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Study on Shear Behavior Characteristics of Completely Weathered Granite Soil Based on Ring Shear Tests

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Received: June 14, 2025, Accepted: November 6, 2025

Abstract: This study investigates the shear behavior of completely weathered granite soil using a series of ring shear tests. The effects of normal stress, shear rate, and degree of saturation on the mechanical response were analyzed. The results indicate that the shear strength of the soil shows strain-softening behavior, with peak strength higher than residual strength. As saturation increases, both peak and residual shear strengths first rise and then decrease. Moreover, the residual friction coefficient decreases with increasing shear rate, exhibiting a negative rate effect. These findings contribute to a better understanding of the shear mechanism of completely weathered granite and provide theoretical support for the prediction and prevention of rainfall-induced landslides.

Keywords: ***Completely weathered granite, Shear behavior, Ring shear test.***

Introduction

Completely weathered granite is widely distributed in the southeastern coastal areas of China, characterized by its high porosity, softening upon immersion in water, easy disintegration, and poor physical and mechanical properties. Extensively covering slope surfaces, completely weathered granite is a major geological carrier of landslides in the region (Bai et al., 2022). Under extreme rainfall conditions, it is highly susceptible to triggering landslides, seriously threatening the safety of people's lives and property.

Many researchers have conducted numerous studies on the physical and mechanical properties of residual soil from completely weathered granites from various perspectives (Lu et al., 2024 and Hu et al., 2024). Most studies use direct shear and triaxial tests, which do not fully capture the mechanical behavior of rainfall-induced landslides during flow. In contrast, the ring shear tester has the advantage of performing long-distance shearing, measuring not only peak shear mechanical characteristics but also residual shear characteristics (Wang et al., 2022).

Therefore, this paper investigates the shear behavior of completely weathered granite through a series of ring shear tests, and analyzing the influence of different normal stresses, shear rates, and saturation conditions, providing necessary theoretical support for the prevention and mitigation of landslide disasters on this type of soil.

Materials and methods

Materials

The test soil samples were collected from the Huangzhutang landslide in Xiaba Township, Wuping County, Longyan City, Fujian Province, China. The sampled soil mainly consists of coarse-grained quartz, highly weathered feldspar, and kaolinite. It appears brick-red in color, exhibits low strength, and tends to disintegrate easily after disturbance. The material is classified as completely weathered granite soil.

The grain size distribution curve and the physical property indices of the test soil samples are shown in Table 1 and Figure 1, respectively.

Table 1, Physical properties of the test soil.

Indices	Natural water content, ω_0 (%)	Specific gravity, G_s	Maximum void ratio, e_{max}	Minimum void ratio, e_{min}
Values	14.08	2.626	1.383	0.545

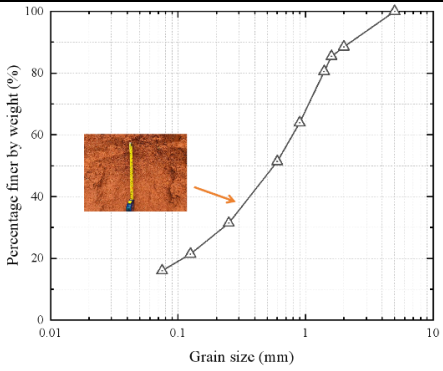

Figure 1, Grain size distribution curve of completely weathered granite soil samples.

Methods

This study was conducted by the SRS-150 ring shearing apparatus from Tongji University. The structural schematic diagram of the device is shown in Figure 2, which consisted of the upper loading plate and the lower shearing box. The apparatus consolidates the specimen

in the lower shear box by applying a load on the upper lid and then subjects it to shearing through the action of the shear axis.

Figure 2, SRS-150 ring shear apparatus.

This study investigates the effects of different normal stresses, shear rates and degrees of saturation on the shear behavior of the soil. The test conditions are summarized in Table 2.

Table 2, Summary of the test condition.

Normal stress, σ (kPa)	Saturation, S_r (%)	Shear rate, v (mm/min)	Relative density, D_r (%)
20, 50, 100, 150	0, 33, 66, 100	1.1-10.9-21.8-32.7-65.4-98.2-130.9-196.3-294.5-392.7	77%~78%

Results

Effect of saturation on shear behavior

To investigate the effect of saturation on the mechanical properties of landslides, shear tests were conducted on soil under different saturation conditions. The results show that, in most cases, the samples exhibit strain softening characteristics, with peak shear strength exceeding residual shear strength. As saturation increases, the shear strength of the samples (including peak and residual strength) initially increases and then decreases; that is, the shear strength reaches its maximum at a certain saturation level and then decreases with further increases in saturation.

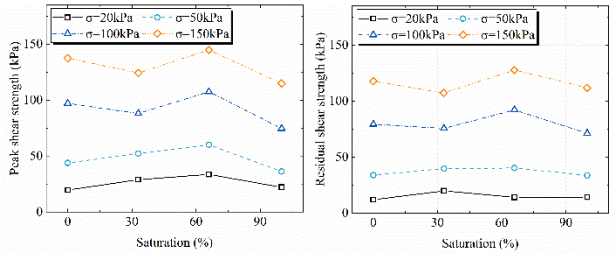

Figure 3, Peak and residual shear strength-saturation relationship curves.

Effect of shear rate on shear behavior

To investigate the effect of shear rate on the shear behavior of the samples, continuous shearing at ten different rates was conducted. The experimental results show that, overall, the residual friction coefficient μ of most samples decreases with increasing shear rate, exhibiting a negative rate effect (Figure 4).

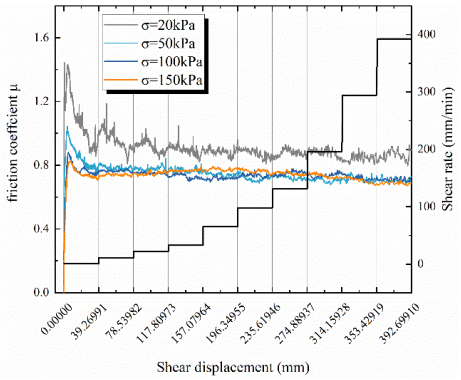

Figure 4, Residual friction coefficient μ -shear displacement curve (taking S_r=33% as an example).

Conclusion

In conclusion, the shear mechanical properties of completely weathered granite are closely related to soil saturation. Under saturated conditions, both the soil cohesion and internal friction angle decrease significantly. These findings provide important theoretical support for the prevention and control of landslides occurring in clusters.

Acknowledgement

This work was supported by the National Key R&D Program of China (Grant No. 2024YFC3012600).

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