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Role of non-plastic fines in the landslide behavior: based on the flume test and ring shear test

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Introduction

Rainfall-induced landslides, especially those fluidized ones, pose a significant threat to local properties and human lives. Non-plastic fines are frequently found in many fluidized landslide materials. These fines could be the original ones contained in the landslide materials, and could also be the results of fragmentation of landslide materials during sliding. These fines may play key roles not only in the initiation and movement of the original landslide but also in the secondary landsliding phenomena occurring on the original landslide deposits. Hence, this study aims at examining the effect of non-plastic fines on the initiation and movement of rainfall-induced landslides.

Material and Method

A series of flume tests were performed to simulate the rainfall-induced landslides occurring on the slope formed by the mixtures of silica sand No. 7 with different contents (0%, 10%, 20%, 30%, 40%) of silica powder by weight and different initial densities. Mixtures were prepared to have an initial water content 10%. A flume has transparent sides and is 180 cm long, 24 cm wide, and 20 cm high. During the test, the flume was sloped to 25°. Pore-water pressure and tilting transducers were installed to monitor the water pressure and soil rotation. A laser sensor and a liner transducer were used to capture the inner displacement of soil mass. Cameras were used to monitor the test process from one side of the flume and also from the toe part.

On the other hand, a series of ring shear tests were conducted on these mixtures under dry conditions to study the effect of fines on the frictional behavior at different shear rates.

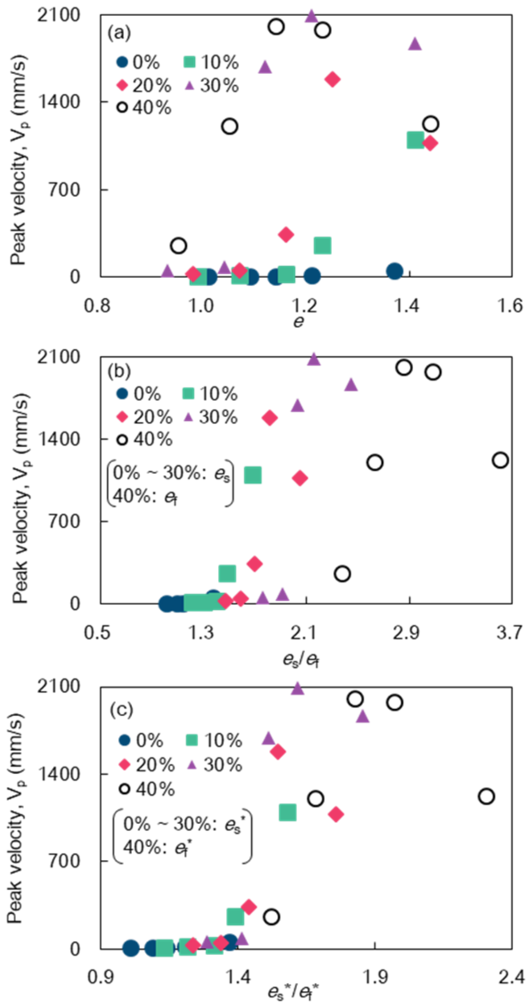

Fig. 1 (a), (b), (c): Peak velocity (V_p) against global void ratio (e), intergranular/interfine void ratio (e_s/e_f) and equivalent intergranular/interfine void ratio (e_s^*/e_f^*) for different samples, respectively.

Results and Conclusions

The landslide phenomenon transforms form slow individual retrogressive sliding to fluidized sliding with fines content increasing and initial density decreasing. Comparing with e and e_s/e_f, the V_p increases with increase of e_s^*/e_f^* in general (Fig. 1), u_p also shows same general tendency with increasing in e_s*/e_f* (Fig. 2). However, no clear tendency could be observed between Δu and e_s^*/e_f^* (Fig. 2).

The results demonstrated that equivalent void ratio could be used to better explain the behavior of mixtures with fines, the addition of fine particles into coarser grains alters the internal contact microstructure of matrix. Compared to the plots of V_p (peak velocity in the rainfall-induced landsliding) against e (shown in Fig. 1), the plots of V_p against e_s/e_f for S7, M10, M20, and M30 shift to a narrow domain, while those for M40 shift away from other mixtures. Nevertheless, these plots of V_p against e_s^*/e_f^* shrink to a relatively in a narrow range, indicating that e_s^* and e_f^* are more appropriate as the indexes to provide a unified interpretation for the variation of V_p with void ratio.

Fig. 2 presents the plots of u_p and Δu against e_s^*/e_f^*. It is noticed that through using e_s^*/e_f^*, both u_p and Δu can be integrated into a relatively smaller domain, indicating the appropriateness of using these void ratios in the examination of roles of fines in the mixture.

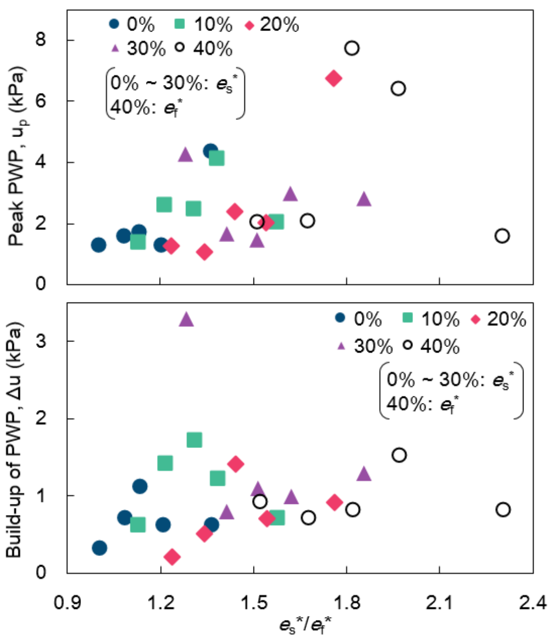

Fig. 2 Peak PWP (u_p) and build-up of PWP (Δu) against equivalent intergranular/interfine void ratio (e_s^*/e_f^*) for different samples.

Fig. 3 shows the results of friction coefficient variations with increasing in shear velocity by using DPRI 5. As shown, comparing S7 and M10, the mixtures with high content fines, such as M20, M30 and M40, shows a slight velocity-weakening phenomenon in general. Namely, the friction coefficient in steady state decreases with increasing in velocity. However, for M50, there is no obvious velocity-weakening phenomenon.

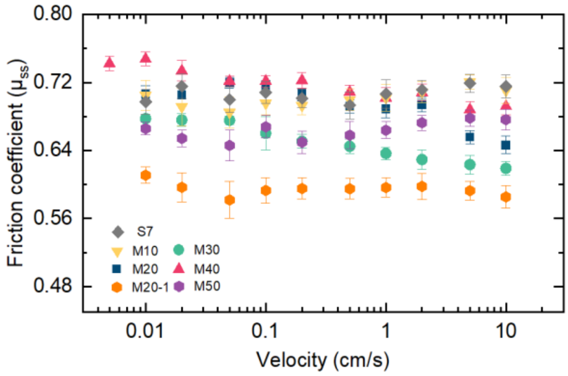

Fig. 3. Friction coefficient against velocity in DPRI 5

Fig. 4 presents the results of friction coefficient variations with increasing in shear velocity by using DPRI 6 with larger shear box in larger volume using mixtures with high content fines. As shown, for larger volume samples with high fines content, slight velocity-weakening phenomenon could also be observed in general.

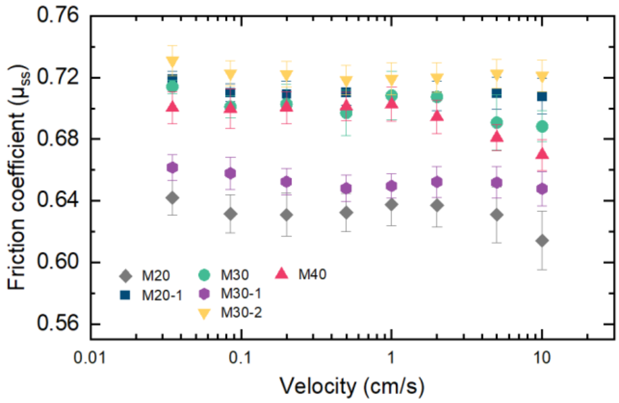

Fig. 4. Friction coefficient against velocity in DPRI 6

Based on these results, we inferred that the addition of fines could change the structure of test materials and then result in different mobility of landslide by affecting both interparticle contacts (fine particle itself) and PWP responses.

Acknowledgments

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