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Physical modeling of rainfall in the geotechnical centrifuge

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Introduction

Due to rain infiltration into soil, both the increase in the positive water pressure and the decrease in the matric suction cause the reduction in the shear strength of soil and finally lead to slope failure (Rahardjo et al., 2007). Influenced by the intensity and duration of the rainfall, slopes show various deformation patterns (shallow failure or deep-seated failure, debris flows, and minor soil movement). In this study, physical modeling of rainfall-induced slope failure was carried out in one geotechnical centrifuge experiment where a rainfall simulator was applied to provide rainfall above a small-scale slope model in the hyper-gravitational field.

Inflight rainfall simulator

Rainfall simulator (in Fig. 1), which was made with 18 nozzles, was mounted on top of the container. Air pneumatic nozzles were used where air was to break the water into smaller droplets and water supply was to provide the nozzles with water. A remote control was used to control the starting and ending of rainfall could be realized inflight.

Fig. 1 Rainfall simulator

Test program

One test where an infinite slope (the length of slope is as long as possible) was subject to rainfall (with an intensity of 5 mm/h in the prototype scale) provided by the inflight rainfall simulator. The centrifuge model test geometry and instrument were shown in Fig. 2.

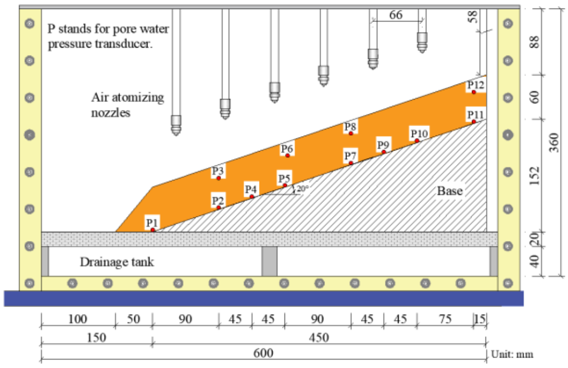

Fig. 2 Centrifuge model test geometry and instruments

Results

The recorded progressive failure of the slope and the final slope shape were shown in Figs. 3 and 4. Displacement in each section (Fig. 5) was obtained through image analyses and the results were in Fig. 6. Pore pressure pressures in the slope were in Fig. 7.

Fig. 3 Inflight slope photos (time in the model scale)

The slope failure was characterized by two flow slide. Displacement in A1 displaced the largest value both in the first and second slide, which were 15.3 mm and 12.3 mm. As rainfall continued, soil below the slide plane didn't mobilize, instead, soil above A-A section including soil between B-B section and

E-E section started moving and the second surface failure occurred and ended at 113.1 s. The maximum traveling velocities of soil in A-A section in the first and second slide were 34.7 mm/s and 20.6 mm/s.

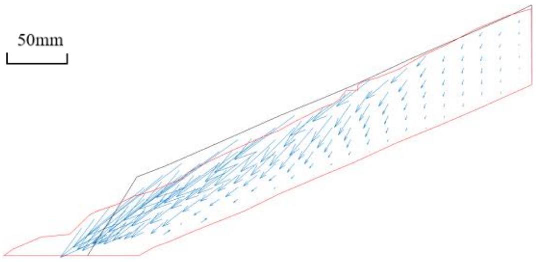

Fig. 4 Final soil displacement (model scale)

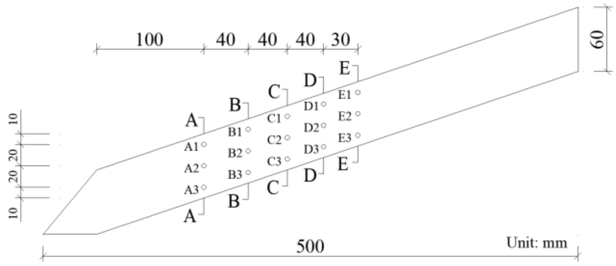

Fig. 5 Sections selected for displacement analyses

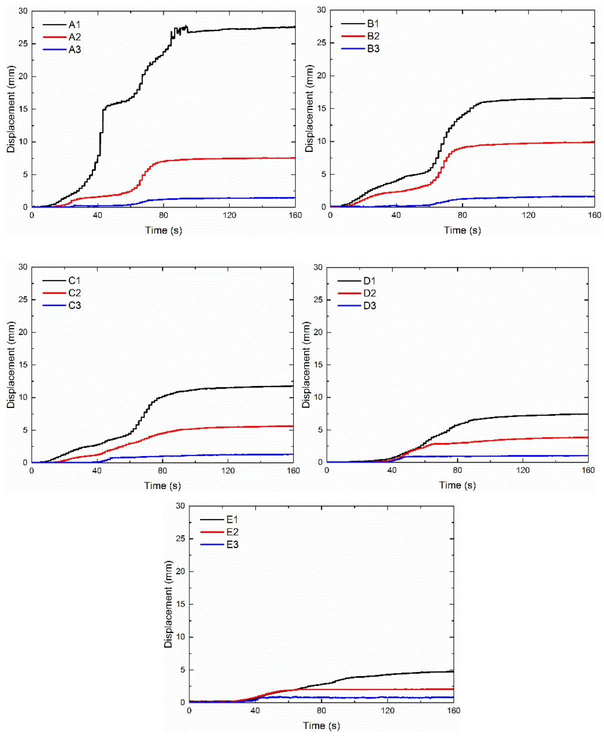

Fig. 6 Displacement in various sections (model scale)

Considerately large displacement was mainly in the lower part of the slope where rainfall was evenly distributed to the slope surface and pore water pressures increased to high levels when the steady state flow was achieved. Pore water pressures near the slope surface, however, showed quite small growth.

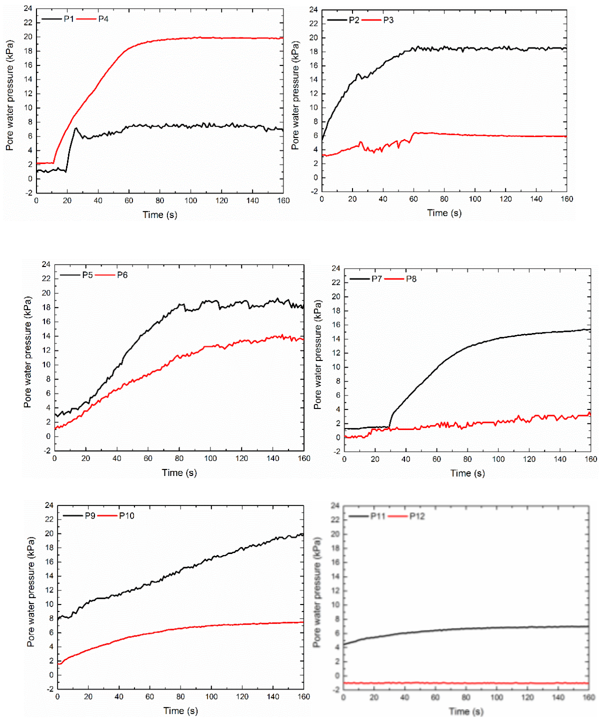

Fig. 7 Pore water pressures in the slope (model scale)

Conclusions

Surface failure occurred above the phreatic line and the slide was mobilized along a plane 2 cm at most below the slope surface. The first slide was initiated at the lower part of the slopes and travelled at fast speed, resulting in a following second slide away from the collapsed soil took place. The slope failure took place during the transient flow state when pore water pressures within the soil were still increasing. Slope stability depends on the rainfall intensity and a more intense rainfall is needed to cause large landslides.

Acknowledgments

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Reference

Rahardjo, H., Ong, T. H., Rezaur, R. B., and Leong, E. C. Factors Controlling Instability of Homogeneous Soil Slopes under Rainfalls. Journal of Geotechnical and Geoenvironmental Engineering, 2007, 133 (12), 1532-1543.