Study on the Influences on the Width and Shape of Collapses in Water Paths

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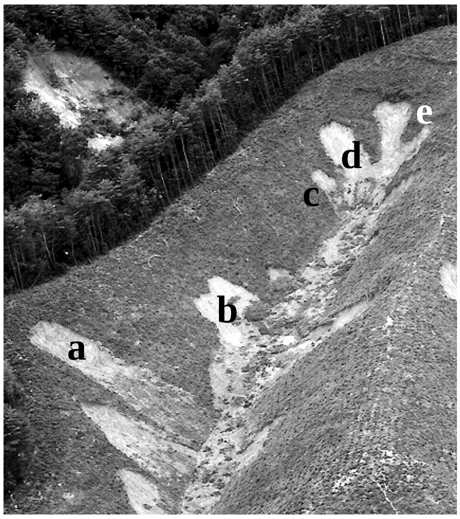
1. Overview

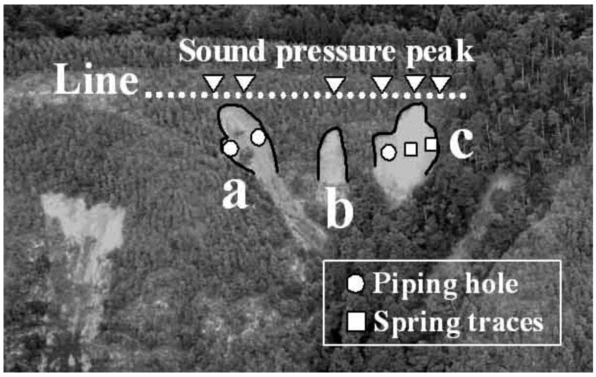
In order to clarify differences between locations where collapses occur and locations where collapses do not occur, the authors carried out groundwater aeration sound surveys at areas where collapses occurred in all regions of the country. On those occasions, we noticed there was a correlation between the width and the shape of the collapse and the locations where the groundwater aeration sounds are loud. Picture 1 is one typical example of a shallow landslide. When carefully observing the shapes of collapses, we noticed that collapses which appear to have a horseshoe shape at first glance actually have various shapes. For example, the scarps of shallow landslides a and c have a beautiful horseshoe shape but shallow landslides b, d, and e are in a heart shape in which the center part of the scarp is left un-collapsed. When examining the scarps of shallow landslides at a local site, we noticed that those which have a heart shape tend to have a wider width of collapse than those which are horseshoe shape. In addition, when investigating groundwater aeration sounds in the direction of contour lines on top area of the scarps of collapses, we noticed that there were some cases in which multiple peaks of groundwater aeration sounds were detected in one collapse and that occured more frequently in heart shape rather than horseshoe shape collapses. This study examines the influence of water paths which affect the width and shape of collapses.



Picture 1 Case Examples of the Shapes of Shallow Landslides

2. Investigation Site and Investigation Method

We examined the widths of collapses and water paths at 10 shallow landslides occurring on 4 natural slopes and 63 slope collapses occurring on 40 forest roads within Okayama prefecture and Tottori prefecture. To investigate water path locations we set up measuring lines, in the case of shallow landslides 5 m above scarp and in the case of forest road slopes 1 m above the road surface of forest roads, and measured the groundwater aeration sounds at 1 m or 2 m intervals on these measuring lines. Groundwater aeration sounds characteristically are loudest directly above water paths (Tada et al. 2006).



Picture 2 Shallow Landslide Occurring on a Natural Slope A

3. Result and Consideration

3.1 Widths of Collapses and the Number of Water Paths

Picture 2 shows collapses occurring on natural slope A. The natural slope A has geological features of tuff breccia and welded tuff originating from pyroclastic flow deposits from Mount Daizan located in west Tottori prefecture. Figure 1 shows the distribution of the sound pressure level of groundwater aeration sounds measured on dashed lines in the Picture. In addition, hatches in Figure 1 represent locations of collapse a, b, and c, which correspond to Picture 3. Groundwater aeration sounds are louder in collapses a, b and c than in surrounding areas. In addition, the number of peaks of groundwater aeration sounds which exist within the collapse width indicated by hatches are two in collapse a, one in collapse b, and three in collapse c. Locations where sound pressure peaks were confirmed are indicated with ▽ in Picture 2. The correspondence between the collapse shapes and peaks of groundwater aeration sounds can be summarized as follows.

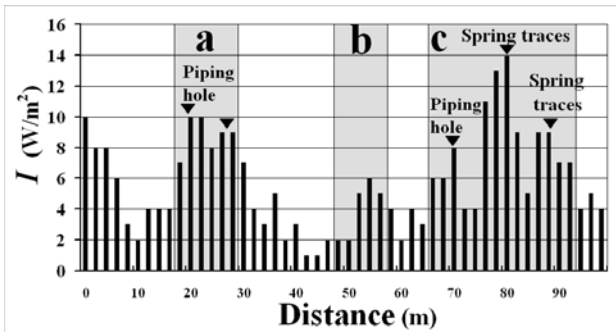


Figure 1 Distribution of Groundwater Aeration Sounds on Natural Slope A

(1) Collapse a: There are two sound pressure peaks on groundwater aeration sounds, which are located to the right and left of the collapse. As shown in Picture 2, there are piping holes at locations below the sound pressure peaks on the scarps. The shape of the scarp is distorted but heart shape and sound pressure peaks are located on the two tops of the scarp. Positions of sound pressure peaks and apexes of the top of scarps are aligned.

(2) Collapse b: There is one peak of groundwater aeration sounds, which is located a little to the right of center of collapse. The shape of the scarp is horseshoe shape but is not bilaterally symmetrical and is located a little to the right of the center of collapse, as in the sound pressure peak. Positions of sound pressure peaks and tops of scarps are aligned.

(3) Collapse c: There are 3 peaks of groundwater aeration sounds, which are located at both the right and left ends and the center. In addition, there are traces of springs at the right side and the center of the collapse and piping holes at the left side of the collapse, which aligns well with the relationship of the locations of peaks of groundwater aeration sounds. The shape of the collapse scarp is three-pronged and sound pressure peaks on groundwater aeration sound align with the top parts of each block. From these observations mentioned above, we obtained the following understanding.

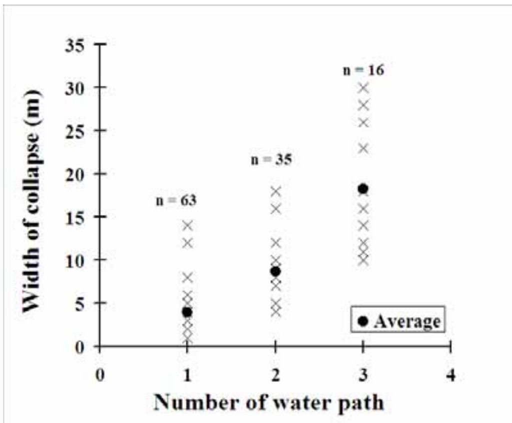


Figure 2 Relationships between The Number of Water Paths and Collapse Widths

(1) There are some collapses which are not generated by a single water path but multiple water paths.

(2) The shape of the collapse corresponds with location and the number of water paths and the shape of scarp also tends to divide into multiple blocks. In addition, in many cases, the apexes of the collapse scarps occur at the locations of water paths.

Next, we studied the relationships between the number of water paths and collapse widths. The size of the width of collapse a, b, and c shown in Picture 2, in which one to three water paths were confirmed, are collapse b < collapse a < collapse c from narrowest to largest. In other words, the tendency is that the larger the number of water paths, the larger the collapse width. After that, we examined the number of peaks of groundwater aeration sounds occurring within the collapse width, measured at all investigation points, and summarized the relationships between the number of water paths and collapse widths in Figure 2. A tendency can be observed that the greater the number of water paths, the larger the collapse widths.

3.2 Collapse Widths and Water Path Locations

Figure 3 shows the frequency distribution of water path locations within the collapse width. This means that the relative position Pw of water path is given a value between 0 to 1, at Pw=0, there is a water path located at the left end of the collapse area, at Pw=0.5, center, and at Pw =1, the right end. The following trends can be understood from the figures.

(1) When there is 1 water path, in many cases, water path is located at the the center of the collapse.

(2) When there are 2 water paths, in most cases the water paths are located around the right and left ends of the collapse.

(3) When there are 3 water paths, the tendency is that the water paths are located in the vicinity of the center and the right and left ends.

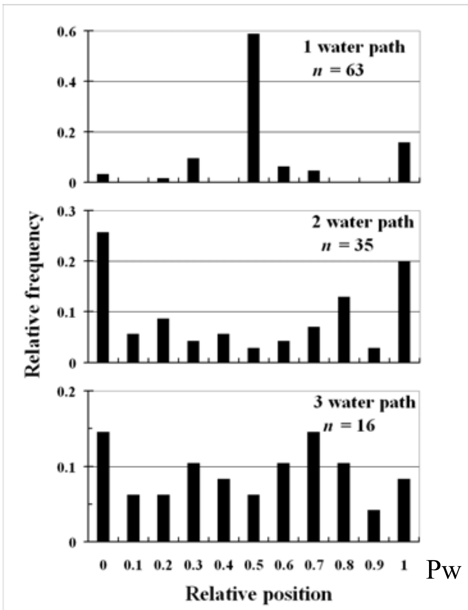


Figure 3 Relative Frequency Distribution of Water Path Locations

4. Conclusion

This study examined the influences of water paths which affect the width and shape of collapses. The results suggest that when there is single water path on a slope, a collapse occurs on the route of the water path. On the other hand, when there are two water paths on a slope, it was revealed that a soil layer sandwiched by 2 water paths collapses. If the number of water path increases to three or four, a soil layer sandwiched by adjacent water paths collapse. Since multiple collapse blocks combine into one to form one collapse, it is considered that the collapse width becomes larger.