# 遠心場における降雨時の浅層斜面崩壊に間隙水圧と間隙空気圧が与える影響
# Effects of pore water pressure and pore air pressure on shallow slope failure during rainfall in a centrifuge field

○May Than Thar CHO*(メイ　タン　ター　チョー)
Tomotaka SATO*(友孝佐藤), Yuji KOHGO*(雄二向後), Hirotaka SAITO*(広隆斎藤), Akira IZUMI**(明良泉)

## 1. Introduction

Slope failures are difficult to predict since they collapse suddenly by the loss of shear strength with increased pore water pressure under the influence of rainfall. The increased pore pressure is a critical factor leading to the slope's instability. In previous studies, the influence of the PWP on slope stability had been relatively investigated. However, due to the difficulty of monitoring and simulating the PAP, the research on the influence of PAP on slope stability is relatively few. Therefore, our primary purpose was to investigate slope failure mechanisms under heavy rainfall by tracking the response of pore water pressures (PWP) and pore air pressure (PAP).

## 2. Methodology

In total, three cases of centrifuge rainfall model tests were conducted. The initial conditions of slope models are shown in Table 1. The slope dimension was 35 cm in height (including 25 cm height DL clay and 10 cm height surface sand), 30 cm in crest width, and 60 cm in base length. The gradient of the slope was 45 degrees. The slope models were constructed in a steel soil tank by compacting the foundation (DL Clay) at the compaction ratio of $D$ = 100 % with a water content of approximately $\omega$ = 17 %. The surface sand layer was then constructed at a relative density of $D_r$ = 25% and 50% for different cases with a water content of approximately $w$ = 9 %. During the construction, PWP and PAP sensors were installed at the prescribed location as shown in Figure 1. Then 30 g centrifugal force was applied. After the centrifugal force reached the desired 30 g, rainfall with constant intensities of $I$ = 50 mm/h and $I$ = 100 mm/h were applied above the soil tank using an artificial rainfall simulator.

Table 1. Initial conditions

| Case | Surface Soil | Water content $\omega$ (%) | $D_r$ (%) | $S_r$ (%) | Rainfall intensity $I$ (mm/h) |
|---|---|---|---|---|---|
| T-1 | Toyoura | 8.3 | 50 | 28.35 | 50 |
| S-2 | Silica No.6 | 8.9 | 50 | 33.41 | 100 |
| S-3 | Silica No.6 | 8.9 | 25 | 29.48 | 100 |

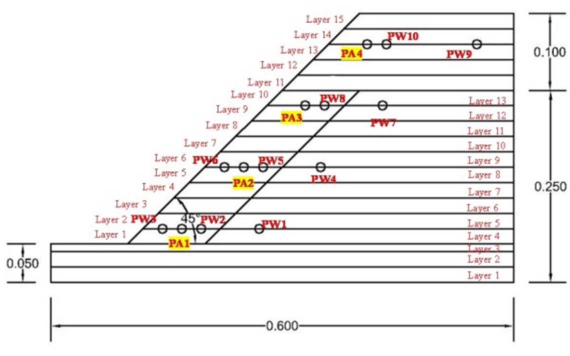


Figure1. Slope model

*東京農工大学大学院（Graduate school of agriculture,TUAT）/**農研機構(NARO)/キーワード：斜面安定

## 3. Results

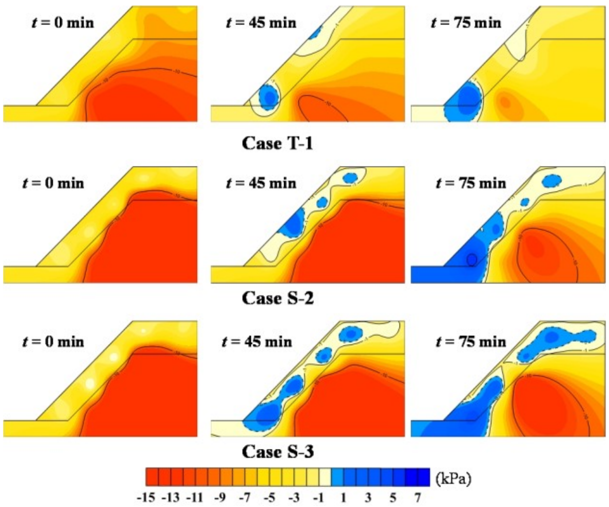


Figure 2. PWP distribution

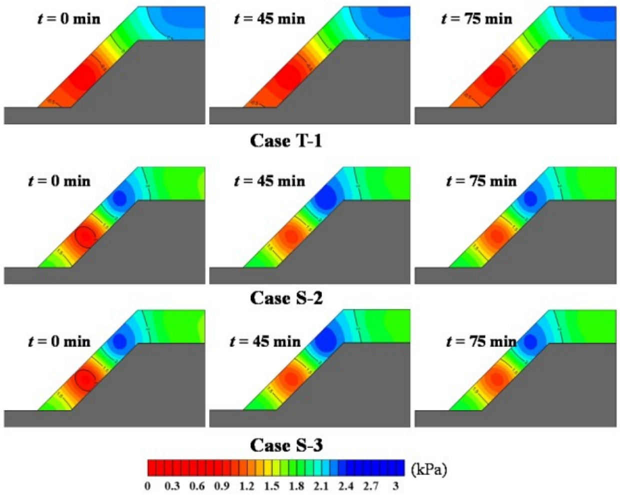


Figure 3. PAP distribution

Figure 2 shows the results of pore water pressure distributions. The time $t$ expresses the elapsed time since the start of the rainfall. Case T-1 started to show a clear phreatic surface around the slope toe at $t$ = 45 min, and the failure started. Then the phreatic surface expanded around the slope toe until the end of the test as the failure continued to the upper part of the slope. In Case S-2, a temporary phreatic surface appeared around the middle part of the slope then it expanded to the slope toe. As the rainfall intensity was higher than Case T-1, the phreatic surface area at the slope toe was large. The initial failure started around $t$ = 60 min. In Case S-3, a phreatic surface was investigated around the slope toe and along the slope, expanding with the elapsed time. A significant phreatic surface also appeared at the slope crest in this case. The initial failure was investigated around $t$ = 45 min in this case. Comparing Cases T-1 and S-2, which had the same $D_r$=50% and a different sand surface soil, the phreatic surface appeared quickly, and failure started early when the surface soil particle was fine (Case T-1).

In contrast to Cases S-2 and S-3, which had different $D_r$, a few tensile cracks appeared at the slope crest in Case S-3 when $D_r$ was reduced to 25%. Figure 3 shows the pore air pressure distribution. The air pressure was almost the same and did not observe apparent changes during the experiment. However, as the soil particle size in Case T-1 was smaller than in Cases S-2 and S-3, the value of PAP was small.

## 4. Conclusions

In Case T-1, the large surface slide was investigated. No significant slide was found in Cases S-2 and S-3. However, some slip line was found at the slope crest in Case S-3 with $D_r$=25%. There were no obvious changes observed in pore air pressure during the experiments. While this result suggests that pore air seems not to play a significant role, we found out that surface soil particle size and relatively density $D_r$ influence slope failure patterns.

## References


Izumi et al., 2021. *Soil Dynam Earthq Eng*, 151, Article 106963.