Trial Manufacture of the Groundwater Aeration Sound Measuring Device

Forestry and Forest Products Research Institute ○ Yasuyuki Tada, Takuwa Corporation, Shinji Okuda, Hisato Yasumoto, Hidetoshi Yoshimura, Kouji Aoyama
Kyoto University Masaharu Fujita, Takamasa Mizuyama, Tottori prefecture Kan Koyama, Tottori University Takayuki Kawai
Forestry and Forest Products Research Institute Toshiaki Sanmori, Hiromu Daimaru, Ibaraki University Naomasa Honda, Tottori University honorary professor Takenobu Okumura

1. Overview

In order to accurately estimate potentially dangerous slopes using aeration sounds (hereinafter referred as "groundwater aeration sounds") generated when groundwater flows, the authors have carried out various experiments, investigations, and observations. In addition, we have developed device which we are aiming to popularize so that even engineers who do not have special skills can accurately estimate water path locations.
In this article, we summarize the characteristics of the predispositions and triggers at collapse locations, which were revealed by the groundwater aeration sound measurement, various kinds of experiment, and investigations. In addition, we report about the popularized device that be used even by engineers who do not have special skills to accurately estimate water path locations.

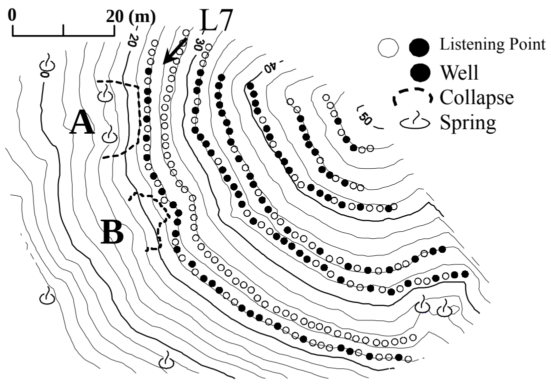

Figure 1 Investigated Slope and Various Points of Measurements

2. Outline of Investigation

An investigation was carried out at ridge type slope composed of granite, which is located in north Okayama prefecture (Figure 1).
Two collapses, A and B, occurred on this slope. We carried out groundwater aeration sound measurements and simple penetration tests at locations of ○● upstream of these two collapses. In addition, in order to confirm the presence of groundwater, we installed maximum water level gauges at locations where stronger and weaker groundwater aeration sounds were detected (● in the Figure). The maximum water levels were measured during a total of 11 rainfall events. The rainfall amounts observed at each rainfall event were 21, 40, 40, 42, 43, 58, 62, 69, 86, 148, 206 mm and the events of 80 mm or more were observed during typhoons. Next, at the lowest measurement line L7, we excavated trenches at 18 locations downstream of locations where maximum water level gauges were installed and collected soil every 10 cm deep in the direction to the bedrock from the ground surface. In addition, we crushed and collected bedrock at the locations of Nc = 40 in each trench. For the collected soil and bedrock, after processing for organic substances we carried out loss on ignition tests and investigated weathering.

3. Results and Considerations

3. 1 Collapse Locations and Groundwater Occurrence Locations

Figure 2 shows the distribution of groundwater aeration sounds measured at the measurement line L7 and the average value of the maximum water level observed in rainfall events of rainfall amounts of 80 mm and more and 80mm and less. In addition, the hatched areas in the Figure indicate locations of collapses A and B. The following points can be understood from the figures.
(1) High values of maximum water level and groundwater aeration sounds are shown at locations of collapse occurred. Both trends are aligned.
(2) The distribution of maximum water levels observed during rainfall amounts of 80 mm or less and the trend of distribution of groundwater aeration sounds measured after normal rainfall are well aligned.
(3) We compare rainfall amounts of 80 mm or less and 80mm and more and maximum water levels. Even at locations where the groundwater level is low during rainfall of 80 mm or less, in the case of 80 mm or more rainfall, the groundwater level rises. In other words, when little rain falls, groundwater is generated in close proximity to the water path but when the rainfall amount increases, the water paths expand into the surrounding area.
For these reasons, in mountain regions, there are locations where groundwater levels dramatically increase with little rainfall and locations where the levels do not increase. A collapse occurs around locations where groundwater levels dramatically increase. The groundwater aeration

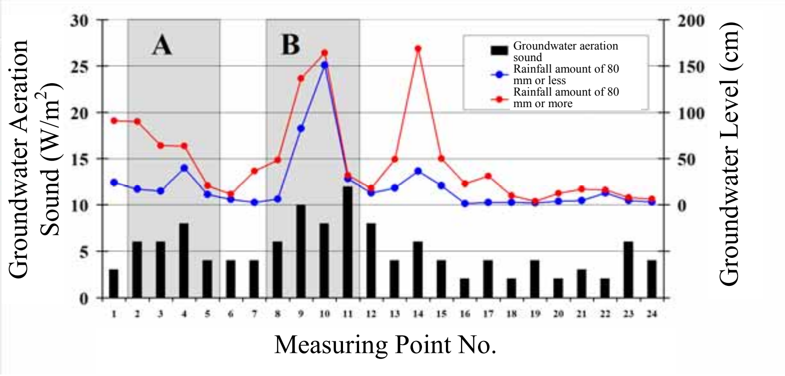

Figure 2 Distribution of Groundwater Aeration Sounds and Maximum Water Levels

sound measurement efficiently identifies these locations where groundwater levels dramatically increase.

3.2 Weathering of Soil Layer and Bedrock, and Groundwater

Figure 3 shows the distribution of average values of the maximum groundwater levels, which were observed during 11 rainfall events and the ignition loss of bedrock at Nc = 40 obtained through simple penetration tests. The average value of the maximum water level shows that the higher the value, the more easily the groundwater increases against rainfall and the ignition loss shows that the higher the value, the more weathering of the minerals which comprise the bedrock. Looking at the Figure, at the collapse positions indicated by gray hatching, not only is the average groundwater level high but the value of ignition loss for the bedrock is also high. Similar results were confirmed in the soil. At locations where groundwater levels increase easily, the weathering of the bedrock was more progressed compared to the surrounding areas.

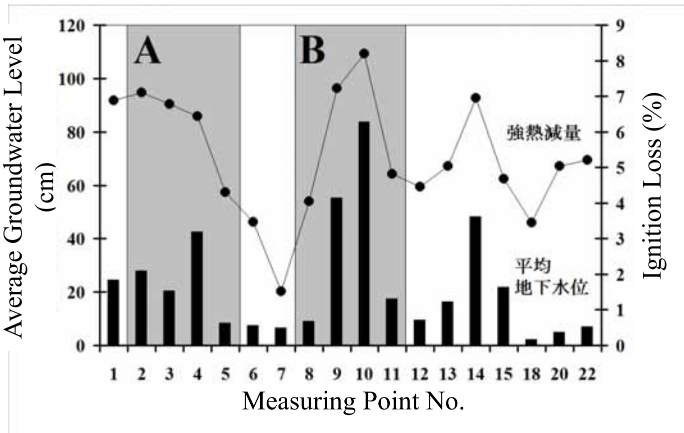

Figure 3 Distribution of Average Groundwater Level and Ignition Loss of Bedrock (Nc=40)

3.3 Characteristics of the Predispositions and Triggers for Collapse Locations and the Groundwater Aeration Sound Measurement

The groundwater aeration sound measurement is a simple method to identify locations where groundwater concentrates by measuring the sound generated from groundwater flow. However, when compared to surrounding areas, at locations where the groundwater aeration sounds are strong, not only does the groundwater level easily increase but the weathering of soil and bedrock also progresses. Tada et al. (2007) succeeded in predicting collapse positions on forest road slopes using the groundwater aeration sound measurement. It can be considered that the groundwater aeration sound measurement identifies locations where groundwater easily concentrates and where the soil and bedrock are weathering; in other words, locations where the conditions of both the predispositions and triggers for collapses are aligned.

Given the above, the groundwater aeration sound measurement is a rational method to predict collapse positions.

Picture 1 Popular Type Groundwater Aeration Sound Device

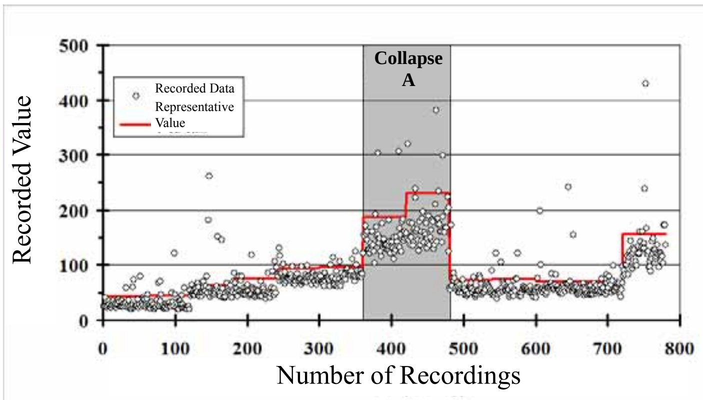

Figure 4 Measuring Examples Using Popular type Device

4. Trial Manufacture of Popular Type Device

Conventional groundwater aeration sound measurement devices have the problems that if measurer is lacking in skill, water path locations can not be correctly identified. Therefore, popularization of this device is difficult unless device can be produced enabling the correct identification of water path locations even without special skills. For that reason, we developed device which can, just with the push of a measuring button, extract and record the peak values of groundwater aeration sounds 60 times, and determine the representative value of groundwater aeration sounds of with the noise generated at a local site deleted(Picture 1).

Figure 4 shows a measuring example of the popular type device shown in Picture 1. The tendency in which groundwater aeration sounds are strong at the collapse position was well reproduced. It enables even those taking measurements who have no special skills to correctly estimate water path locations.

Cited Reference

Yasuyuki Tada et al. (2007): "Relation between collapse and water path position in slopes", Journal of the Japan Society of Erosion Control Engineering, Vol.60, No.4, p.3-11