Effect of Flooding Fluid Quality on the Properties of an Expansive Soil during Wetting and Drying Cycles

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Extended Abstract

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Introduction

Expansive soils are a very common cause of extreme damages because they are susceptible to volume change due to a change in water content. Geotechnical problems associated with the expansive soils are well documented in different literature. As a result, a clear understanding of the behavior of such soils is required for the effective design of structures and infrastructures on these soils. The effects of hydrocarbon pollutants as a flooding fluid on the swelling potential of an expansive soil during wetting and drying cycles have not been considered in the previous researches. The aim of this research is to study the properties of an expansive soil with different flooding fluids, i.e. distilled water and solutions of glycerol with 10 and 20% through a number of cycles of wetting and drying tests under constant surcharge pressure.

Material and methods

The soil that was used in this work was a highly expansive clay soil (according to the classification by McKeen (1992)). It was prepared by mixing 20% bentonite and 80% kaolin. This soil was classified as a clay with high plasticity according to the Unified Soil Classification System (USCS). The optimum water content in the standard compaction test was 18.11% and the maximum dry unit weight was 16.27 kN/m^3.

Distilled water and solutions of glycerol with concentrations of 10 and 20% were used for flooding the samples. To prepare the glycerol solutions, the required amount of glycerol was mixed with distilled water.

For making compacted samples for testing, the needed air-dried soil was weighed and the required water was added to it to reach the desired water content (4% below the optimum water content according to the compaction curve). The soil and water were mixed by hand and then was kept in a plastic bag for 24 hours to allow the uniform distribution of moisture in the soil. Samples were prepared by static compaction of the moist soil in a special mould.

A conventional oedometer was modified to allow the wetting and drying tests to be conducted under controlled surcharge pressure and temperature. During wetting and drying, the vertical deformation of the sample was measured by using a dial gauge. The variation of water content with void ratio during wetting and drying cycles was determined by using the information from the duplicated samples.

Results and discussion

Fig. 1 shows the variations of vertical deformation during wetting and drying cycles for samples that were flooded with distilled water and solutions of 10 and 20% glycerol. This figure illustrates that by increasing the number of cycles the amount of irreversible deformation is reduced until the equilibrium condition is achieved where the deformation due to wetting and drying is nearly the same. These results indicate that by increasing the concentration of glycerol the equilibrium condition with reversible deformation is reached in a fewer cycle of wetting and drying than the sample that was flooded with distilled water.

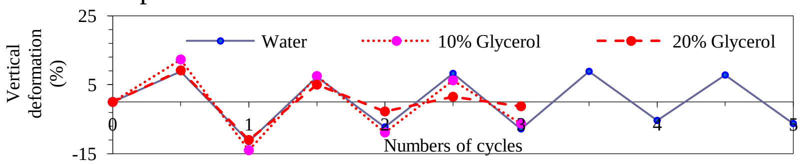

Figure 1. Wetting and drying cycles for different quality of flooding fluids

The results of void ratio versus water content at the equilibrium conditions for the samples flooded with distilled water and solutions of 10 and 20% glycerol (that were obtained from duplicated samples) are shown in Fig. 2. This figure displays that the paths of drying-wetting for different flooding fluids are nearly S-shaped curves. It is also seen in this figure that the order of the curves in this space is dependent on the percent of glycerol, the curves for the sample flooded with distilled water and 20% glycerol are located at the top and bottom of the space of void ratio against water content.

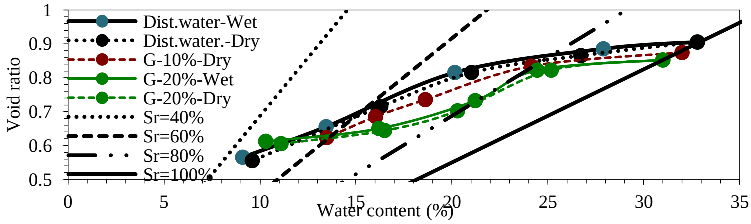

Figure 2. Water content-void ratio paths for different quality of flooding fluids

The change in the thickness of the diffuse double layer (DDL) affects on the swelling behavior of soil. The thickness of DDL is dependent on factors such as valency and concentration of cations, temperature, and dielectric constant. The value of dielectric constant for water is 80 and for solutions of 10 and 20% glycerol are 74.9 and 71.8, respectively. The magnitude of the attractive and repulsive forces between clay particles are inversely and directly depended on the value of the dielectric constant. The reduction in the value of the dielectric constant causes an increase in the attractive forces and leads to a reduction in the thickness of DDL. When the flooding fluid is a solution of glycerol, the initial chemical composition of pore fluid in the sample is changed. The chemical composition of pore fluid has different effects on the structure of clay soil such as changes in the thickness of DDL. When the flooding fluid is distilled water the pore fluid of samples has a dielectric constant of about 80. Therefore, the values of attractive and repulsive forces are not changed because of the same dielectric constant of flooding fluid and pore fluid. The results of tests on these samples (flooded with distilled water) show that by repeating the wetting and drying cycles the potential of swelling is reduced and after several cycles a reversible equilibrium condition is attained as depicted in Fig.1. When the pore fluid is the solution of glycerol, the attractive forces are increased due to the reduction of the dielectric constant of pore fluid and causes a reduction in the thickness of DDL. The shrinking of DDL is led to the formation of flocculated structure in the soil and results in pasting of particles together leading to the reduction potential of swelling. When the concentration solution of glycerol is increased the dielectric constant is decreased, the magnitude of attractive forces is increased and the degree of flocculation of the soil structure is increased that is yielded to a reduction of swelling potential.

Conclusion

Effect of different flooding fluids on the properties of an expansive soil during wetting and drying cycles were studied. The following conclusions can be drawn from the present research:

- After a number of wetting and drying cycles, the observed irreversible deformation was diminished and equilibrium was achieved. The solution of glycerol causes more reduction in the potential of swelling than distilled water.
- The wetting and drying paths in the space of void ratio and water content are S-shaped curves. The variations in the void ratio of samples flooded with the solution of glycerol are smaller than distilled water.

Keywords: Expansive soil, Wetting and drying cycles, Glycerol, Wetting and drying paths, Surcharge pressure.

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