Effect of unsaturated expansive soils on canal linings: A case study on Tabriz plain canal, Iran

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Abstract

Based on the linear nature of water conveyance projects, they include various geological formations and are usually in contact with water. Because of these reasons, most of the constructed irrigation and drainage networks are subject to deformation and displacement due to problematic soils. One of these problematic beds is unsaturated expansive soil. The unreinforced trapezoidal canals are damaged when constructed on this type of soils. In the current paper, this phenomenon has been studied using field observations, experimental tests, and numerical modeling. In practice, a filter layer is used to reduce the soil swelling effects on canal lining in Tabriz plain project. For performance investigation of this layer, the amount of soil swelling and relative displacement of canal section panels are measured by recording of surveying points. This phenomenon is also modeled numerically. Using the obtained results, the swelling of the bed soil is calculated at different parts of the canal section with filter and without it and the locations of maximum movements are determined. In order to predict the interaction behaviour between unsaturated expansive soil and concrete lining at different moisture conditions, the special constitutive unsaturated soil behaviour model is selected in software. The results of analysis show the location of maximum deformation and lining bending moment on the canal section. In addition, comparison between the results of numerical modeling and field data illustrates acceptable precision of the numerical modeling.

Keywords: Canal, Expansive soil, Lining, Filter, Bending moment.

۱. INTRODUCTION

Expansive soil is a main type of problematic soils. These soils are causing a lot of problems in different projects for civil engineering and especially for geotechnical engineering. The volume of expansive soil changes during variation in its moisture content. It swells when its water content increases and shrink when water loses. These volume changes lead to serious damages in most light structures found on or in expansive soil [۱،۲].Expansion is generally occurred in some clay minerals because of absorbing water by particles. This phenomenon lead to change the distance between particles and finally distortion of internal stress equilibrium.

Some of the most important lightweight structures that are damaged as a results of swelling and shrinkage can be mentioned following: the foundation of light buildings, retaining walls, pavements, airports, sidewalks, canal linings and beds. Evidence indicated that in Iran, most of the lining canals in irrigation and drainage networks cracked after first impounding [۳]. If the swelling pressure of bed soil is more than the weight stress of light structure, it cannot endure this pressure and cracking occurs. The range of such damages can be varied from fine cracking of pavements or small displacement of foundation, which is very common, to impressive cracking of canal lining or large displacement of footings.

Repairing cost of civil engineering structures which damaged due soil expansion was estimated many billion dollars per annum worldwide. Every year many new structures are constructed on the swelling soils in Iran, over ٦۰٪ of these structures suffered minor damages such as cracking, and about ۱۰٪ of these structures are heavily damaged that cannot be repaired [٤]. After occurring first cracks in hydraulic canal lining, over time they become larger because of thaw and freeze cycles. This factor may be gradually destroy all surface of canal section.