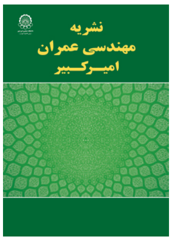

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Influence of Temperature on Desiccation Cracking of Clay Soil

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ABSTRACT: Drying of soils and shrinkage cracks is a crucial issue in geotechnical and geo-environmental engineering. Better understanding of the soil cracking process is essential in analyzing desiccation effects on buildings integrity. In this study, cracking behavior of the clay due to desiccation investigated experimentally at different temperatures on thin clay layer. Experimental tests carried out on the clay slurry saturated with water content about 60%, (1.5 times of its liquid limit). In this study, the clay supplied from clay mine in Abadeh, a city in Fars province in Iran.

Experimental results showed that the critical water content, which corresponds to the initiation of desiccation crack increases when the temperature rises. In addition, the number of produced cracks decreases by increasing the temperature. This phenomenon can be attributed to the reduction of water surface tension force or voids central tendency in soil mass. Also, the width of crack opening decreases by increasing the temperature.

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1- Introduction

The specific fabrication causes montmorillonite to absorb more water content in comparison with other clay minerals. Occurrence of cracks in clay soils is a factor that can be due to changes in the behavior of geotechnical fields such as hydraulic conductivity and soil-structure built interactions. Studies on soil desiccation cracks are not widely executed in literature. A research showed that hydraulic conductivity of barriers may be increased up to 500 times when shrinkage cracks occur and moreover, shrinkage cracks create a weak region which has lower strength and bearing capacity with high compressibility [1]. Fine grain soil shrinkage is upon water evaporation from soil media. When soil drying initiates from soil surface and extends in soil depth, this causes a surface shrinkage and as a result, tensile stress is produced.

The surface cracks create if soil shrinkage is limited or restrained in some directions [2,3]. While numerical models using finite element methods or discrete element methods were developed, soil shrinkage cracking models need laboratory tests and field experiences [4].

In present study conducted, laboratory tests were carried out on thin layers of clay soil to investigate behavior of soil drying in different temperature conditions. As well, an influence of temperature on generation and growth of cracks was investigated experimentally.

2- Methodology

Clay soil sample was prepared from a mine in Abadeh. Soil chemical compound and physical properties were listed in Table 1 and 2 respectively.

Table1. Chemical compound of clay soil sample

compound	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Cao
%	53.35	26.58	7.90	1.22	0.39
compound	MgO	Na_2O	K_2O	SO_3	P_2O_5
%	0.28	0.98	1.57	0.02>	0.22

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Table2. Physical properties of clay soil sample

Quantity	Value	Test Standard
Liquid limit (%)	40	ASTM D 4318
Plastic limit (%)	24	ASTM D 4318
Plastic index (%)	16	-
Shrinkage limit (%)	15	ASTM D 427
Optimum water content (%) Max. dry density(kN/m^3)	19.3 17.1	ASTM D 1557
Gravity, G_s	2.73	ASTM D 548
c_u (kPa)	15.7	ASTM D 2850

All tests were conducted in the molds with dimensions of 30 cm length, 5 cm wide and 1.2 cm depth which its floors have grill form to prevent soil sliding. The soil specimen passed from sieve no. 40 (0.425 mm mesh size) and then mixed with water content about 60 % (1.5 times of its liquid limit). The selected soil and water were mixed in a closed container for 24 hours.

This procedure guarantees saturation, homogeneity and no flocculation (no structure formation) in the soil samples.In order to avoid sticking the soil to mold walls all side walls were greased, before mold impounding. Weight of the soil samples in different times during desiccation in constant temperatures of 27, 40, 60, 80 and 100 oC were measured with 0.1 grf accuracy, then relation of water fraction to solid fraction calculated as soil moisture.

3- Discussion and Results

Based on experimental results, about 90 % of desiccation cracks created in constant evaporation rate phase when the specimens were still saturated with water.

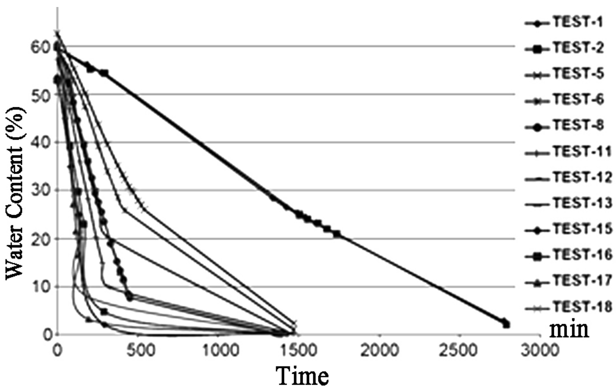

Figure 1. Reduction of water content of soil versus time

Experimental results showed that when temperature increased from 27 oC to 40 oC, desiccation time's length need for crack initiation reduced about 3 times.

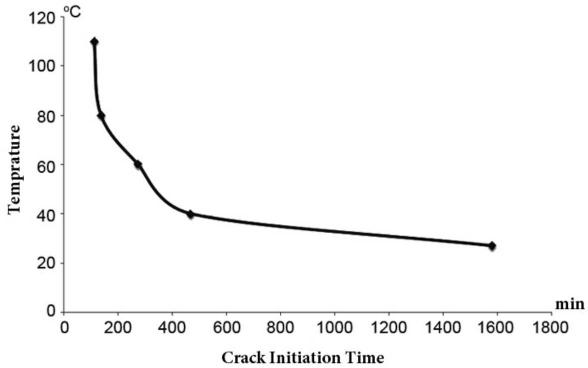

Figure 2. Effect of temperature on crack initiation time

Shrinkage strains during desiccation tests were created in longitudinal, transverse and vertical directions. These strains were calculated averagely as follows. Initial and contracted dimensions of specimen in calculations of strains depicted in Figure 3.

$$\varepsilon_l = \frac{\Delta l}{l} \ , \ \varepsilon_b = \frac{\Delta b}{b} \ , \ \varepsilon_h = \frac{\Delta h}{h} \qquad (1)$$
$$\varepsilon_v = \varepsilon_l + \varepsilon_b + \varepsilon_h$$

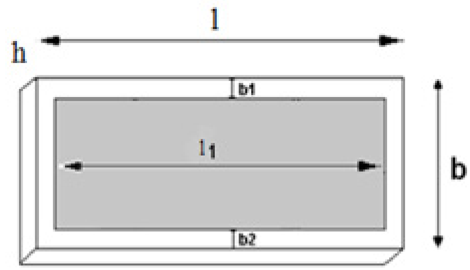

Figure 3. Dimensions used for calculation of strains

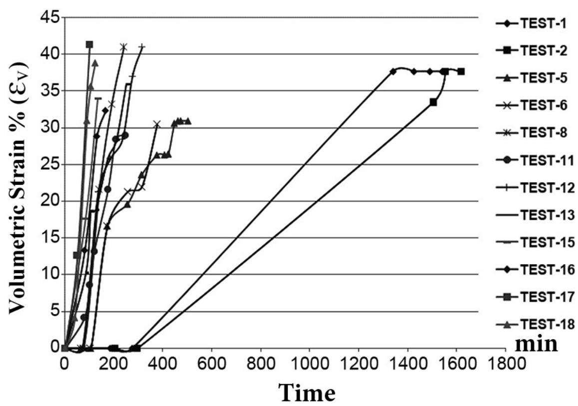

Figure 4. Volumetric strain versus time

4- Conclusions

Surface crack phenomenon of clay soil was experimentally modeled and the effect of temperature on shrinkage cracking in range of 27-110 oC was studied. Experimental test results showed that cracking pattern related to the constrained boundaries and moisture gradient in soil layer depth. Water evaporation from soil mass accelerated with temperature rising severely. Evaporation rates, phase 1, at temperatures of 27, 40, 60, 80, 110 ^{o}C have ratios of 1, 3.3, 5.5, 9.4 and 13.8 respectively. Water content for first crack initiations, ω_{1c} measured for total depth of soil layer in average. When temperature rise from 25 to 60 oC, ω_{1c} increased from 23.6 to 25.7 %, based on experimental results. At different temperatures, it was observed that longitudinal strain and vertical strain had minimum and maximum value, respectively.

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