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Physical Modeling of Joint Effect on Interaction Behavior of Expansive Soil and Canal Lining

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Abstract

Construction of irrigation networks on unsaturated expansive soil have led to serious damages to the structure of unreinforced canals. In current paper, this phenomenon is studied by physical modeling. In this research, Tabriz plain canal is selected as a case study and based on characteristics of this canal, the physical model is constructed as small scale (1/10) in laboratory. During the tests, PIV method is used for evaluating the soil swelling behavior and the lining deformations are measured by the appropriate sensors. Considering joints on lining is a way to reduce the effect of swelling on canals. This solution is studied in this paper to obtain the optimal number and location of joints on lining. Test results show the distribution of soil displacement, the amount of lining uplift and the location of maximum interaction force. In addition, the effect of joints on lining behavior is completely determined.

Keywords: Physical modeling, expansive soil, canal, PIV, joint .

1. INTRODUCTION

One of the most common types of problematic soils is expansive soils. Expansive soils are a worldwide challenge. They pose problems for civil engineering in general and for geotechnical engineering in particular [1]. Such soils cause damage to structures founded in them because of their potential to react to change in moisture. They undergo severe volume changes corresponding to change in moisture content. Expansive soils swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water [1,3].

Due to alternate swelling and shrinkage, they result in detrimental cracking of lightly loaded civil engineering structures such as foundation, retaining walls, pavements, airports, sidewalks, canal beds, and linings [1].Destruction of concrete lining of canals is the most common form of problem in irrigation and drainage network in Iran [4]. The damages in the hydraulic canals which constructed on expansive soils are observed in the forms of cracking in the concrete lining and their uplift. Over time and with occurrence of melting and freezing cycles, fine micro-cracks in the lining become larger and provide a pathway for water penetration and plant growth. These factors eventually lead to change of hydraulic canal characteristics and finally its destruction.

Physical modeling has an important role in geotechnical studies in recent years. But the study of interaction behavior between expansive soil and light structure with physical modeling is a topic that less attention has been done in compared with other issues. The behavior of slopes and tunneling in expansive soils are important issues that were studied with physical modeling over the years [5].

The aim of this paper is to study and discuss the effect of expansive soil on canal structure by physical modeling. Also, it is attempted to suggest the ways to control and reduce the effect of soil swelling on canal lining damages. For this purpose, Tabriz plain canal is selected as a case study and the geometric properties and initial joint locations of physical models are selected based on its characteristics with considering small scale relations (1/10).

The irrigation and drainage network of Tabriz plain is under construction on expansive soil in the northwestern part of Iran. The length of the main canal is 29 km, width of floor between 2.5 to 5.0 m, and its height between 2 to 2.75 m. The slope of canal walls is 1 (vertical) to 1.5 (horizontal). The canal lining is made of unreinforced concrete. Three series of joints are considered in the canal section: two joints in canal walls in the level of 0.5 meter from the floor and one joint in center line of canal floor [2]. It should be noted