

Array Analysis of Microtremors Measured at Landslide Sites in Tokushima, Japan

Kosuke Chimoto^{1*}, Minoru Yamanaka¹, Shuichi Hasegawa¹ and Masaki Ooku²

¹Kagawa University, Takamatsu, Kagawa, Japan

²Yonden Consultants, Takamatsu, Kagawa, Japan

(*Corresponding E-mail: chimoto.kosuke@kagawa-u.ac.jp)

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Abstract: The array microtremor exploration was performed at landslide sites in Tokushima, Japan. The array microtremor records were used to estimate dispersion curve of Rayleigh wave by using SPAC and F-K methods. The model was finally determined from the inversion analysis of dispersion curves. The models were almost consistent with that of PS logging data.

Keywords: Microtremors, Array, Landslide, Tokushima.

Introduction

The Microtremor survey is now widely used for the engineering purpose especially for seismic disaster. It is considered suitable for estimating sedimentary layers. Recently, microtremor array surveys have shown potential applicability in mountainous areas as well (Cho, 2023). This study performs microtremor measurements at landslide sites in Tokushima Prefecture, Shikoku Region, Japan, and examine the applicability of microtremor survey to landslide areas.

Microtremor measurement

We measured microtremors at a landslide site in Tokushima (Figure 1), where a Hi-net, K-NET/KiK-net seismic station is installed, and the borehole PS-logging is conducted. The site is located at the elevation of 605 m.



Figure 1, Survey site. TKSH06 is a seismic station. Triangle shows the array with 29m and 4m sizes.

We measured microtremor in September 2024, by using 7 set of seismometers, JEP-6A3(10V/G) produced by Mitutoyo with a data logger LS-8800 produced by Hakusan Corp. The sensor was distributed with a configuration of double triangular array with the sizes of 29m and 4m.

Array analysis

SPAC method

We applied SPAC method to the measured array microtremor records in the vertical component. A phase velocity dispersion curve is generally obtained by fitting the SPAC coefficient to the 1st order zero-th Bessel function (Figure 5). However, in this study, it was not easy to read a dispersion curve, therefore we accepted several candidates of dispersion curves for the inversion analysis. An example is shown in Figure 2. Not only by fitting to the Bessel function, but also, we used the zero-crossing method which is thought to be more robust in reading phase velocity.

F-K method

F-K method is also used to estimate phase velocity dispersion curve in microtremor array analysis to the same records. Figure 4 shows the estimated dispersion curves with the theoretical dispersion curve. Figure 3 also compares the dispersion curves estimated with the SPAC method. The dispersion curves show difference at about 1Hz and F-K method estimates larger phase velocity.

Inversion

We estimated S-wave velocity structure models through the inversion of Rayleigh wave phase velocity dispersion curves. We used a hybrid heuristic inversion technique which incorporates both Genetic Algorithm and Simulated Annealing. The search area of S-wave velocity and layer thickness were set by referring to PS-logging data. P-wave velocity was followed by using the relationship by Kitsunezaki et al. (1991). The density was also set an appropriate value set from S-wave velocity.

Figure 3 shows the inversion result. The estimated models from SPAC method by using several candidates

of dispersion curves are similar each other. However, the model estimated using the dispersion curve from F-K method shows some difference with the models from SPAC method, but it estimates deeper part.

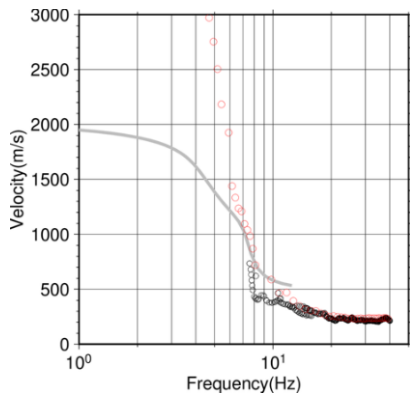


Figure 2, Observed phase velocity dispersion curve with SPAC method (black circle) and F-K method (red circle). The gray shows the theoretical curve computed using PS-logging data.

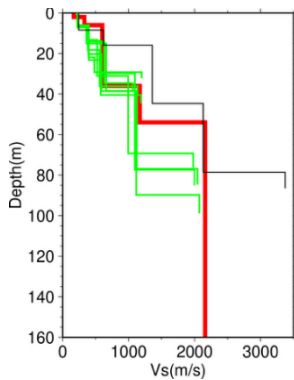


Figure 3, S-wave velocity structure. Green shows the models estimated using SPAC method and black.

Figure 4 shows the comparison between the observed H/V curve and the Rayleigh wave ellipticity computed using the model estimated using microtremor survey. Most of the peaks of the H/Vs from estimated model is generally consistent with the peak in H/V from microtremors. However, slight difference can be also observed in some H/Vs.

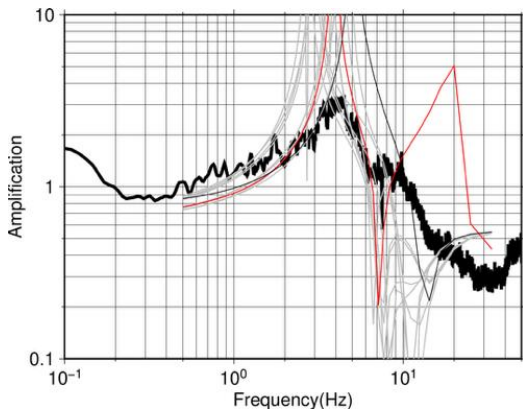


Figure 4, H/V curve. Thick line is H/V from measured microtremors. The red is the computed H/V using PS-logging model. Gray is computed H/V from estimated model by SPAC and thin black is for the F-K method

indicates the model by F-K method. Red is the PS-logging data.

Conclusion

The microtremor exploration is generally recommended to apply in lowland area and it is thought to be difficult to apply in mountain area. A possible reason may be the low power of microtremor due to low amplification of hard rock in mountains. We tried to apply microtremor exploration at a landslide site and found that even the low power at some frequency ranges but still we observe clear peak in H/V and it must be attributed to the existence of low velocity layer due to landslide. We then applied array analysis, and the inverted model shows low velocity layers. This must be an important case study that shows a possibility of applying microtremor exploration to landslide sites. However, we also find some issues that must be solved such that the SPAC method and F-K method estimate slightly different dispersion curves.

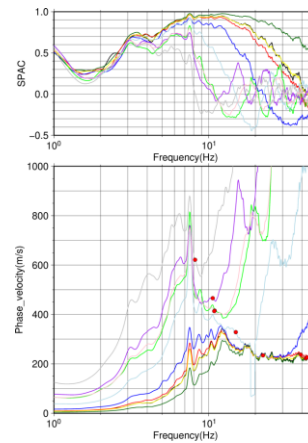


Figure 5, SPAC coefficient (Upper) and Phase velocity dispersion curve (red circle, Lower). Each array has five distances. Two sizes of arrays give ten SPAC coefficients.

Acknowledgement

We thank those who cooperated microtremor measurements. We used the KiK-net borehole logging data from NIED (2019).

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