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Behavior Study of the Gypsiferous Sand Soil of AlNajaf City with Presence of Matric Suction Using Unsaturated Triaxial Device

Mustafa M. Abdalhusein[1], Ali Akhtarpour[2,*], Mohammed Sh. Mahmood[3]

[1] Ph.D. Student, Department of Civil Engineering, Ferdowsi University of Mashhad, Iran
[2] Ph.D., Department of Civil Engineering, Ferdowsi University of Mashhad, Iran
[3] Ph.D., Department of Civil Engineering, University of Kufa, Najaf, Iraq

ABSTRACT: Al-Najaf city is considered one of the gypsiferous rich soils cities in Iraq. When a building is constructed on a gypsiferous soil in the unsaturated state, no effective settlement will be distinguished. When a gradual saturation has occurred, the soil gives a clear deformation and may be collapsed. This paper presents how the degree of saturation can affect on the deformation of a gypsum sand soil. A triaxial test device has been modified to have the ability for unsaturated tests. The soil samples were taken from Al-Najaf city in Iraq. Disturbed samples with two different gypsum contents; 14% and 29%, are tested with the presence of different matric suctions, initial matric suction, 60% initial matric suction, 30% initial matric suction and zero matric suction. A loading-path was adopted to symbolize when construction is built on a gypsiferous sand soil in a specific matric suction (specific degree of saturation). In addition to the previous tests, two conventional saturated tests (CD) were added under the above mentioned of confining stresses. The results were when increasing matric suction, the stiffness and shear strength are reduced and the volumetric strains increase significantly. The percentage increases are 60% and 50% under confining pressure of 100 kPa and 200 kPa, respectively for the two selected gypsum contents. The results of this study can be used to estimate the settlement that results from decreasing matric suction due to water table rise or other phenomena.

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1- INTRODUCTION

The different between saturated and unsaturated soils is due to differences in their performance. Soil in unsaturated state does not keep an eye on its behavior to saturated soil mechanic [1]. With minimum values of water content with high values of matric suction, the main mechanisms are the relatively short-range adsorption effects governed by the surface properties of the soil particles. While, the dominant pore water retention mechanism becomes capillarity at low values of suction [2]. The stresses in saturated and unsaturated states, like; net normal stress and matric suction term, have been developed for unsaturated soils [3, 4]. Many researchers had been determined Soil Water Retention Curves (SWRCs) [5, 6], shear strength and strain stiffness [7, 8], in unsaturated soils. Shen et al. (2016) studied the strength parameters of silty sand that had been affected by matric suction and they showed that the matric suction affects on the peak value of angle of friction [9]. Also, Haeri et al. (2014) investigated the soil from the “Hezar-pich” Hills area near the city of Gorgan in the northeast of Iran [10]. They showed more severe collapse for specimens subjected to higher values of mean net stress during wetting process [10]. Triaxial apparatus for unsaturated soil have been developed by many researchers. Aversa and Nicotera (2002) designed apparatus for unsaturated testing for both triaxial cells and Oedometer [11]. The radial strains, the variation of water content and suction are controlled by using double walled burettes. Cabarkapa and Cuccovillo (2006) developed computerize triaxial testing systems to obtain accurate measurements in unsaturated soil testing in static states and dynamic [12]. Padilla et al. (2006) presented a computerize flushing device to remove the air bubbles and escape through high air entry (HAE) ceramic discs in unsaturated soil testing [13]. Haeri et al. (2014), improved a triaxial cell with axis translation technique according to Hilf (1956) with states; unsaturated and saturation control by means of a closed circuit pressure controllers and sensors with water flow measurements via digital devices for volume change [10].

*Corresponding author’s email: akhtarpour@um.ac.ir

2- METHODOLOGY

The tests were done like loading-path; what happens when a new structure is constructed on a these soil (load increasing with a constant specific matric suction). The soil specimens were prepared in the triaxial mold with equal eight layers as stated by Ladd (1978) [14]. For two gypsum contents (S1 and S2), 90 % of the maximum dry density from Proctor test was pointed. The specimens that were tested in unsaturated conditions were sixteen remolded specimens; eight teste for high gypsum content (S2) and the same number for low gypsum content

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(S1). Every group was divided into two groups depending on confining stress; 100 and 200 kPa. Also, for conventional triaxial tests (saturated conditions), four tests were performed; CD (Consolidated Drained) for each confining stress that is mentioned before. A confining stress of 10 kPa was adopted in all tests (saturated and unsaturated) as a pre-stress to avoid any shape deformation due to specimen itself. Every unsaturated test was started with 30 kPa as initial matric suction that was calculated from filter paper method. Depending on Soil Water Characteristic Curve (SWWCC), four matric suction levels were selected to achieve the area under the SWCC; 100% of initial matric suction, 60% of initial matric suction, 30% of initial matric suction and zero matric suction.

3- RESULTS AND DISCUSSION

Figure 8 explains the water volume changes in unsaturated tests (WVC) for S1 specimen with σ_3=100 kPa. These WVCs that were recorded during the test were used to determine the degree of saturation to check that the pointed volumetric water content (θ) is reached. A time of 72 hours was fixed in all unsaturated tests to keep the specimens in the same conditions for all stages. While Fig. 9 illustrates the volumetric strains of the tested specimens from the cell volume change device (CVC) due to wetting process to reach to the mentioned matric suctions before the shear stage. Figures 10 and 11 show the results of loading stage for low gypsum content and high gypsum content, respectively. In both gypsum contents specimens, under σ_3=100 kPa, the strain is increased by 150%, while under σ_3=200 kPa, the strain is increased by 100%.

4- CONCLUSION

The results of this study are the volumetric strains in unsaturated tests (with presence of HAE ceramic disc) under zero matric suction are higher than the volumetric strains in the conventional tests (CD). These increases of volumetric strains for both types of soil under confining stresses 100 and 200 kPa are 60% and 50%, respectively.

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