Study of expansive clayey sand (SC) soil in Sudan

Étude du sol expansif de sable argileux (SC) au Soudan

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ABSTRACT: Many areas in Sudan are dominated by clayey sand (SC) soils. These soils are classified as (SC) soil according to USCS with compliance to its sand content, clay faction, LL and PI. As a result of moisture content changing, (SC) soils still have noticeable volume change and tend to swell and/or settle causing distress for constructed structures and facilities. The damages were reported and illustrated in foundation movement, walls and floor cracks. Experimental work program implemented on clay-sand mixtures (natural soil samples) to study this behavior and it included index tests, compaction and swelling tests. Soil parameters were calculated, analyzed and presented in MS excel charts. This paper concludes that prediction of swelling potential of (SC) soils essentially depends on mineralogy and density which could be changed simply by increasing sand fraction and consequently could improve the physical properties and reduce this expansive behavior.

1 INTRODUCTION

Clayey sand (SC) soils are known to exist in different places in Sudan, especially in the eastern and center of Sudan and along the river Nile valley. These soils tend to have relatively high values of LL & PI and noticeable variations of volume change as their moisture content changes. Although soils are identified as (SC) according to Unified Soil Classification System (USCS) they can have an appreciable volume change characteristics that will affect the safety of the foundations and the floors of the buildings. Several factors can influence the swelling pressure and swelling potential of the clay soils. These factors include the amount and the type of clay minerals, the cation exchange capacities of clay minerals, the initial water content and other factors related to the clay deposition history such as fabric and overburden pressures.

2 LABORATORY TESTING PROGRAMM

Clay-sand mixtures were made up of a clay soil (obtained from excavated tests pits in (Soba) district in Khartoum) mixed with fine sand in percentage of the total weight of mixture (i.e. 17 % [as origin sample (N1)], 25%, 40%, 55%, 60%, and 65% from the total weight). The fine sand used in this testing program is classified as uniform sand (composed of 4.0% coarse, 62.0 % medium, and 33.0% fine size). Laboratory test results of these samples are shown in Table (1).

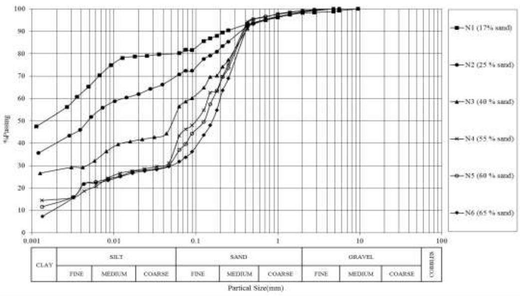

Figure 1. Grain size distribution curves

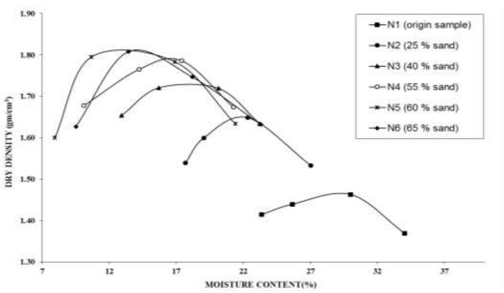

Figure 2. Moisture-density relationships

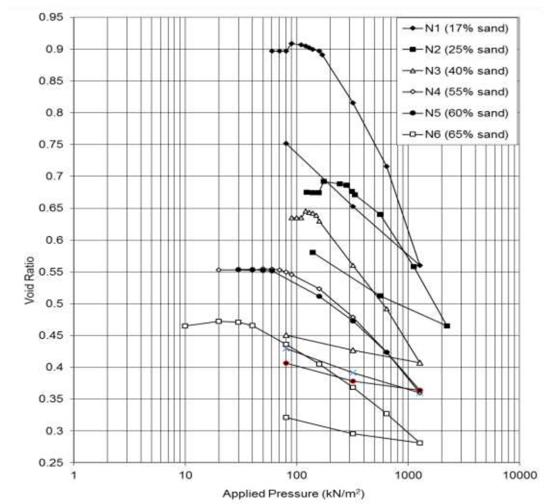

Figure 3. Consolidation curve results

Table 1. Test results for clay-sand mixtures

Soil code	*N1*	*N2*	*N3*	*N4*	*N5*	*N6*
Sand content (%)	17	25	40	55	60	65
LL (%)	78	77	66	52	37	35
PI (%)	54	52	40	34	23	21
LS (%)	14.7	13.6	10.6	7.9	7.1	6.2
Clay fraction ($< 2\mu m$)	53	40	28	16	13	11
Swelling pressure (kN/m^2)	320	315	160	80	65	30
Swelling potential (%)	0.35	0.32	0.27	0.18	0.16	0.14

3 ANALYSIS AND DISCUSSIONS

3.1 Atterberge Limits

Atterberg limits results showed that LL decreased from 78% to 35% and PI decreased from 54% to 21% (see Table 1). Soil sample designated (N4) showed high values of LL and PI despite the sand fraction is more than 50%. This soil sample presents the object of this study.

3.2 Classification and identification of expansiveness

In Table (2), sample (N4) exhibits expansive soil with medium to high swelling potential from several classifications. Although soil sample (N4) contains sand content more than 50%, but significantly it has an expansive behavior which attributed to the mineralogy composition, particles shape, texture and particles size distribution.

Table 2. Classification and identification of expansiveness

Soil code	*N1*	*N2*	*N3*	*N4*	*N5*	*N6*
Sand content (%)	17	25	40	55	60	65
USCS classification	CH	CH	CH	SC	SC	SC
Swelling potential (Chen 1975)	VH	VH	VH	M	M	M
Potential expansiveness (Dakshanamurthy & Raman 1973)	CV	CV	CH	CH	CI	CI
Swelling potential (Snethen 1980)	VH	VH	VH	H	Mo	Mo
Potential expansiveness (Van der Merwe 1964)	VH	VH	VH	M	L	L
Swelling potential (Seed 1962)	VH	VH	H	M	L	L

*Where:
CH = High plasticity clay
SC = Clayey Sand
VH = Very high
H = High
M = Medium
CV = Very high swelling
CH = High swelling
CI = Medium swelling
L = Low swelling
Mo = Moderate

3.3 Compaction test results

Soil samples results present increasing in MDD with the increasing of sand fraction (see Table 1 and Fig. 2). It's postulated that the sand will fill the voids between soil grains and that will result increasing dry density. Many authors (Sorochan 1991, Elarabi 2004, Nelson and Miller 1992) were conducted many experiments and concluded that the swelling rate increases when the density of soil is increased.

3.4 Consolidation and swelling test results

Soil samples showed reduction in swelling and compressibility characteristics as the percentage of sand fraction was increased (see Tables 1 and Fig. 3). A very good correlation coefficient was obtained between LL, PI with SP (R^2= 0.96) (see Fig. 4).

The influence of volume change on the consolidation characteristics of expansive soil is not similar to non-expansive clay soils. In expansive soils, larger change in moisture implies higher degree of volume change (swelling and settling) in soil structure. In non-expansive clays, it shows flatter e-log P curves (Mesfin Kassa 2005). Soil sample (N4) has shown that the soil exhibit a steeper e-log P plot (see Fig 3). Consolidation is the property of the soil mass that is highly dependent on permeability which depends on the structural arrangement of soil particles. On the other hand, swelling is the property of the soil particle, which depends on the mineralogy of soil particle. In effect, both phenomena bring about volume change in the soil mass. As can be seen from the test results, the factors that affect the swelling characteristics of expansive soils (i.e. moisture content variation and density) have also affected the consolidation characteristics of expansive soil and consequently affect the characteristics of expansive (SC) soils.

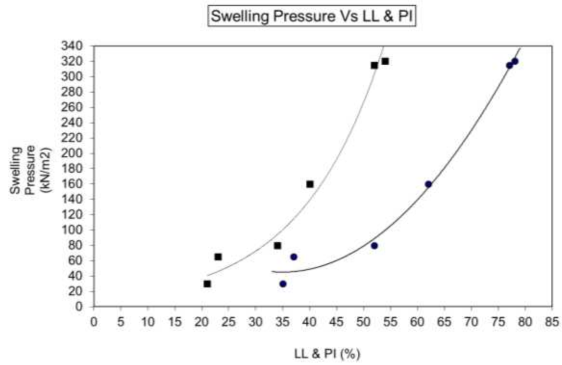

Figure 4. Relationship between SP, LL and PI

4 CONCLUSIONS

Mineralogy and density of clay are essential parameters to predict the behavior of (SC) soils and to classify its expansiveness. Soil samples showed decreasing in volume change characteristics with increase of sand fraction from 7% to 10% and will give considerable strength and low volume change materials to use in construction.

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