D06

Effect of non-plastic fines content on the initiation and movement of rainfall-induced landslides in flume tests

○Chao HUANG, Gonghui WANG

Introduction

Landslide denotes "the movement of a mass of rock, debris or earth down a slope". Landslides affect the flanks of mountainous and volcanic edifices on earth, which 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, Japan.

Debris avalanches are a kind of large-volume and high-speed landslides. A hypothesis of dynamic fragmentation has been proposed as one of the reasons for their high mobility. It means that the presence of fine-grained material may lower the shear resistance of the sliding debris. Some rock avalanche deposits show "inverse grading", with mean particle sizes fining from the surface to the base.

Wenchuan earthquake induced a number of coseismic landslides and landslide dams, and some dams composed of unconsolidated fine debris resulting from the fragmentation of landslide materials during transportation. 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. It is noted that these fine materials resulting from mechanical fragmentation are no plastic, because they did not suffer from chemical weathering during the short period after the earthquake. 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 a series of 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 10%. A flume as descripted in Fig. 1 was employed, which has transparent sides and is 180 cm long, 24 cm wide, and 20 cm high. 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. Cameras were used to monitor the entire test process from one side of the flume and also from the toe part. Artificial rainfall (100 mm/h) was simulated by sprinklers mounted above the soil model to trigger landsliding.

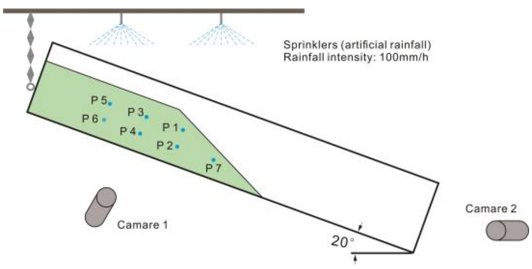

Fig. 1 Arrangement of the flume test. P1-P7: locations where tilting transducers were installed.

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.

Results of tilting angle variation of the P 4 in the test of silica 7 with dry density 1.2 g/cm^3 was presented in the Fig. 2, where it is noted that the soil mass began to title at the time of 1879 s, then the curve of tilting angle increased gradually, and the sharply dropped to -30 degree at 1953 s, indicating the soil mass rotated rapidly from 1953 s to 1986 s. According to Fig. 2, we define the location (1879 s) where the tilting sensor began to rotate as the initiation point of the landslide, and the lowest point of rapidly dropping curve as the end point of the landslide since tilting sensors could detect the rotation of inner soil mass, the time scale from initiation to end was the period of entire landsliding progress.

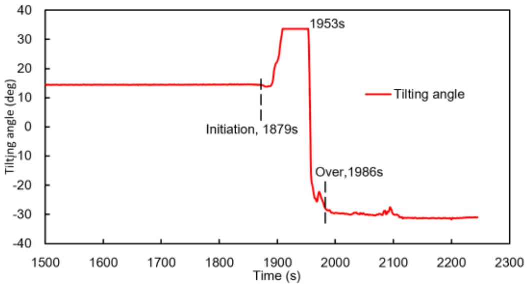

Fig. 2 Results of tilting angle variation of one certain soil mass point

Fig. 3 shows the different periods of landslides in the flume tests. As shown in Fig. 3, 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%.

Fig. 4 shows the tilting rates of P 2 (showed in figures 1and 3) in all tests against the silica powder contents. From this figure, it is concluded that the peak tilting rate increases with silica powder contents increase until the silica powder content reaches to 20% and 30%, then decreases with further increasing fines contents. The results presented in Figs. 3 and 4, and also 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.

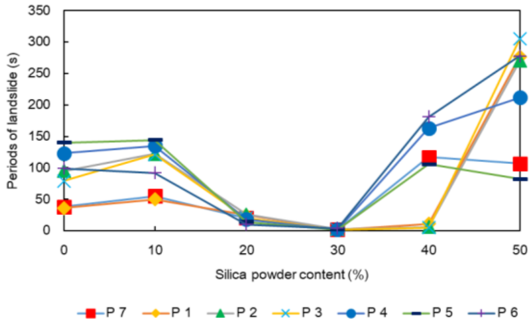

Fig. 3 Periods of landslide against the silica powder contents

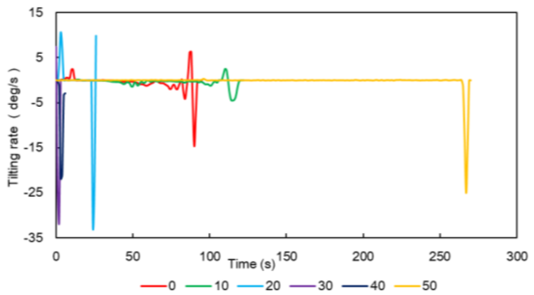

Fig. 4 Tilting rates of point P_2 (showed in Figs. 1 and 3) in all flume tests against the silica powder contents

Conclusion

Non-plastic fines content has a remarkable 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 debris avalanche, while the landslide type transforms from debris avalanche 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 and peak tilting rate of inner soil mass is the greatest.