Detection of Landslide Layer Thickness using Single Microtremor Survey

Minoru Yamanaka[1*], Masaki Ooku[2], Shuichi Hasegawa[1] and Hiromichi Yano[3]

[1]Kagawa University, Takamatsu, Kagawa, Japan
[2]Yonden Consultants Co., Inc., Matsuyama, Ehime, Japan
[3] Shikoku Electric Power Co., Inc., Takamatsu, Kagawa, Japan

(*Corresponding E-mail: yamanaka.minoru@kagawa-u.ac.jp)

Abstract: Landslide topography can be interpreted from topographic maps, but it is generally difficult to determine the depth of a landslide, and the application of geophysical surveys is desirable. In this study, single microtremor investigations were carried out at some locations on the outside and inside of landslide terrain identified from ridge interruptions using red relief image maps. As a result of this study, it was found that the peak frequency of the H/V spectrum is lower on the inside of landslide area, and that the depth of the surface layer obtained from the theoretical dispersion curve corresponding to this peak frequency is greater inside the landslide area.

Keywords: ***Landslide, Microtremor, S-wave velocity.***

Introduction

An older landslide is generally difficult to discern because their topography has been dissected and is unclear. However, knowing the range and depth of past landslides is very important from a disaster prevention perspective (Inagaki et al., 2005). But it is possible to extract landslide terrain by identifying discontinuities in ridges and changes in slope gradients by using a red relief map (Kanbara et al., 2021).

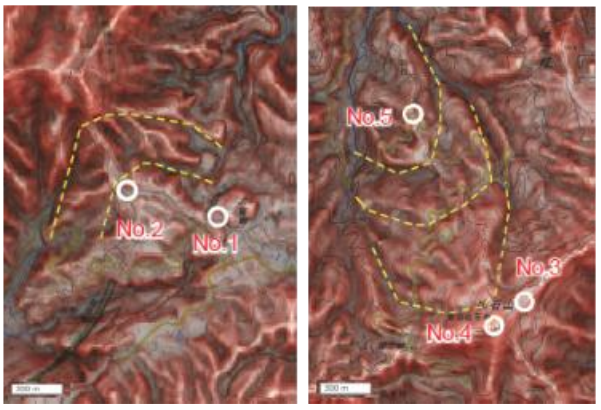
For landslide investigations, the application of geophysical surveys is necessary as an alternative to boring. Microtremor surveys can be considered to obtain the depth of landslide block (Ooku et al., 2025).

In this study, to clear the depth of landslide block, single microtremor surveys were carried out on the outside and inside of landslide terrain identified from ridge interruptions using red relief image map.

Investigation Site

The investigation site in this study is a steep slope located in Iyo and Ozu City, western Shikoku. The surface layer consists of the Izumi Group, which is a sequence of alternating gravel, sand, and shale stones.

Figure 1 shows the survey locations of the microtremor survey on red relief image map. In this figure, estimated landslide lines interpreted from the topography are also added. At site A shown in Figure 1a, microtremor investigations were conducted at two locations, No. 1 and No. 2, where the elevations inside the landslide terrain differ. And at site B shown in Figure 1b, No. 3 and No. 4 are located outside the landslide block, while No. 5 is located inside it.



a) Site A b) Site B

Figure 1, Site location on red relief image map.

Method of Microtremor Survey

The microtremor survey was carried out by McSEIS-AT, manufactured by OYO Co., Ltd. It can measure velocity in three components: NS, EW, and Vertical directions. It is compact and highly portable, making it suitable for surveys on steep mountainsides (see in Figure 2).

Figure 2, Microtremor used this study.

The sensor of this device (geophone) was installed horizontally at the measurement point, and after determining its position with GPS, measurements were taken for 20 minutes at each location.

Difference of H/V spectrum

Figure 3 shows the H/V spectra obtained by microtremor (No.1, No.2, No.5) located within the landslide terrain area. Each point shows a clear peak frequency. The peak frequency is in the range of 3.3 to 4.1 Hz.

Figure 4 shows the H/V spectra (No.3, No.4) outside the landslide terrain area. It shows a clear peak frequency, which ranges from 9.9 to 14.1 Hz.

Therefore, comparing the peak frequencies inside and outside the landslide terrain, it was found that it is lower on the inside of one.

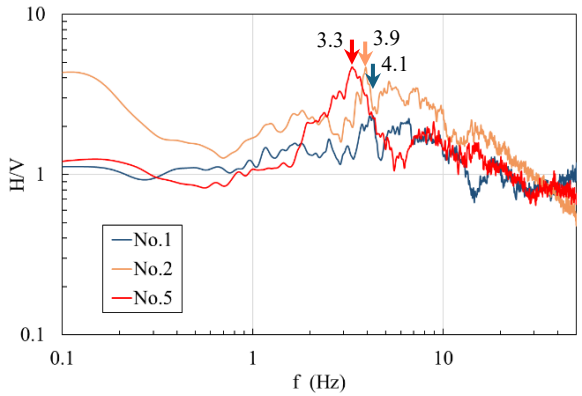


Figure 3, H/V spectrum (Inside of landslide).

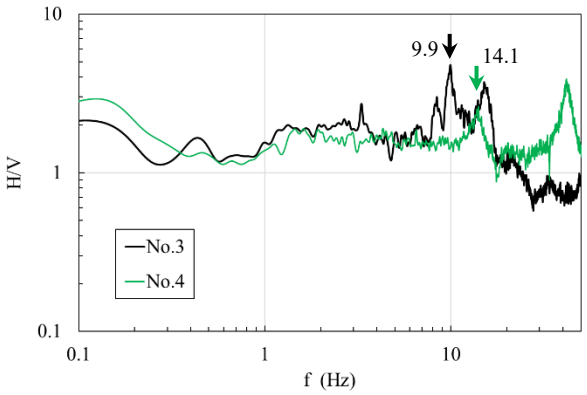


Figure 4, H/V spectrum (Outside of landslide).

Depth distribution of S-wave velocity

The depth distribution of S-wave velocity Vs was obtained by matching the peak frequency of the theoretically analyzed dispersion curve for a two-layer structure to this peak frequency. Using the results of PS logging carried out at nearby sites, the thickness of the surface layer was analyzed by setting the surface layer Vs to 250 m/s and the underlying Vs to 750 m/s.

The depth of the surface layer at the point of inside of the landslide terrain is 15 to 20 meters (see in Figure 5). On the other hand, the depth of the surface layer on the outside of the landslide terrain is shallow, about 4 to 6 meters (see in Figure 6). Thus, it was found that the depth of the landslide layer can be estimated using the single microtremor survey.

Conclusion

As a result of this study, it was found that the landslide areas determined by topographic interpretation and the results of the H/V spectral analysis were almost consistent. This suggests that it may be possible to estimate zones of loose depth from past landslides based on the peak frequencies obtained from microtremor analysis. And we plan to conduct array microtremor investigations that will accurately determine the S-wave velocity structure in the depth direction.

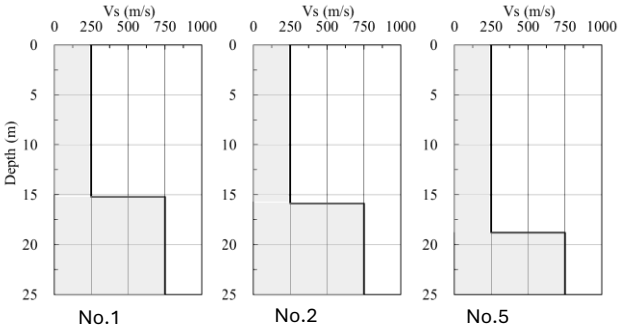


Figure 5, Vs versus depth (Inside of landslide).

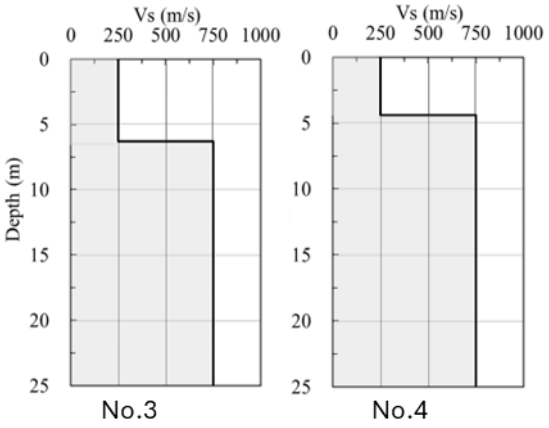


Figure 6, Vs versus depth (Outside of landslide).

References

Inagaki, H., Ookubo, T., Hasegawa, S., and Yatabe, R. (2005). Stability of old landslide. Tsuchi to Kiso, 53 (7), 17–19. (in Japanese).

Kanbara, D., Hasegawa, S., Nonomura, A., Chiba, T., and Kimura, M. (2021). New index for identifying large-scale dissected landslide along the Median Tectonic Line. Journal of the Japan Society of Engineering Geology, 62 (5), 296–307. (in Japanese with English abstract).

Ooku, M., Tsuyuguchi, K., Aono, S., Hasegawa, S., Yamanaka, M., Araki, H., Chimoto, K., Nonomura, A., Ikeda, T., and Nagata, T. (2025). A case study of microtremor exploration in a plane and landslide area in Shikoku. Proceedings of the SEGJ Conference, 152, 57–59. The Society of Exploration Geophysicists of Japan. (in Japanese).