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The Importance of Drying and Wetting Scanning Curve on Slope Stability

Alfrendo Satyanaga[1], Sung-Woo Moon[1], Jong Kim[2*]
[1]Associate Professor, Department of Civil and Environmental Engineering, Nazarbayev University, 010000, Astana, Kazakhstan
[2]Professor, Department of Civil and Environmental Engineering, Nazarbayev University, 010000, Astana, Kazakhstan
*Corresponding Author: jong.kim@nu.edu.kz

Abstract:

Landslides are one of the leading natural disasters, claiming human lives annually. In most cases, this hazard occurs in unsaturated soil regions above the groundwater table, where climatic events, such as evaporation and rainfall, alter soil properties, potentially triggering failure. Many studies have incorporated the unsaturated soil mechanics parameters, such as the soil-water characteristic curve (SWCC), to assess slope instability. However, they often overlook SWCC hysteresis, limiting their ability to represent actual hydraulic soil properties in the field. Although some studies incorporate drying and wetting cycles of the soil-water characteristic curve (SWCC) into slope stability analyses, few have explored its scanning curves. These scanning curves trace intermediate paths within the hysteresis envelope, providing a more accurate representation of soil behavior under cyclic moisture changes. To address this gap, a comprehensive laboratory setup was established to simulate field conditions, using advanced tensiometers and capacitance moisture sensors for real-time monitoring of the SWCC scanning curve. Continuous measurement of water content and soil suction in an engineered soil sample enabled us to determine multiple drying and wetting cycles, including scanning curves. These data were then integrated into numerical analysis software for modeling seepage and slope stability. The results demonstrate that real-time monitoring consistently defines the scanning curve within the SWCC hysteresis loop across multiple cycles. Simulations using these scanning curve properties, which account for evaporation and rainfall, identified the most conservative Factor of Safety (FoS). These findings demonstrate that scanning curves prevent overestimation of the FoS, and enhance slope stability predictions.
Keywords: unsaturated soil; soil-water characteristics curve; scanning curve; slope stability; climate change