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EXTENDED ABSTRACT

The Effect of Silt on Soil-Water Characteristics of Unsaturated Sand

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1. Introduction

The structure of the earth, atmospheric conditions, and hydrogeology, has led that groundwater levels in most parts of the world, including Iran, to decline significantly. This issue causes the large amount of soils above the ground water level to be in unsaturated state. Various activities associated with soils, such as subsurface explorations, foundation engineering and building constructions in unsaturated soils, etc., necessitates the study of the properties of unsaturated soils. One of the most important and fundamental properties of unsaturated soils is water holding capacity or soil suction. The soil-water characteristic curve (SWCC) has been found to be a conceptual and interpretative tool by which the behavior of unsaturated soils can be understood (Vanapali et al., 1999). The SWCC defines the relationship between soil matric suction (the difference between the air and water pressure in the soil) and the volumetric water content.

In this study, the SWCCs of Firoozkoh sand mixed with two silty soils will be investigated to find out the effect of silt on soil-water characteristics of sand in unsaturated state. By conducting this research, one can predict the behavior of natural silty sand for geotechnical applications in practice. In the context of this study, in order to obtain laboratory SWCCs, Tempe pressure cell device will be designed and built.

2. Methodology

2.1. Soil water characteristic curve models

Due to difficulties of laboratory measurements and time consuming of tests, several models for estimating SWCCs have been proposed. The Brooks-Corey (1964) model is

$$\theta = \theta_r + (\theta_s - \theta_r)(\alpha h)^{-\lambda} \tag{1}$$

Where θ is the volumetric water content due to suction (h). θ_r is residual water content, θ_s is saturated water content and α is reverse of air entry suction. λ is the pore-size distribution index and is related to the slope of the curve. The van Genuchten (1980) model is

$$\theta = \theta_r + (\theta_s - \theta_r)\left[1 + (\alpha h)^n\right]^{-m} \tag{2}$$

Where the parameter n controls the slope of the SWCC about the pivot point and the parameter m rotates the sloping portion of the curve.

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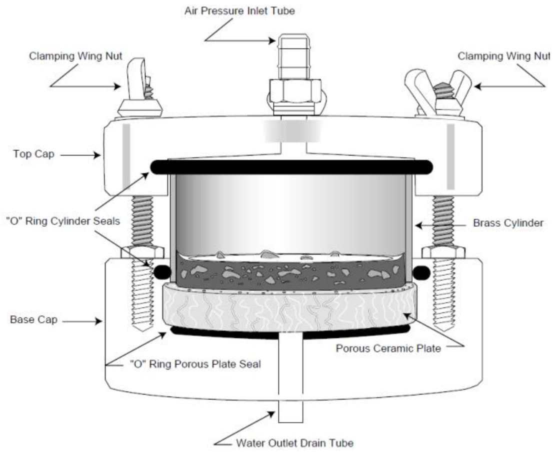
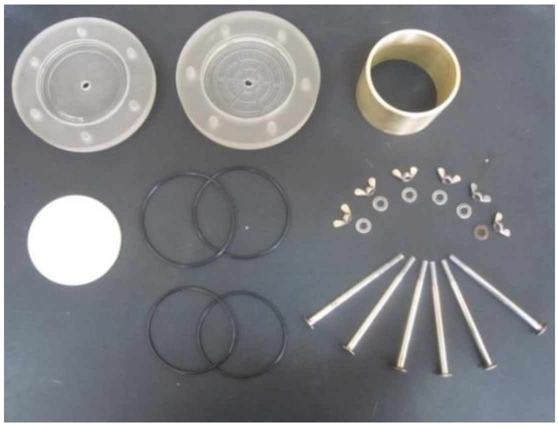
2.2. Design of Tempe Pressure Cell Apparatus

In this study, the Tempe pressure cell apparatus was designed. This apparatus consists of three parts. The top and base caps made of Plexiglas, a brass cylinder that contains the soil sample, and a porous ceramic plate with a certain air entry value placed under the soil. The Tempe pressure cell provides a simple method to determine SWCC. This characteristic of soils is determined by weighting the complete cell at pressure equilibrium points. Fig. 1. shows a schematic cross-sectional view of the Tempe pressure cell and its components.



(a)



(b)

Fig. 1. Tempe Pressure cell apparatus: (a) Cross sectional view, (b) prepared components

2.3. Materials

The sand used in this study was obtained from Tamin Mase Rikhteghari Company in Firoozkoh, Iran. The silt 1 and 2 used was obtained from different regions in Urmia City. Properties of soils are given in Table 1.

Table 1. Properties of soils

Properties	Sand	Silt1	Silt2
Specific Gravity, Gs	2.64	2.76	2.54
Liquid Limit, LL(%)	-	38.6	36
Plastic Limit, PL(%)	-	27.3	26.1
Unified Soil Classification	SP	ML	ML

2.4. Testing Procedure

Prior to making a run, the ceramic disk was saturated by soaking in distilled water for 24 hours. After compaction of soil sample in the cylinder, Tempe pressure cell components including wire mesh, filter paper, aluminum porous plate, and spring, were placed on the sample and the upper cap was attached to the cylinder. Air pressure was applied to the distilled de-aired water tank which caused the water flow from bottom to the top of the sample. At the end of saturation process, the accumulated water above the sample was drained. The suction on sample was applied in increments of 10kPa air pressure and water exiting from the compartment below the ceramic disk was monitored. At the end of the test, the cell was dis-assembled and the final water content of the sample was measured. The water content at each suction level was back-calculated based on the final water content and the amount of water losses recorded at each suction level.

3.Results and discussion

3.1. Laboratory SWCCs

Fig. 2. shows SWCCs of samples of Firoozkoh sand mixed with silt1 and silt2. Results illustrated that as silt content increased, holding capacity of water in samples increased; this is due to the influence of several factors such as texture, mineralogy, and type of soil. Vanapalli et al., (1999) represented these factors that influence the SWCCs. In silt 1 with increasing 15% silt to sand from 5% to 20%, residual water content of sample increased from 4.2% to 13.4% and also air entry suction increased from 10 kPa to 19 kPa.

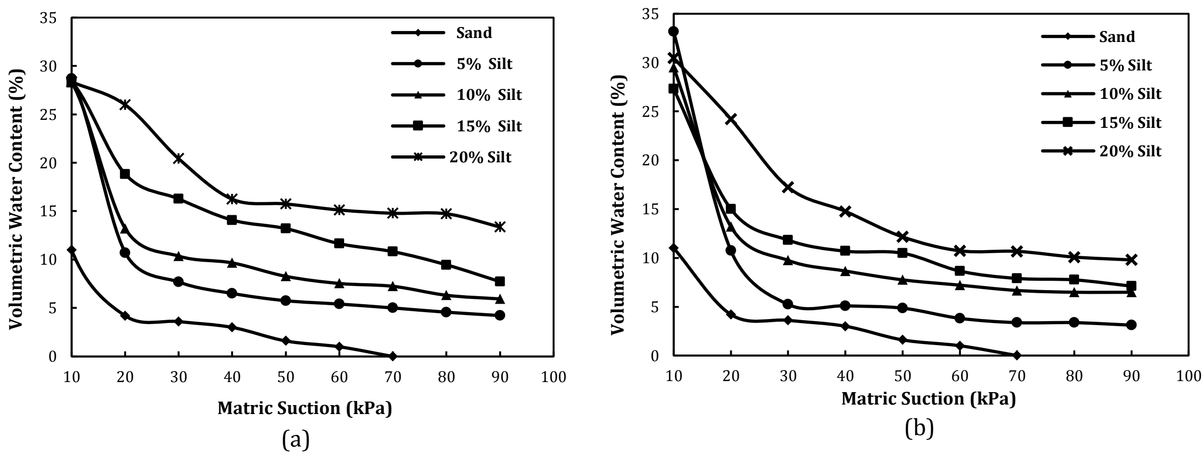


Fig. 2. Laboratory SWCCs of Firoozkoh sand mixed with: (a) silt 1, (b) silt 2

3.2. Fitting of laboratory SWCCs and theoretical models

Laboratory data obtained in the tests were fit to the models described by Van Genuchten (1980) and Brooks-corey (1964) equations in RETC computer code. According to values of SSR, each of models provide an acceptable fit to the experimental data.

3.3. Unsaturated hydraulic conductivities of BES samples

For understanding hydraulic conductivities of samples in different soil suction and range of changes, laboratory data contains SWCCs obtained from Tempe pressure cell apparatus were analyzed with Mualem (1976) and Burdine (1953) models in RETC computer code. Results illustrated that changes of hydraulic conductivities were large and with increasing of suction, hydraulic conductivity decreasing; for example saturated hydraulic conductivity of Silt1 is 4.2×10^{-4} cm/s whereas hydraulic conductivity in 1250 kPa according to Mualem model is equal to 1×10^{-11} cm/s.

4. Conclusions

Results of SWCCs illustrated that as silt content increased, holding capacity of water in samples increased. For example, with increasing 15% of silt 1 and 2 from 5% to 20%, the increase of volumetric water content in 90 kPa is 68%. The effect of silt 1 in increasing water holding capacity of sand was more than silt 2, because the particle size of silt1 was finer. Analysis of laboratory data contains SWCCs and hydraulic conductivities with Mualem (1976) and Burdine (1953) models in RETC computer code illustrated that changes of hydraulic conductivities were large and with increasing of suction, hydraulic conductivity decreasing. According to Mualem model, the minimum unsaturated hydraulic conductivity of sand was obtained in 40 kPa whereas this value for silt 1 and 2 was 1460 kPa, therefore the effect of silt on hydraulic characteristics of sand was severe and should be considered in geotechnical issues.

5. References

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