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WETTING CHALLENGES ON THE GYPSIFEROUS SOILS

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Abstract—Many structures that have been constructed on gypsiferous soils have big problems, especially in drying-wetting sequence, contrast of construction on non-gypsum-soils due to the collapsibility of gypsum. These soils are formed by the evaporation of saline groundwater when the water table is near the ground surface. Gypsiferous soils are widespread in the Middle East especially in regions peripheral to the Red sea and Arabian Gulf. They cover large areas of Iraq which may be extended to 20% of the total Iraq's area. The present work condenses on the effect of soaking and leaching progresses on the soil stability in the saturated and unsaturated conditions.

Keywords- gypsiferous soils; collapsibility; soaking; leaching

1. Introduction

Most natural occurrence of collapsible soils is comprised primarily of silt and fine sand-sized particles with small amounts of clay, and under some circumstances may contain gravel and cobbles. These natural soils are typically lightly to heavily cemented by various salts, oxides, dried clay and soil suction, and exist in a loose, metastable condition at relatively low density [1].

The gypsiferous soils are considered as one type of collapsible soils; this is because the gypsum present between the soil particles provides an apparent cementation in the form of bonds that tightened the soil particles together [2].

There are numerous situations resulting the soils in fully saturation state or have high water content. Soaking can take place in different ways such as shallow or deep wetting, and slow and uniform rise of level of groundwater. The leaching of the soil fine particles and formation of the pipes causes serious damages [3].

During the wetting-drying cycles, the soils engineering characteristics, especially their strength, are obviously affected and crack spread and stability failure occur [4].

The dissolution of different types of salts contained inside the mass of gypseous soil will generate new pores inside the soil skeleton and loosen the cementing bonds between the particles. This process creates a meta stable structure that facilitates the sliding of particles into a denser state, i.e. collapsibility. The rate of dissolution of gypsum depends primarily on environmental changes in moisture content generating from fluctuation of ground water table and/or surface water, climate changes typically temperature, permeability and state of flow conditions in addition to the type and content of gypsum [5].

There are many attempts through intensive research to investigate and understand the behavior of gypsiferous soils under various environmental and loading conditions. Abundant of data obtained from the researches, under soaking, leaching and collapsibility circumstances, revealed challenging results due to the complexity of the gypsiferous soils. The recent paper reviews the challenges of gypsiferous soils. Summarizes the effect of the soaking and leaching process on the geotechnical characteristics and collapsibility.

2. Challenges Of Gypsiferous Soils

Al- Saoudi et al., 2013, there are many challenges from gypsiferous soils due to the scarcity and complexity. These challenges are with existence of plentiful data collected regarding the geotechnical properties of such natural material. The authors summarized many attempts to investigate and recognize the behaviour of gypsiferous soils under different environmental and stresses circumstances. They concluded that there is no real firm solution or a general improvement technique can be proposed. They instructed that geotechnical engineers must explore each case of soil problems separately depending on the different parameters, such as, structure type, site characteristics, environmental conditions attached to the consultant engineering decision [5].

3. Effect of Soaking On Gypsiferous Soil

3.1. Effect of Time-Based Soaking

Salman, 2011, studied 24 hrs soaking of 12 soil samples from different sites in Baghdad city. These samples compared with other 12 dry tested samples. He stated that there was a reduction in cohesion by approximately (2-2.5) folds, while the angle of internal friction exhibited marginal reduction [6]. This behavior may be due to short soaking time (24 hrs) . While Razouki and Al-Azawi, 2003, investigated the behavior during long-term soaking soil samples in the California Bearing Ratio (CBR). Sixteen CBR samples compacted at optimum moisture content and 95% of the maximum dry density of the modified AASHTO compaction test were prepared. The authors stated that the soil swells initially, then the swelling becomes maximum at about 20 days soaking period then decreases gradually indicating that settlement takes place at an increasing rate. They showed that the settlement eliminated the swelling after about 45 days then the settlement continues to increase at a relatively constant rate until a soaking period of 120 days in reached, thereafter, the settlement rate decreases but the settlement continues to increase so that even at 180 days the settlement did not stop indicating the significant effect of the soaking period on the deformation behavior of gypsiferous soils. They specified that wrong conclusions can be drawn from the common four days soaking [7]. Mahmood, 2017, also, noted that with advancing in the soaking duration, the Ø changed, but, for S-2 (one-week soaking) this angle exhibited an increase of +11.42% related to the reference one (unsoaked), then the Ø decreased with increasing of the soaking time with percentage change of -3.83% and -12.68% for two weeks and four-weeks soaking respectively related to the unsoaked samples. So, with advancement in soaking duration there was a clear decrease in angle of internal friction. So, the effect of soaking took long-term situation and Ø-soaking-change (decreasing) increased with increasing the soaking duration, and this decrease in Ø affects intensely on the bearing capacity of soil [8].

3.2. Effect of Cyclic Soaking

Razouki and Salem, 2014, depending on ASTM D1883 (ASTM 2007), concluded that the CBR decreased on soaking and increased on drying, so that the equilibrium state (steady state) was reached after the fifth cycle irrespective of frequency and it was clear from this figure that the cycle length did not affect the onset of equilibrium state in terms of number of cycles required for onset of equilibrium, since the equilibrium CBR was achieved at the end of the fifth cycle for all cycle lengths. They believed that the cyclic soaking and drying causes ‘fatigue’, leading to more weakening of the soil as compared with ‘static’ condition represented by continuous soaking [9].

4. Effect of Leaching on Gypsiferous Soil

Many researchers investigated the effect of leaching (case of water movement) on the characteristics of gypsiferous soils. Karkush et al., 2008, performed tests to obtain the physical and mechanical properties of the soil. In addition; permeability-leaching tests were conducted by using oedometer and large-scale Rowe cell apparatus to obtain the variation of the coefficient of permeability, dissolved gypsum and leaching strain with time. The authors conducted three stages tests: dry compression stage, saturation stage and leaching stage. They concluded that the coefficient of permeability resulted from Oedometer test decreased rapidly with the time in the first 50 hrs of time of tests and for the three samples tested by large-scale Rowe cell, the permeability coefficient was unsteadily oscillated with time. Also, they stated that the higher effective radius of soil particles meant coarser grains and consequently affected the reorientation of the soil particles during leaching process. They established that the final values of the coefficient of permeability were much lower than its values at the beginning of the test [10]. While Al-Sharrad, 2007, investigated the cyclic Leaching-Collapse Test (CLCT). The sample was loaded at its natural state to a stress of 50 kPa until settlement eventually ceased then the sample was soaked and exposed to three cycles of soaking and draining by controlling the inlet and outlet valves. The author showed that the strain was sharply increased as stress exceeded 25 kPa due to crashing of some gypsum bonds which act as cementation agent and the leaching process yields finer gradation. He marked an increase in strain attained as time exceeded 30 min [11]. Abbas and Muarik, 2012, concluded that, as expected, increasing gypsum content increase the settlement during soaking and leaching process, but, the settlement obtained from soaking sandy gypsiferous soil was more than from leaching process and the total settlement/width of footing ratios were relatively high [12].

5. Collapsibility

The collapsibility of gypsiferous soils have been got high interesting by researchers. Najah et al., 2013, concluded that the high value for collapse potential (CP) at 50% SM mixed with gypseous soil and the value reduced with increase percentage of SM content. For ML soil the height value for CP at 10% mixed with gypseous soil and the lower value at 90% and 95% ML content [13]. Whereas Al-Obaidi et al., 2013, stated that the increase the collapse potential is directly proportional to overburden effective pressure to join the soils containing high levels of gypsum. Secondary consolidation rate (Creep) has major effect on the collapse potential Ic of sandy soil, while such effect not observed for clayey soil. The dry compression strain of Sandy soil is almost because affected by disturbance and/or low value of specific gravity and dry density of gypsum. Single Oedometer Test (SOT) gave more accurate and higher values of ((Ic) than these value of (Ic) getting from Double Oedometer Test (DOT) due to more losing of cementing agent by dissolving of gypsum and singularity of specimen [14]. For field tests, Fattah et al., 2017, indicated that the collapse potential resulted from complete wetting of soil layer may not be achieved in the field, due to the inability to reach full saturation state through a single step wetting. Therefore, the multi-step wetting procedure is more convenient due to the slowly rising of ground water by capillary forces, especially in the low rainfall regions [15].

6. Effect Of Saturation And Unsaturation

Gypsiferous soils have been studied in the past within the classical framework of soil mechanics that is related to saturated condition. As such, they are characterized as collapsible, problematic soils that suffer large deformation and have significant loss of strength under long term flooding. However, in arid and semi-arid areas where gypsiferous soils are found, the top soil layers are mostly in unsaturated. Studies on gypsiferous soils within unsaturated zone, where the impact of gypsum presence on the soil characteristics and usability of such soils may be largely different, are quite rare. Thus, in hot deserts when gypsiferous soils are mostly dry or unsaturated, gypsum may acts as a cementing agent between soil particles leading to a clear increase in soil cohesion. On the other hand, in wet regions, the dissolution of gypsum due to rainwater percolation or the fluctuation of water table may result in softening of these soils and serious damage to the structures founded on such soils may occur [16].

7. Conclusions

As a result of the urban development and expansion that took place during the last decades in Iraq have been completed several strategic projects in large areas of the country while the implementation of some of these projects has been delayed because of their locations (gypsiferous soil locations) that are causing collapse when wetting-process is occurred. So the presence of high gypsum is motive to study this type of soils in this research.

Many buildings have been damaged because of gypsum content. When these buildings was constructing, the water table was far from the effective depth for design consideration. So, in case of rising of water table, the softening of gypsum materials that are between the soils particles is occurring. In this state, the bonds that the gypsum materials were made them between the soil particles are broken.

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