Postprint: Desiccation Cracking Behavior of Undisturbed Loess under Freeze-Thaw Cycles

Authors: Luqing Zhao, Zhou Cuiying, Peng Jianbing

Date: 2025-07-18T00:00:00+00:00

Abstract

Fissures formed in loess under the action of freeze-thaw cycles and wetting-drying cycles adversely affect the seepage and stability of slope engineering. However, research on the influence of freeze-thaw cycles on desiccation cracks in undisturbed loess is limited. This study conducted evaporation tests on undisturbed loess with different water contents, followed by freeze-thaw cycle tests with varying numbers of cycles. To explain the desiccation cracking behavior, scanning electron microscopy (SEM) tests were performed to determine the microstructure of undisturbed loess specimens. The results indicate that freeze-thaw cycles further exacerbate the inherent loose structure of undisturbed loess by forming pore expansion, pore connectivity, and continuous channels, and destroy the bonding formed by fine particles and cementing minerals within the undisturbed loess. Undisturbed loess that has not undergone freeze-thaw cycles primarily forms single-type fissures, whereas undisturbed loess subjected to non-zero freeze-thaw cycles exhibits both single-type fissures and Y-type fissures. The difference in fissure morphology is attributed to the formation of numerous structural defects in the looser microstructure under the action of freeze-thaw cycles. Furthermore, the crack ratio, average crack width, and total crack length of undisturbed loess increase with increasing number of freeze-thaw cycles. This can be explained by two effects induced by freeze-thaw cycles: one is the reduction in tensile strength due to bonding destruction, and the other is non-uniform shrinkage deformation caused by rapid water evaporation in specimens with higher water content. Moreover, the effect of freeze-thaw cycles on desiccation cracks in undisturbed loess with higher water content is more significant than that in loess with lower water content, primarily due to the greater frost heave force generated in the former.

Full Text

Influences of Freeze-Thaw Cycles on Desiccation Cracking of Intact Loess

Luqing Zhao[1], Cuiying Zhou[1], Jianbing Peng[2]

[1] School of Civil and Transportation Engineering, Guangdong University of Technology, Guangzhou 510006, China
[2] Chang' an University, Xi' an 710064, China

Abstract

Cracks formed in loess under freeze-thaw and wetting-drying cycles adversely affect seepage and stability in slope engineering; however, research on the influence of freeze-thaw cycles on desiccation cracking of intact loess remains limited. This study investigated intact loess samples with varying initial water contents through evaporation tests, followed by subjecting them to different numbers of freeze-thaw cycles. Scanning electron microscopy (SEM) was employed to characterize the microstructure and elucidate the mechanisms governing desiccation cracking behavior.

The results demonstrate that freeze-thaw cycles exacerbated the inherently loose structure of intact loess by inducing pore expansion, enhanced pore connectivity, and continuous channels, while simultaneously destroying bonds formed by fine particles and cementing minerals. Consequently, intact loess without freeze-thaw exposure primarily developed single-type cracks, whereas samples subjected to freeze-thaw cycles exhibited both single-type and Y-type cracks. The difference in crack morphology is attributed to the formation of numerous structural defects within the looser microstructure induced by freeze-thaw cycles.

Furthermore, the crack ratio, average crack width, and total crack length all increased progressively with the number of freeze-thaw cycles. These phenomena can be explained by two mechanisms induced by freeze-thaw cycles: (1) reduced tensile strength resulting from bond destruction, and (2) non-uniform shrinkage deformation caused by rapid moisture evaporation in samples with higher water content. Additionally, the influence of freeze-thaw cycles on desiccation cracking was more significant in intact loess with higher initial water content compared to lower water content samples, primarily because the former experienced greater frost heave forces.

Keywords: intact loess; desiccation cracks; freeze-thaw cycles; microstructure

Note: Figure translations are in progress. See original paper for figures.