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SWELLING AND SHRINKAGE OF CLAY SOIL IN SAUDI ARABIA

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ABSTRACT

swelling and shrinkage are interrelated. Damage of structures may be caused mainly from swelling, shrinkage or both. An attempt was made to find the correlation between moisture and density on the effect of swelling and shrinkage. the concept of critical dry density has been introduced. Critical dry density could be the key to the swelling and shrinkage phenomenon.

1- INTRODUCTION

Clay soils have the potential for swelling and/or shrinking upon change in the moisture contact. The magnitude and direction of volume change depends on compositional and environmental factors. The compositional factor include type of minerals, amount of each mineral, type of absorption and pore water constitutent. They determine the swelling or shrinking potential of the soil. The environmental factors determine the actual value for volume change and include water contect, density, state if in situ stresses, temperature, plasticity index, fabric and availability of water.

Volume change of active clays containing expandable montomorilinite type minerals are highly sensitive to the changes in the in situ water contact. These clays have the ability of sucking and storing large amounts of water resulting in significant swell deformation. The potential volume changes " swelling and shrinkage " are more pronounced in arid climatic conditions as in most of the middle east countries including the Kingdom of Saudi Arabia.

The objective of the present investigation is to study the various change characteristics of Al-khatt clays with special reference to their swell behavior at different moisture

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conditions. Also a compersion of these results with another area form Saudi Arabia is made. It is aimed to draw attention to potential heave problems which may be encountered as a result of changes in the in situ moisture conditions of the clays.

2- DISTRIBUTION OF EXPANSIVE SOILS IN SAUDI ARABIA

A general map for potentially swelling soils of the Arabian peninsula was presented in [1]. This map is based on a comparison of the geological ages of known swelling soils of the United States with geological ages of suspected swelling soils in the Arabian peninsula. The map lacks field exploration and laboratory testing for the suspected soils. Based on field and laboratory investigation [2], the properties and behavior of expansive soils at five main regions in Saudi Arabia where sever building damages were noticed have been described. Additional data and information about the expensive soils investigated in [2] were reported by [3]. Figure (1) is presented to show, in general, the distribution of various types of the expensive soils in Saudi Arabia [4].

The samples used in the this paper were collected from Al-khatt city, Saudi Arabia. The khatt region is covered with silt, clay and sand matrix underlain by part of the predominant formation in the region called "Dhruma" formation. the shales are laminated, highly weathered and rich in gypsum. At shallow depths there are frequent intrusions of sandstone and siltstone [4].

3- SOIL CHARACTERISTICS

The physical and chemical characteristics of the collected samples were investigated to evaluate the percentage of swelling and shrinkage. The typical clay used for the study was remolded clay shale from the khatt area. Its basic physical and mineralogical properties are as follows :

Natural water content (w)	12.4%
Specific gravity (G_3)	2.72
Bulk density (gm/cm^3)	1.28
Void ratio (e)	0.88
Liquid limit ($L.L$)	63.4%
Plastic limit ($P.L$)	30.5%
Plasticity index ($P.I$)	32.9%
Clay content	63%
Free swell index	90%

Size distribution:

Sand	0.5%
Silt	24.5%
Clay	75%
Standard Classification	(CH)

Clay mineralogical analysis gave the following results:

Montmorillonite	27.81%
Kaolinite	33.20%
Illite	12.64%
Vermiculite	3.76%

The clay shale was pulverized and prepared in the conventional manner so as to obtain uniform test specimens for repeated testing. The testing was conducted in two series. In the first series, dry density was held constant and moisture contact was varied. In the second series, moisture content was held constant and the density was varied.

A conventional oedometer was used for testing. The clay shale was compacted into a ring 7 cm in diameter and 1.9 cm in height. A surcharge load of $0.07 Kg/cm^2$ was applied at the initial moisture contact. When compression was completed, the sample was immersed in distilled water and allowed to swell for a period of two to three days. After swelling was completed, water was drawn out without disturbing the sample and allowed to air dry at room temperature. At the same time, the weight of the sample was reduced to the initial sample weight, the moisture content and dry density were determined and recorded. From the above data, the percentage of swelling and shrinkage was determined.

4- EFFECT OF DENSITY ON SWELLING AND SHRINKAGE

swelling is defined in this paper as the increase in the thickness of the sample after wetting, expressed as percentage of initial sample thickness before wetting. Shrinkage is defined as the ratio of shrank volume to the initial volume, expressed as percentage of initial volume. The shrank volume is the volume of the soil from a saturated state to the initial moisture content state.

The initial moisture content was 12.4% and the dry density was varied from 1.18 gm/cm^3 to 1.62 gm/cm^3. Figure (2) is a plot of measured swelling and shrinkage for various dry density. It is seen from Figure (2) that swelling increased rapidly with increase in dry density. Such phenomenon has been established by [5,6,7]. Shrinkage remained fairly uniform with increase in density, varying from 11% to 12%. It can be surmised that dry density variation has little effect on shrinkage. In other words, if the moisture content is kept constant, a change in dry density will not substantially change the shrinkage value. Considerable difficulty was experienced in controlling the final moisture content. When the sample was air dried from saturation to the initial moisture content. It is tentatively concluded that there exists a point at which point is defined as critical dry density. Critical dry density varies with soil property and initial moisture content. If initial dry density is greater than the critical dry density, swelling will be larger than shrinkage. If initial dry density is less than critical dry density, shrinkage will be greater than swelling.

5- EFFECT OF MOISTURE CONTENT ON SWELLING AND SHRINKAGE

There exits a critical moisture content rang within which shrinkage takes place [7]. Beyond the critical moisture content rang, any further change of moisture content will not cause further shrinkage. Further, shrinkage is divided into three stages: initial shrinkage, normal shrinkage and residual shrinkage. In practice, variation of moisture content in day soil usually falls within the critical moisture content rang. In this study, the dry density kept constant at 1.55 gm/cm^3 and initial moisture content varies from 12.5% to 21.5%. This rang of moisture content is believed to be within the critical content rang as defined by [7]. The test results are shown on Figure (3). It is seen from Figure (3) that the swelling decreases with the increase of initial moisture content. It is postulated that shrinkage remains unchanged and less than swelling when the initial moisture content is less than shrinkage limit. Where initial moisture content reaches the shrinkage limit, shrinkage decreases with the increase of initial moisture content, and the rate of decrease is lower than the rate of swelling. Therefore, with an increase in initial moisture content, a point will be reached where the shrinkage will be equal to swelling, as shown in Figure (3). With further increase in initial moisture content, the shrinkage will be greater than swelling. As further moisture content increase continues, shrinkage goes from the residual stage to the normal stage. Within the normal stage, the rate of shrinkage decreases with increase in initial moisture content which be at the highest level. These shrinkage decrease rate is larger than the rate of swelling decrease.

6- EFFECT OF CYCLE WETTING AND DRYING

The behavior of expansive soil under wetting and drying cycles has been studied by many investigator [5,8,9,10]. During the first several cycles of drying and wetting, the swelling decreases steadily and eventually levels off. This has been identified by [11] as the fatigue of swelling. Fatigue was also observed in practice. When seasonal wetting and drying takes place, pavement and building foundations move up and down and the movement has a tendency to reach a stable state after several wetting and drying seasons.

This study indicates that there is a distinct reduction of swelling tendency as the drying- wetting cycle continues. However , shrinkage behavior appears to be unchanged with repeated drying and wetting. Shrinkage value appears to be equal to the final stage of swelling as shown in Figure (4).

By wetting and drying, the dry density has a tendency to reach the critical value, that is, the value where swelling and shrinkage equalizes. The fatigue of swelling is probably due to the gradual decrease of the dry density. When the dry density reached the critical density, a state of equilibrium was reached. At this point, swelling, shrinkage and dry density become stable and further change took place.

Based on the above theory, it is conceivable that if the soil sample has a dry density less than the critical dry density, then under drying and wetting, the swelling will not decrease but will increase until the critical point is reached.

7- CONCLUSION

- Initial dry density has little effect on shrinkage but is a controlling factor of swelling.
- There exits a critical dry density at which swelling is equal in magnitude to shrinkage. Critical dry density varies with soil property and initial moisture content. When initial dry density is greater than the critical dry density, swelling will be greater than shrinkage .
- When dry density approaches critical dry density, shrinkage and swelling will be stabilized. Further wetting and drying will not affect the soil behavior.
- Initial moisture content plays an important role the swelling and shrinkage relationship. This relationship is shown in Figure (3).
- There is not a consistent relationship between shrinkage and swelling. It is doubtful that swelling and shrinkage are reversible. Further research will be required.

8- REFERENCES

[1] Slater, D. E. (1983). *"Potential Expensive Soils In Arabian Peninsula,"* Journal Of ASCE, Geot. Eng. Vol. 109, No. 5.

[2] Ruwaih, F. A. (1984). *"Case Studies On Swelling Soils In Saudi Arabia,"* Proc. 5Th. Int. Conf. On Expansive Soils, Australia.

[3] Dhowian, A. W., Ruwaih, I. A., Erol, A. O. And Youssof, A. F. (1986). *"The Distribution And Evaluation Of The Expensive Soils In Saudi Arabia,"* Proc. 2nd Saudi Eng. Conf., Dhahran ,KFUPM.

[4] Ruwaih, I. A. (1988). *"Experiences With Expansive Soils In Saudi Arabia,"* 6Th. Int. Conf. On Expansive Soils, New Delhi, India.

[5] Chen, F. H. (1975). *"Foundation On Expansive Soils,"* Elsevier Publishing Company.

[6] Demiral, T. And Handy, R. L. (1988). *"Swelling Pressure Vs D-spacing Of Montmorillonite,"* 6th Int. Conf. On Expansive Soils, Vol. 1, New Delhi, India.

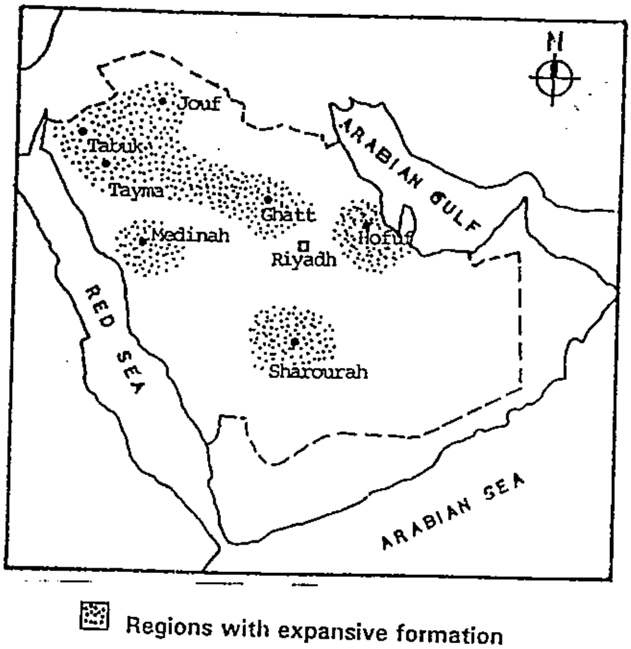
[7] Popescu, M. (1980). *"Behavior Of Expensive Soils With A Crumb Structure,"* 4Th. Int. Conf. On Expensive Soils.

[8] Radwan, A. M. (1988). *"Effect Of Wetting And Drying On The Reports Of Natural Swelling Clay,"* Eng. Reshearch Bulletin, Vol. 5, University Of Helwan.

[9] Obermeier, S. F. (1974). *"Evaluation Of Laboratory Techniques For Measurement Of Swell Potential Of Clays,"* Bulletin Of The Association Of Eng. Geologists, Vol. 6, No. 4.

10] Chen, X. G. And Lu, Z. W. (1984). *"Calculation Movement Of Building Foundation Of Expansive Soils,"* 5th edition, International Conference On Expensive Soils.

[11] Chen, X. G., Lu, Z. W. And He X. F. (1985). *"Moisture Movement And Deformation Of Expensive Soils,"* 11th Int. Conf. On Soil Mechanics And Foundation Eng., Vol. 4.



figure(1) Distribution of the expansive formation in saudi arabia

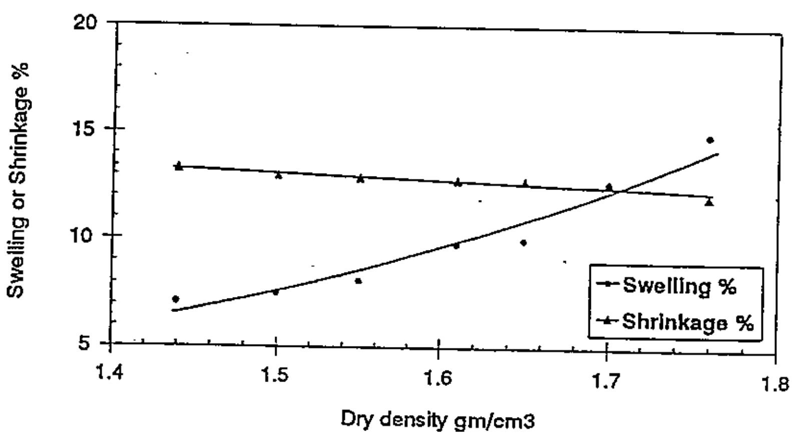


figure (2) Relationship between dry density & swelling or shrinkage

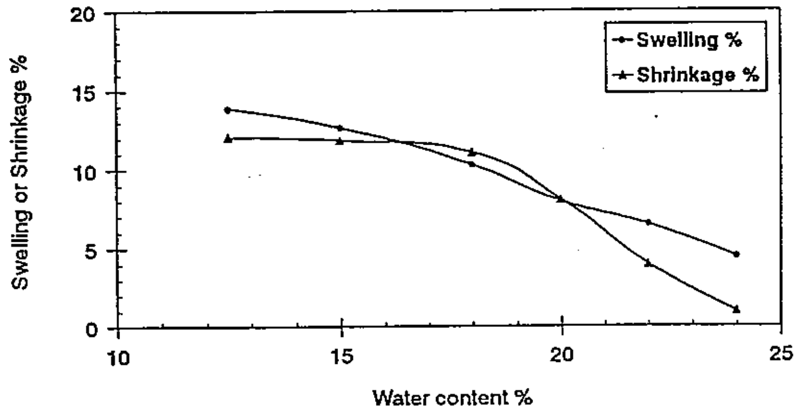


figure (3) Relationship between water content & swelling or shrinkage

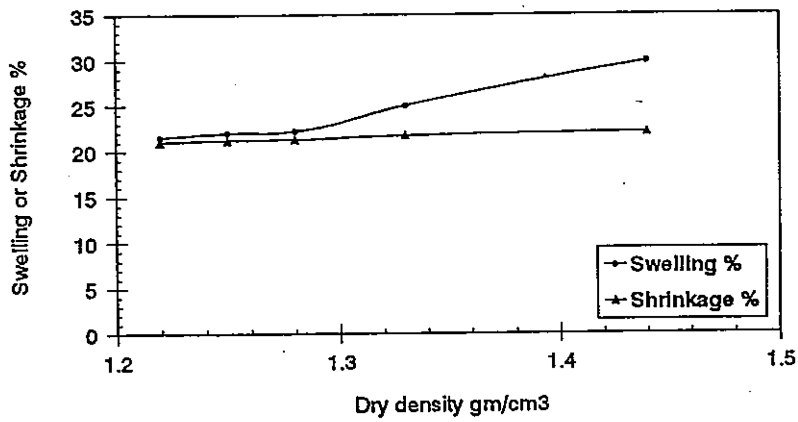


figure (4) Relationship between dry density & swelling or shrinkage on expansive soils subject to repeated wetting & drying