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The effect of freeze-thaw cycling on the mechanical properties of expansive soils

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Abstract

Expansive soils, which contain the clay mineral montmorillonite, are extensively distributed throughout many regions of the world and represent a source of risk to civil engineering structures. For example, some cutting slopes on the Jilin-Tumen-Hunchun high-speed railway in Northeast China consist of expansive soils. These soils, when exposed to freeze-thaw (F-T) cycles, can cause heavy economic losses, as well as present risk to the earth retaining system. In this study, consolidated-undrained (CU) triaxial tests were performed to investigate the effect of F-T cycles on the strength of expansive soils. The stress-strain relationship, elastic modulus, failure strength, effective stress paths, and effective shear strength parameters (i.e., effective cohesion and internal friction angle) were measured for expansive soils after a maximum of 9 F-T cycles. The test results indicate that expansive soils tend to exhibit strain-hardening behavior as the confining pressure is increased. By increasing the number of freeze-thaw cycles (N_{FT}), the elastic modulus, failure strength, and effective shear strength parameters (i.e., effective cohesion and internal friction angle) of expansive soils decrease significantly. However, when the N_{FT} exceeds a threshold value, the effect of F-T cycles on the strength behaviors of expansive soils is not significant. With the increase in the number of F-T cycles, the curvature of the effective stress paths also increases. In addition, based on the experimental results, a unified stress-strain relationship considering the effect of F-T cycles on the mechanical behavior of expansive soils was formulated in a disturbed state concept (DSC) framework. A state function based on the DSC was employed to characterize the gradual change in state of the expansive soils under the influence of F-T cycles.

Keywords: Expansive soils; Freeze-thaw cycles; Triaxial tests; Disturbed state concept (DSC)

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