Evaluation the effect of surcharge intensity on collapse potential of soils in different water infiltration patterns

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ABSTRACT

Collapsible soils have good stability in dry state, but it experiences significant settlements due to wetting. Many characteristics can affect the collapse settlement. The amount of wetting pressure is one of the most important parameters affecting the collapsible soil. Water can enter the collapsible soil from various sources such as floods, rainfall, irrigation, etc. But in the tests used to investigate the behavior of the collapsible soils, the influence of these sources cannot be investigated. An apparatus capable of simulating different patterns of water infiltration in the soil was built and using three wetting pressure of 100, 200, and 300 kPa, the effect of surcharge in each pattern of water infiltration was investigated separately. The results show that for collapsible soil is used, in all three surcharges, the collapse potential of the oedometer test is different from the water infiltration tests. The biggest difference is related to the surcharge of 300 kPa that the maximum difference between the oedometer and water infiltration tests is 16%. When the water enters as top-point pattern, the highest collapse potential is created among the different patterns. The collapse potential decreases with the increase of the surcharge, but the amount of changes is different for each pattern. For example, with the increase of surcharge from 100 to 200 kPa, the greatest reduction of the collapse potential with a value of 27.2% is created in the bottom-point pattern.

KEYWORDS

Collapse potential, Water infiltration, Apparatus, Surcharge, collapsible soil.

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1. Introduction

Collapsible soil, as one of the problematic soils, can cause a lot of damage to construction projects. collapsible soil shows good stability in the dry state, but with the entry of water, it undergoes sudden and significant settlements.

Collapsible soils are found in many countries around the world, including China, Russia, United States, France, Germany, New Zealand, and Argentina. These soils make up approximately 10% of the global land area. [1]

The characteristics of collapsible soils include low dry density, open structure, high void ratio and porosity, geologically young, partial saturation, enough particle-to-particle bonding agent to hold particles together in their unsaturated state. [2,3]

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. [4]

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

Where: C_p is collapse potential, 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.

The value of the collapse potential is based on the definition that is made for a certain amount of surcharge, and this value is different in another surcharge, which shows that the amount of collapse potential is dependent on the amount of surcharge at the time of saturation. One of the subjects that has been studied up to now is the investigation of the changes in the amount of settlement and the collapse potential against the changes in the surcharge. [5]

In this study, a sample made in the laboratory was used, and firstly, the behavior of this collapsible soil was investigated using an oedometer device, and then using a large-scale device with the ability to model different patterns of water infiltration in the soil, the impact of surcharge on the collapse potential in different water infiltration patterns was investigated separately and the results were compared.

2. Experimental Investigation

In the laboratory studies, a soil sample made in the laboratory was used. According to the studies of Hanna and Suleiman [6], it is possible to make a collapsible soil by combining fine sand and kaolin clay and adding some moisture. Sand plays the role of main particles and clay plays the role of bonding between sand particles.

According to the limitations of the existing tests, an apparatus capable of simulating different water infiltration patterns was built and used.

3. Results

3.1 Top-point pattern

Three saturation Surcharge of 100, 200 and 300 kPa are used and in each test, after loading up to the desired Surcharge, water enters the sample from top as a point and the amount of settlement is measured at different times. Figure 1 shows the stress-settlement diagram related to this water infiltration pattern. Based on these results, the amount of collapse potential for three Surcharges of 100, 200 and 300 kPa is calculated as 11.28, 9.08 and 6.91, respectively.

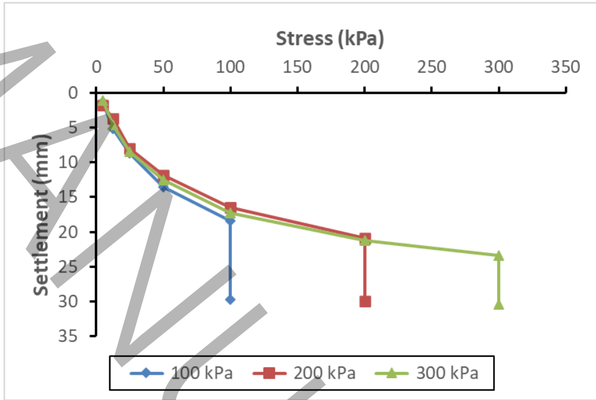

Figure1. Stress-settlement diagrams of Top-point water infiltration pattern for different Surcharges

4. Analysis of the results

Figure 2 shows the changes of the collapse potential against the increase of the Surcharge from 100 to 300 kPa in the oedometer test and the tests with the ability to simulate different water infiltration patterns. With the increase of the Surcharge, the amount of the collapse potential decreases in all the experiments. The results related to the 100 kPa Surcharge are considered as the basis and the amount of change of the collapse potential for the two Surcharges of 200 and 300 kPa are investigated. In the increase of Surcharge from 100 to 200 kPa, the largest decrease in the collapse potential is related to the bottom-point water infiltration pattern with a rate of 27.2% and the lowest is related to the top-point water infiltration pattern with a rate of 19.5%. The rate of reduction of collapse potential in patterns with water movement from bottom to top is higher than patterns with water movement from top to bottom.

In the increase of surcharge from 100 to 300 kPa, the amount of reduction in collapse potential in the oedometer test is lower than in tests capable of simulating different water infiltration patterns, and in general, the reduction in collapse potential in different tests is close to each other and there is little difference, and in this amount of increase surcharge, the collapse potential decreases by about 37%.

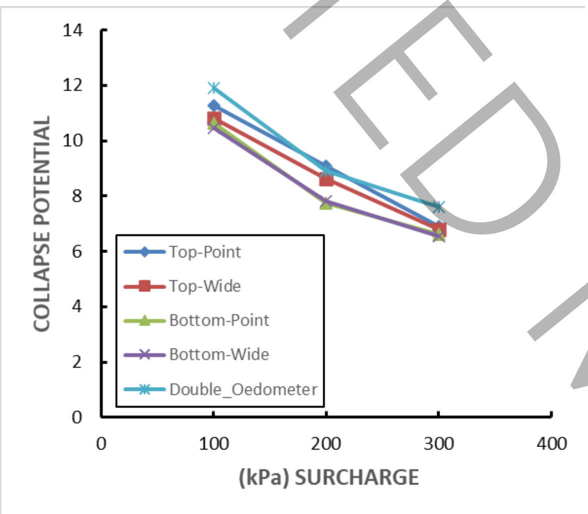

Figure2. Comparison of the changes in the collapse potential against the increase of the surcharge

5. Conclusions

The amount of surcharge is one of the influencing parameters on the behavior of collapsible soil. The effect of this parameter was first investigated using an oedometer test, and then using a large-scale device with the ability to simulate different water infiltration patterns, the amount of collapse settlements in three surcharges of 100, 200 and 300 kPa for different water infiltration patterns was investigated. The most important results obtained are:

1. The amount of collapse potential depends on the water infiltration pattern. For the used soil, in all three surcharges of 100, 200 and 300 kPa, the amount of collapse potential obtained from the oedometer test is higher than the tests capable of simulating different water infiltration patterns.
2. The comparison between the three Surcharges shows that the effect of simulating water infiltration patterns in the Surcharge of 300 kPa is greater than the other two Surcharges, and in this Surcharge the maximum amount of the difference in collapse potential between the oedometer test and the water infiltration pattern tests reaches 16%.
3. In the increase of the Surcharge from 100 to 200 kPa, the largest decrease in the collapse potential is related to bottom-point water infiltration pattern with the rate of 27.2% and the lowest is related to the top-point water infiltration pattern with the rate of 19.5%. In the increase of the Surcharge from 100 to 300 kPa, the amount of reduction of the collapse potential in the oedometer test is lower than the tests with the ability to simulate water infiltration patterns.

6. References

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