SWELLING AND SHRINKAGE AS RELATED TO COMPONENTS AND PROPERTIES OF SOME REPRESENTATIVE SOILS

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1. INTRODUCTION

Montmorillonite is the predominant mineral in most Egyptian alluvial soils . These soils , particulary the sodium heavy textured classes, undergo drastic volume changes when subjected to alternating wetting and drying. The hydrological behaviour of swelling soils is completely different from that of non-swelling ones. As a consequence, the classical concepts of ground water hydrology are not valid for swelling soils. Moreover, the overburden potential is one of the main components of the total potential which plays a great role in investigating the behaviour of swelling soils. Recently, the overburden potential coefficient has been considered in estimating the water movement in expansive soils.

The presence of air in the soil voids is essential for planting purpose , that is the soil has a well developed crumb structure and may show no signs of normal shrinkage as the water is decreased. The total shrinkage is therefore lower than it would be if normal shrinkage occured (Yong and Warkentin, 1975). According to the available data in literature, soil structure is qualitatively evaluated. This does not, however, indicate the fabric changes on drying in expansive soils. Therefore, quantitative evaluation of the soil structure is more pertinent in classifining soils for agricultural use.

Current views of infiltration of water into soils are based on piston type flow. In general, the effect of rapid flow of water down macropores and cracks on water-solute distribution in soil has not yet been taken into consideration (Thomas and Phillips, 1979). Rapid flow through soil devides soil water mobility into dynamic and stagnant (Van. Genuchten and Wierenga, 1976). These affect the degree of soil saturation within the [illegible] water table fluctuation zones.

The aim of this work is to study the swelling and shrinkage as related to soil components and properties. Changes in soil surface elevation are investigated for various degrees of dryness through linear shrinkage concept. This concept is instrumental in estimating water requirements based on ratified moisture contents. The overburden potential coefficient has also been used as a new parameter in evaluating the structure status of a soil. Flow pattern, using inexpensive macromorphometric technique with chloride breakthrough curve, has been prepared to evaluate the hydrological properties for the tested soils.

Heavy clay soils and medium textured with or without sufficient amount of calcium carbonate are investigated to [illegible] the [illegible] and para- [illegible]. Clay percentage, [illegible] constituents are correlated with swelling [illegible] parameters of the soil.

2. REVIEW OF LITERATURE

Swelling and shrinkage as related to soil properties are complex phenomena. The volume changes experienced in expansive soils depend on several factors such as : mineralogical composition, geological precipitation and moisture migration. The expansive soils do not obey the conventional theories regarding the ground water hydrology.

The available literature in the field of ground water hydrology in expansive soils is rather few. The informations obtained from the literature indicate that further work is still needed to correlate swelling and shrinkage of expansive soil with its constituents and physical properties. In the following, a historical review of the expansive soil characteristics and behaviour is given.

2.1 Volume changes as related to some soil characteristics

The volume change of expansive clayey soils is related to variation in the moisture content. On drying, the soil decreases in volume and cracks appear. On the other hand, the soil swells on rewetting. As a consequence, large volume changes take place in soils in the zones where climatic conditions show alternate wet and dry seasons.

Remoulded soil blocks shrink on progressive drying. Shrinkage is either normal or residual. Normal shrinkage takes place as long as the loss in the soil volume is equal to the water lost (Tempany, 1917). The air starts to enter the voids of the soil at water content of about pF "5" , (Schofield, 1938). In such a case the shrinkage is termed as residual shrinkage (Hains, 1923).

Surface soils, with a low clay content or with a well developed crumb structure may show no range of normal shrinkage as the water content is decreased. This is because air replaces the water on drying and the shrinkage becomes lower than it would be if normal shrinkage occurs.Influence of aggregate size on swelling and shrinkage is shown in Fig."1" (Chang and Warkentin, 1968). This is termed as structural shrinkage (Yong and Warkentin, 1975).

Fox (1964) and Berndt and Coughlan (1976) studied the effect of changing water content on the bulk density of undisturbed cores of cracking clays. Over the soil moisture range measured in the field, they found that laboratory cores shrink in three dimensions and normally. Small deviation from normal strinkage is attributed to high water contents of the wet cores. Swelling is appoximately three dimensional, except for some unconfined swelling which takes place on the surface of the core. Unidimensional swelling is induced by lateral

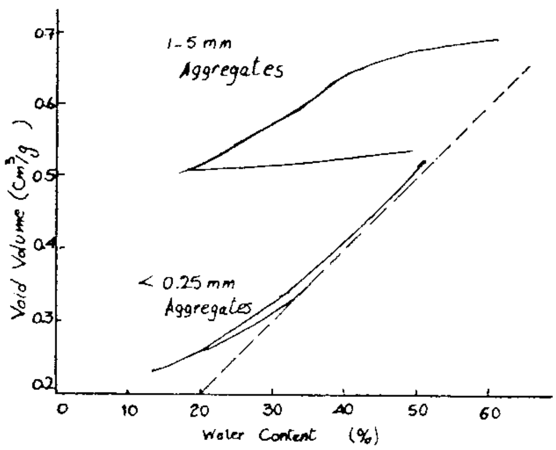

Fig.(1) Influence of aggregate size on swelling and shrinking of soil, (Chang and Warkentin,1968).

confinement of dry cores before wetting.

The swelling characteristics of expansive soils depend primarily upon the clay minerals present in the soil. Montmorillonite clays almost show reversible shrinkage and swelling on drying and rewetting. On the other hand, Kaolinite and illite clays show an initial large volume decrease on drying and a limited swelling on rewetting (Yong and Warkentin, 1975). Also, they reported that exchangeable cations, such as sodium, causes greater swelling than divalent calcium ions. This is explained by the greater extension of the diffused double layer in case of sodium exchanges. Swelling and dispersion of soils with exchangeable sodium are reduced at higher salt concentrations. Cementation between the soil particles limits the swelling process. Iron hydroxides, carbonates, and various organic molecules act as a cementing material.

Calcium carbonate affects the swelling behaviour of the soil. In one way, it can act as an inorganic cement which bindes the clay particles together resulting in a decrease in the liability of the soil to swell. The extreme of the action might be encrusting, in which a cluster of clay particles is completely coated with calcium carbonate. In another way, calcium carbonate can act as a source of calcium ions which suppress the formation of diffuse double layers. This in turn decreases one of the main driving forces which causes the soil to swell (Quirk, 1968).

2.2 Bulk density and soil moisture

Agronomists, soil physicists and engineers find it necessary to define cracking clays by a specific relation between bulk density and water content. Then variation in soil surface elevation and coefficient of overburden potential are determined.

After exerting a certain pressure head upon a soil sample, the equilibrium soil moisture content can be determined. Applying different pressure heads step by step, a curve of pressure head "ψ" versus moisture content " θ " can be obtained. Such a graph is called soil moisture retention curve or soil moisture characteristic . The value of "ψ" varies from 0 to 10^7cm, in order to represent this range graphically, the term " pF " was introduced, it is defined as the logarithm of the suction in cm.

Cykler (1946) reported that when water was readily available between field capacity at pF "2" and permanent wilting point pF " 4.18 ", the higher is the soil moisture content, the greater is the use of water. Veihmeyer and Hendrickson (1949) concluded that plants could obtain water with equal facility within the available range of soil moisture. Bradely and Prutt (1954) produced higher yield of potatoes when water was applied before the available moisture decreased to a content below 50% especially in light soils. Krammer (1963), Iden (1964) and Singh and Alderfer (1966) found that plant growth diminishes progressively below field capacity and ceases at the permanent wilting point. Easily available moisture was taken to be equal to ½ and 3/4 of available moisture range.

With respect to water relation with crop feeder roots and tap roots, the root depth should be known. Alfred (1961) mentioned that the feeder root depths for most crops vary from one foot (30.5 cm) to approximately four feet (122 cm). Some plants have deep tap roots. Those roots supply 15% of total plant water use, the 85% remaining are supplied by the feeder roots.

2.2.1 : Variation of soil surface elevation with soil moisture

Field studies concerning the elevation changes of land surface with changing water content retain the complexity of the natural conditions (Aitchison and Holmes, 1953 ; Felt, 1953; Jamison and Thampson, 1967 and White, 1962).

Vertical movement of both surface and deeper soil layers as a consequence of moisture changes is of considrable practical importance. Some investigators have been concerned with the effect of seasonal variations in soil moisture on the stability