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Effect of Mechanical Properties on the Angle of Repose of Clay Soil

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Abstract

The angle of repose (AoR) is a critical calibration parameter in characterizing soil mechanical properties. This study examines the AoR across seven levels of soil moisture content. The fixed funnel method was used to measure AoR, complemented by a newly developed image-processing algorithm for AoR calculation. This algorithm effectively captures the irregular and rugged edges due to moisture-induced soil aggregation. The results indicated a consistent, monotonic increase in AoR with increasing moisture content. A model incorporating soil cohesion and internal friction angle was established to explain the observed AoR trends. Results suggest that changes in AoR are primarily driven by soil cohesion, with a relatively smaller influence from internal friction angle especially in moist conditions.

Keywords: angle of repose, soil mechanical properties, moisture content, clay soil, fixed funnel method

1. Introduction

Soil is a complex, porous, multi-phase material whose mechanical properties vary significantly with changes in moisture content. As moisture content increases, soil progresses through distinct states: starting as a dry, granular material, transitioning to a cohesive, moist plastic state, then to a fully saturated condition where pore spaces are water-filled, and finally reaching a fluidized state when overly saturated, leading to flow. These transitions make soil behaviour highly variable and sensitive to moisture content, presenting challenges in predicting its mechanical properties.

The angle of repose (AoR) is an important parameter used to characterize soil's flow ability and friction properties. Researchers commonly use the AoR experiment to conveniently measure the mechanical properties of soils or granular materials (Anwar et al., 2021). Since soil fluidity is generally linked to its shear resistance and internal bonding force, studying the AoR is essential for understanding the mechanical properties of soil. However, the mechanism of AoR is not yet fully understood. Many factors influence AoR, including particle shape, particle size distribution, cohesive forces and moisture content (Hashemi et al., 2018), with soil type and moisture content being especially significant. For example, clay soil and sandy soil have completely different mechanical properties at the same moisture content.

This paper is devoted to investigating the mechanical properties of soil by changing the soil water content. The AoR of soil is measured using the fixed funnel method, while an image processing method is applied to calculate the AoR from soil pile photographs. A multiple linear

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