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Large-scale Apparatus for Measurement of Collapse Potential of Soils with Simulating the Pattern of Water Infiltration Ability

J. Mahmoudi, R. Pourhosseini *

Faculty of Civil Engineering, Yazd University, Yazd, Iran

ABSTRACT: Collapsible soil as an example of problematic soils can cause problems in structures. Collapsible soil may be stable before the presence of water, but after water enters, it experiences significant and sudden settlement. The most important issue in dealing with these soils is to predict their settlement. Up to now, various experiments have been designed in the laboratory or in-situ to determine the collapse potential, the most common of which is the oedometer test. The most important drawback of the existing experiments is the impossibility of simulating the patterns of water infiltration in the soil. In this study, an apparatus with a mold with a diameter of 14 cm and a height of 10 cm was built that has the ability to simulate water infiltration patterns and can measure the amount of collapse potential based on the source of water infiltration. This apparatus simulates water infiltration patterns into four categories based on the direction of water movement (from top to bottom or from bottom to top) and water distribution (point or expanding). The laboratory results of this apparatus on a sample of collapsible soil show that the collapse potential depends on the water infiltration pattern and it isn't possible to use one collapse potential amount for all patterns. According to the laboratory results, the highest collapse potential is related to the pattern of water infiltration from top to bottom and expanding form, and the lowest is related to the pattern of water infiltration from bottom to top and point form.

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1- Introduction

The collapsible soil has been widely studied as an important issue in the field of geotechnics for more than 80 years. As the name suggests, the volume of these soils can be significantly reduced by wetting (with or without extra loading) and create challenges for geotechnical projects.

The characteristic features of these soils are low unit weight, open structure, high void ratio and high porosity, geologically young, low water content and low inter-particle strength [1-3].

The amount of settlement of collapsible soil depends on various parameters. The most important of these parameters include water content, initial dry unit weight, fine-grained content, pressure applied and soil grain quality [4-6].

Construction of buildings on collapsible soils, which are typically located in arid and semi-arid areas, requires stabilization or improvement of these soils [7].

Water can enter the soil from various sources such as rainfall, floods, tree irrigation, seepage and breaking of water pipes, rising groundwater level, sewage seepage, etc. [8] but unfortunately, to date, few studies have been done on the effect of the type of water infiltration on the collapsible soil.

In this study, the design and construction of an apparatus with the possibility of simulating different types of water infiltration in collapsible soil is presented and the effect of water direction (from top or bottom) and water distribution (point or expanding) on the collapsible potential using this apparatus is investigated. The collapse potential obtained from this apparatus for different patterns of water infiltration was compared with the results of an oedometer test.

2- Measurement of Collapse Potential

The collapse potential is an indication of the amount of change in the total volume of a soil due to loading and wetting. In one-dimensional settlement, the collapse potential is calculated using the change in sample thickness after wetting and applying a load. Equation 1 shows an engineering definition of collapse potential using void ratio changes [9].

$$C_p = \frac{\Delta e}{1+e_0} \times 100 \frac{\Delta h}{h_0} \times 100 \tag{1}$$

Where: Δe is decrease in void ratio due to wetting, e_0 is the initial void ratio, Δh is change in specimen height resulting from wetting and h_0 is initial specimen height.

*Corresponding author's email: r_porhoseini@yazd.ac.ir

Fig. 1. Phase velocity dispersion curves for a steel pipe with outer diameter of 220 mm and wall thickness of 4.8 mm

Table 1. An example of a table

property	Soil classification	γ (kN/m^3)	ω(%)	$\gamma_{d,max}$ (kN/m^3)	ω_{opt}(%)	Gs
value	SW-SC	13	5	20.99	8.3	2.72

3- Apparatus with the Ability to Simulate the Pattern of Water Infiltration

Due to the limitations of the existing experiments, an apparatus was prepared that has the ability to simulate various types of water infiltration in the soil. According to Figure 1, the apparatus consists of three parts, including the loading system, the sample cell and the system for measuring and recording displacements.

4- Results and Discussion

In the laboratory studies, a soil sample made in the laboratory was used. A sample was produced with a weight ratio of clay to sand of 30% and moisture content of 5%, whose characteristics are given in Table 1. The collapse potential of this sample is equal to 8.87 and according to the ASTM standard, the degree of specimen collapse of this soil is moderate to severe.

To check the performance of the built apparatus, four tests were conducted with different water infiltration patterns in the soil. In each of the tests, the sample was first loaded up to 200 kPa and after one hour, water entered the soil according to the pattern of infiltration. Figure 2 shows the settlement-stress diagrams of different water infiltration patterns.

Since the collapse potential is obtained from the oedometer test, which is the most common method of calculating the collapse potential, the results of this test were used as a basis for comparing the results of tests capable of simulating the water infiltration patterns, and the difference between collapse potential obtained from tests with different water infiltration patterns and the oedometer test results were calculated, which is shown in Figure 3.

5- Conclusions

A laboratory apparatus was designed and built that has the ability to simulate all types of water infiltration patterns in the soil. This apparatus divides and simulates water infiltration into four general categories based on the direction

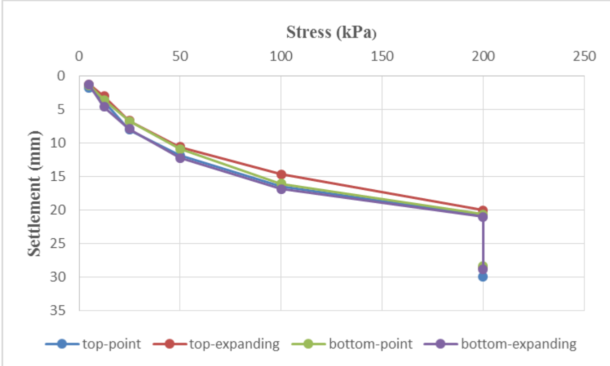

Fig. 2. Stress-settlement diagrams of different water infiltration patterns

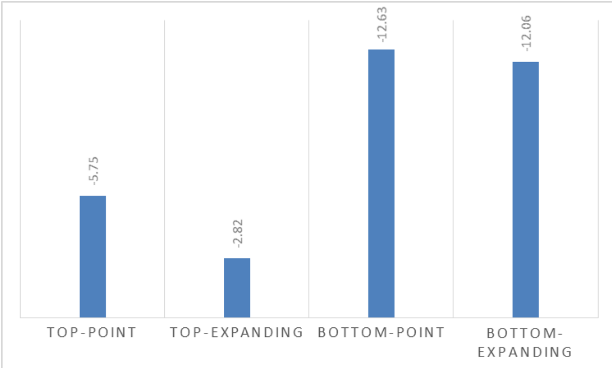

Fig. 3. The percentage of difference in collapse potential of different water infiltration patterns with oedometer test

of water movement (from top to bottom or from bottom to top) and distribution of infiltration (point or expanding). A soil sample made in the laboratory was used and the collapse potential obtained from four patterns of water infiltration and oedometer test was compared. The results obtained from this study are given below:

1- Water can enter the soil through existing sources such as rainfall, floods, irrigation of trees, leakage and failure of water pipes, rise of the underground water level, etc., and the type of water infiltration can be affect the settlement of collapsible soil.

2- Since the existing tests for predicting the collapse potential do not have the ability to model the water infiltration pattern, their results can be accompanied by errors.

3- The value of the collapse potential obtained from the conventional oedometer test is higher than the values of the collapse potential obtained from the tests with water infiltration pattern modeling.

4- The highest collapse potential is related to the time when water enters the collapsible soil from top to bottom and expanding form, and the lowest is related to water infiltration from bottom to top and point form.

5- Water infiltration from top to bottom causes more settlement than water infiltration from bottom to top in the soil. And settlement for two point and expanding water distribution are close to each other and have little difference.

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