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Physical Modeling of Creep Behavior and Rainfall-Induced Landslide Early Warning

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Rainstorm indirectly provokes landslides because of its ability to level up groundwater table after certain hours dropping. This process causes excess pore water pressure generation and soil liquefaction at the sliding surface and determines the behavior of landslides triggered by extreme rainfall. Creep deformations are commonly observed in a slope before failure. Creep behavior, particularly tertiary creep stage, is therefore the main focus in predicting the final failure time of a slope. Progressive failure/tertiary creep deformation is the stage when strain rate exponentially increases just before final collapse. This study aims at simulating geotechnical model of tertiary creep behavior in soils, which was empirically found by Saito (1965) and Fukuzono (1985) to help issue warning of rainfall–induced landslides in developing regions where there is no implemented methodology for issuing effective warming of landslides yet.

Tertiary creep to failure is reproduced by pore-pressure-controlled test in ring shear apparatus, through which obvious relationship of A and α (alpha) values was obtained, whose range is consistent with those found in previous studies under slightly deviated trend due to different test condition: pore-pressure-controlled and shear stress development tests. Constant shear speed test at shear speed of v=1cm/s was conducted in the ring shear apparatus to acquire the relation curve of shear resistance and shear displacement, from which exponential expression of creep behavior is originated. The model formula is governed by two constants: m and γ (gamma), whose relation with constants A and α was examined. Physical simulation of creep behavior is then constructed by assuming that shear strength of soil increases and remains constant after reaching its maximum value in residual condition. This is to quantify normally consolidated condition of soils in natural slope. Shear resistance diminishes, while pore pressure is gradually generated through time till shear resistance is smaller than initial shear stress, and failure encounters. Velocity and acceleration of virtual surface displacement were calculated using the large shear displacement after failure and plotted in log scale to get A and alpha values. In similar way, additional formulation of shear stress development condition to failure was also investigated to check the applicability of the model. The A and alpha values of the model ware compared with those of laboratory tests.

As a consequence, model simulation of creep behavior to develop a most appropriate method for landslide early warning is successfully developed through very good correlation with the experimental results. The constant m and γ are corresponded to A and α respectively. A value gets smaller when m gets higher, whereas alpha and gamma increase accordingly. The m value best fitted is 0.1. Deviated trends were also observed in pore pressure control and shear stress increase simulations. The result shows that higher alpha value, higher landslide susceptibility is expected.