Non-plastic fines content effect on the initiation and movement of rainfall-induced landslides in small flume tests

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Introduction

Landslides locally constitute an important natural hazard on Earth, causing great loss of properties and casualties. For original slope, some landslides with long traveling distances tend to occur on the material rich in fine soil particles like granitic soil generated by weathered coarse-grained granite, such as the 2014 Hiroshima landslides triggered by rainstorm. Debris avalanches are a kind of high-speed landslides. A hypothesis of dynamic fragmentation has been proposed as one of the reasons for their high mobility. Presence of fine-grained material may lower the shear resistance of the sliding debris. Some rock avalanche deposits show “inverse grading”. Wenchuan earthquake induced coseismic landslides and landslide dams, and some dams composed of unconsolidated fine debris. Recent study revealed that the secondary landsliding phenomena had been widely triggered on these landslide deposits, and the initiation and movement of these landslides are greatly related to the involvement of fine materials. Nevertheless, the detailed roles of fine materials had not been clarified. Therefore, study will focus on examining the effect of non-plastic fines content on the initiation and movement of rainfall-induced landslides through flume tests.

Material and Method

Samples for the tests are mixture of silica sand No. 7 with differing contents (0%, 10%, 20%, 30%, 40% and 50%) of silica powder by weight. Before setting, the mixtures were prepared to have an initial water content of 10%. During test, the flume was sloped to 20˚. Tilting transducers are installed at mid-depth within the soil model to monitor the possible inclination of the soil mass. Artificial rainfall (100 mm/h) was simulated by sprinklers mounted above the soil model to trigger landsliding.

Result

In general, the entire process required 30–45 min for slope wetting, and few minutes for failure. In the series tests on silica 7 and its mixtures with 10%, 40%, 50% silica powder, retrogressive sliding occurred in each test. However, in the series tests on the mixture of silica 7 and 20%, 30% silica powder, flowslides were initiated.

The figure shows the different periods of landslides in the flume tests. As shown in figure, the colorful point presents the results of each tilting transducers in the flume tests. It is noticed that the curve firstly decreases with increasing fine particles content until reaching 30%, then grows up with further increasing fine particles content. The period of landslide reaches to the lowest value when the silica powder content is at 30%. Videos recorded by cameras indicate that landsliding transforms from retrogressive one to fluidized landsliding with collapsed failure with the increasing of fines content, while the landslide type transforms from debris avalanche to retrogressive landslide with greater percentage (>30%) fines content.

Conclusion

Non-plastic fines content has an effect on the initiation and movement of rainfall-induced landslides in flume tests. With the increasing of fines content, the landslide type transforms from retrogressive landslide to flow sliding, while the landslide type transforms from flow sliding to retrogressive landslide with greater percentage (>30%) fines content. Periods of landslides and tilting rates of inner soil mass vary with increasing non-plastic fines content. Under the tested conditions, when the fines content reaches to 30%, the period of landslide is the shortest.

Keywords: Non-plastic fines content, Rainfall-induced landslides, Flume tests