Prediction of the soil-water characteristic curve of dune sand stabilized with SBR polymer and MICP process in the Jabal Kandi area

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Extended Abstract

(Paper pages 571-598)

Introduction

The geotechnical engineering problems involving unsaturated soils are included water flow, shear strength and volume change. Soil-water characteristic curve **(**SWCC) describes the constitutive relationship between soil suction and soil water content. SWCC may be determined directly or indirectly in the laboratory. Because of the various difficulties involved in the direct measurements, a simple and economical laboratory method namely filter paper method is of considerable value. The filter paper method is a laboratory technique that has recently been accepted as a standard method of measuring soil potential, reaching far higher ranges of water potential in comparison to other techniques, and is based on the principle of moisture absorption by filter paper until there is a balance in potential between filter paper and soil.

This paper presents an experimental investigation performed to evaluate the soil water characteristic curves of dune sand stabilized with SBR polymer and MICP processes (Sporosarcina pasteurii bacteria with CaCl2 and urea) with contact filter paper method in the Jabal Kandi area.

Material and methods

The dune sand used in this study was obtained from the surface (0–10 cm depth) of Jabal kandi area, located on the south-west of Urmia Lake.

SBR polymer is prepared from Paya Resin Company in Esfahan. In the MICP processes, S. pasteurii from Persian Type Culture Collection (PTCC 1645) was used as the urease positive bacterium. Cultivation of the microorganism was conducted in a medium containing 20 g l^{-1} yeast extract, 10 g l^{-1} NH_4Cl at a pH value of 8. Sporsarcina pasteurii was grown to late exponential phase to final concentration of 1.5 g dry weight l^{-1} and urease activity of 2.2 mM urea min^{-1} under aerobic batch conditions. Broth cultures were incubated in a shaker incubator operated at 120 rpm. Cementation solution of MICP consisted of CaCl2 and urea. All experiments were performed at an ambient temperature of $25^{o}C \pm 2$.

For the tests with Whatman No. 42 filter paper, three different soil samples were prepared (dune sand, dune sand stabilized with (5-10-15) % SBR polymer and dune sand stabilized with (5-10-15) % MICP process). Residual water content is 2.5% and the residual dry density is 15 kN/m^3. The soil is mixed with the right quantity of water and placed in a sealed plastic bag for 24 hours to allow the hydric equilibrium to establish. The contact filter paper tests were carried out on soil specimens stabilized with SBR polymer and MICP process to the residual water content (2.5%) and nearly residual dry density (15 kN/m^3). The soil specimen sizes were 50 mm in diameter and 20 mm height. The test procedure involves placing a piece of initially air dry filter paper against the soil specimen whose matric suction is required and sealing the whole to prevent evaporation. The filter paper was wetted to water content in equilibrium with the magnitude of the soil matric suction, and careful measurement of the water content of the filter paper enables the soil matric suction to be obtained from a previously established correlation. This provides a measure of the matric suction. ASTM D-5298-93 standard is used for the filter paper method.

Results and discussion

The SWCCs for dune sand stabilized with SBR polymer and MICP process under different SBR polymer and MICP process contents are illustrated in this study. Gradual transition from a unimodel SWCC to a bimodal SWCC was observed as SBR polymer and MICP process content increases. The unimodel SWCC is characterized by having two bends defining the air entry value and residual water content. The air entry value is defined as the matric suction above which air commence to enter the soil pores. The residual water content is defined as the water content beyond which no significant decrease in water content occurs. The bimodal SWCC is characterized by having four distinct bindings: two air entry values and two residual water contents. For SBR polymer and MICP process content equal to or less than 5 percent, the SWCC shows a unimodal form of SWCC. With the increase of SBR polymer and MICP process content greater than 5%, the SWCC indicate a bimodal form. It is further observed that the residual water content and the air entry value increases with the increase of SBR polymer and MICP process content. These observations are attributed to the presence of smaller pore size developed as a result of SBR polymer and MICP process particles filling the voids between sand particles. Bimodal SWCC are generally observed for gap-graded soils as well as soils that include two levels of pore sizes defined as macro pores and micro pores. Therefore, it can be inferred that the increase of SBR polymer and MICP process content, resulted in the formation of micro pores within the dune sand stabilized with SBR polymer and MICP process. The portion of the soil water characteristic curves representing macro pore sizes range between matric suction of 0.1 to 100 kPa. Whereas, the portion of the SWCC representing micro pore sizes lies between matric suction of 200 and 1500 kPa.

Summary and Conclusions

In this study, the effect of SBR polymer and MICP process content on the soil water characteristic curves of dune sand was evaluated. SBR polymer and MICP process contents considered include 0%, 5%, 10% and 15%. Results from this study indicated that, as the SBR polymer and MICP process content increased, the shape of the SWCC transforms from a unimodal form to a bimodal form. Furthermore, the air entry value and

residual water content were observed to increase with increase in SBR polymer and MICP process content signifying increase in water retention capacity. The bimodal form of the SWCC indicates the presence of two levels of pore sizes; namely macro pores and micro pores. For 10% and 15% SBR polymer and MICP process content, the macro pores are considered the dominant pore size covering a broad range of the SWCC from 0.1 to 100 kPa. Therefore, it is inferred that the SWCC of dune sand stabilized with SBR polymer and MICP process are strongly related to the texture and pore size distribution of the dune sand stabilized with SBR polymer and MICP process which in turn, has a significant impact on its hydraulic characteristics.

Keywords: Unsaturated soil, Suction, SBR polymer, Dune sand, Sporosarcina pasteurii bacteria

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