). First, we measured microtremors for 2.75 hours and compared the phase velocity calculated by using SPAC method and F-k method. In addition, we conducted another 20-hours microtremor measurement to see if the phase velocity changed with time and if the wave propagation direction of microtremors changed according to time.

Microtremor Measurement

In this research, we used accelerometers (JU410) for the 2.75-hours measurement and another type of accelerometers (SMAR-6A3P) for the 20-hours measurement. Seven instruments were used in each measurement with one at the center and another six devices on the circumference of two circles with a radius of 90m and 180m, respectively (Fig. 1).

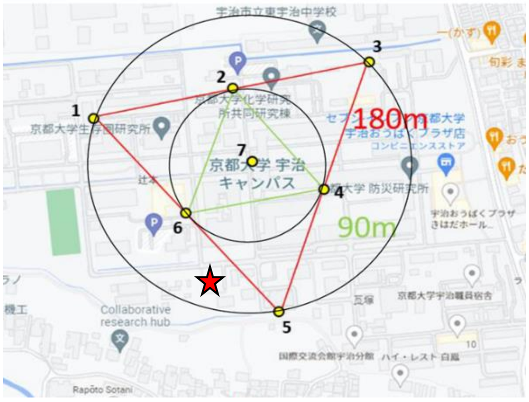

Fig 1. Location of 2.75-hours microtremor measurement (plotted on Google Map)

Microtremor Data Analysis

Rayleigh wave phase velocity was calculated by using the SPAC method and the f-k method. For the SPAC method, BIDO analysis code (version 2.0) (Cho et al., 2006; Cho et al., 2008) was adopted, and for the f-k method, Geopsy program (Wathelet et al, 2020) was adopted. Figure 2 shows the phase velocity dispersion curves resulted from preliminary 2.75-hours measurement.

Blue circles in figure 2 show the dispersion curve of Rayleigh wave phase velocity for the larger triangle and the orange circles show those for the smaller triangle calculated by SPAC method. The Frequency range between 1.16 Hz and 1.51 Hz from the larger triangle and the frequency range between 1.52 Hz and 2.88 Hz from the smaller triangle were picked to form a combined phase velocity curve as shown by yellow circles in Figure 2. The purple line shows the dispersion curve of Rayleigh wave phase velocity obtained by the f-k method. The theoretical phase velocity curve was calculated based on the subsurface velocity structure from borehole which was located near the red star shown in Figure 1 estimated by Shirakawa and Iwata (2007), as shown by a red line.

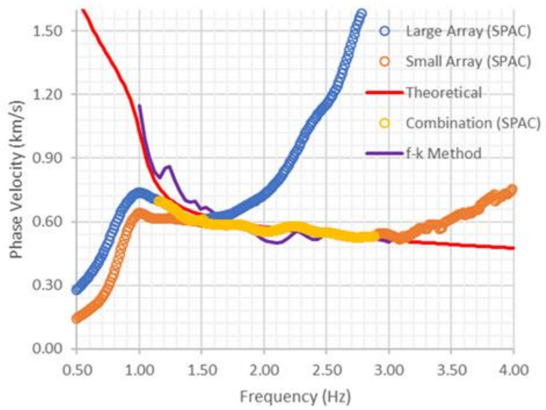

Fig 2. Comparison of phase velocity dispersion curve results for 2.75-hours measurement

The results show that for the frequency range of 1.8 Hz to 2.9 Hz, the phase velocities obtained by the SPAC and the f-k methods are similar and match with the theoretical phase velocity although the result from the f-k method is slightly higher than the theoretical one around 1.2Hz. On the other hand, the results of the two methods have difference of about 30% at maximum between 1.2 Hz to 1.8 Hz. In this frequency range the result of the SPAC method shows good match with the theoretical one. To investigate the cause of this gap, we decided to do another measurement for 20 hours (17:00-13:00 local time) to see if the phase velocity changes or not throughout the measurement and to estimate the wave propagation direction of microtremors during the measurement time. Figure 3 shows the results from 17:00-23:00 local time, as an example. In figure 3, Rayleigh wave phase velocity result from the SPAC method have a good match with the theoretical phase velocity dispersion curve in the frequency range between 1.3Hz and 2.8Hz while the phase velocity dispersion curve resulted from the f-k method match with the theoretical one from 1Hz to 3 Hz. During 17:00-23:00 local time, the direction of microtremor source coming from south-east, south, south-west, west and north-west direction and the obvious changes in the direction of microtremor source cannot be seen throughout our measurement.

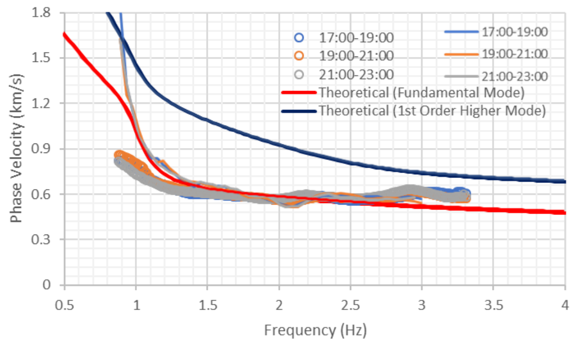

Fig 3. Comparison of phase velocity dispersion curve during 17:00-23:00 local time (for 20-hours measurement)

Conclusion

We conducted two microtremor array measurements for 2.75 hours and 20 hours to investigate the directional dependency of the phase velocity and the change of phase velocity according to time. For SPAC method, frequency range between 1.1Hz and 2.7Hz have a good match with theoretical phase velocity dispersion curve while the result from f-k method show a good match with theoretical one from 1Hz to 3Hz. Obvious changes of the microtremor source direction and the influence of directional distribution of microtremor sources on phase velocity dispersion curve were not seen during our measurement time period.

References

Cho et al. (2006), J. Geophysics, 165 (1) 236-258.

Cho et al. (2008), J. Geophysics, Res 113, B06307.

Luo et al. (2016), J. of Applied Geophysics 126, 172-182.

Shirakawa and Iwata (2007), DPRI Annuals, Kyoto University, No.50 B. http://hdl.handle.net/2433/73328.

Wathelet et al. (2020), *SRL*, **91**(3),1878--1889