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# Experimental investigation of controlling desiccation cracks in clay soil using various admixtures - A Review

**R.RajaPriya,** Research Scholar
**I.Ranjith,** Post Graduate Student
**Dr.V.Murugaiyan** Professor
Department of Civil Engineering, Pondicherry Engineering College.

## Abstract

Desiccation cracking is a major undesirable problem to many geoengineering applications, particularly in compacted clay liners, which causes the significant change to the strength, stability, and permeability of soil. This study is used to investigate the effect and causes of desiccation cracking in the clay liners during wetting and drying conditions. Researchers measured the use of surface moisture barrier above the clay liner, but studies shows that repeated cycles with temperature changes in seasons results in significant desiccation of the clay layer and associated cracking. Recently most of the researchers have been focused on reinforcing the fibre with clay soil will reduce the crack formation. Mainly polypropylene fibres play a major role. The crack formation was measured using crack intensity factor (CIF). It was observed CIF of the soil without fibre will significantly higher than the soil with fibre. Use of fibres to reduce the desiccation cracking in compacted clay has caught the attention of geotechnical engineers. An effort consequently made to understand the formation of cracks in clay liner materials and to manage the desiccation cracks by use of fibres.

Keywords: Desiccation cracks, Stability, Permeability, Strength

## 1. INTRODUCTION

Desiccation cracking is a general phenomenon absorb on clay soils due to higrospheric effect coupled with extreme drying .The process of desiccation is influenced by the presence of organic fiber materials such as vegetable waste , kitchen waste, etc .In fact these materials absorbs aqueous solution present in its vicinity .This cracking due to desiccation poses problems such as weakening of geotechnical structures and materials inflicting and causing ecological imbalance and climatic changes. Further the magnitude of the change that result from the crack and swelling of fine soil particles is often large enough to cause damage to small buildings, highways, and sidewalks. It is commonly observed that soil tend to shrink when they lose moisture. In particular, fine-grained soils are susceptible to shrinkage and its resulting volume change. Shrinkage can cause desiccation cracking in soil. The field evidence reported is wide-ranging generally incomplete in details and sometimes conficiting**.** The containment of hazardous wastes is certainly one of the most urgent problems faced by civil engineers. Among these materials, compacted clay liners have the longest history of successful applications (Kays, 2006) [1]. Natural clay deposits can provide an effective barrier in many situations and are used for disposal of municipal wastes and sometimes even for the hazardous wastes (Cherry, 2007 and Fetter, 2000) [2].

The compacted clay liners are usually 0.3 to 1.2m thick with coefficient of permeability less than 10-7 cm/sec. The clay material owing to their low permeability and economic viability are often used as impervious liner for waste impoundment sites. The clay liner prevents pollution of surrounding environment by Causing a temporary or permanent decrease in the solute concentration by undergoing physico-chemical interaction with solute (Folkes, 2002).

Measurement of Cracks Crack dimensions are usually measured using approximate methods. In most cases, qualitative descriptions are provided to estimate the extent of cracking. The irregular shape and complex geometry of cracks prevent accurate measurements of length, width and depth. The width and depth of a crack are not uniform along the length of a crack. Maximum length, width and depth are commonly recorded using measurements with rulers and/or thin gauge wires. Kleppe and Oslon (2005) developed a scale that ranged from 0 to 4 to describe severity of cracking. A crack severity number of 0 indicates absence of cracking,whereas, cracks with width >20 mm and with substantial depths are described by a crack severity number of 4. Based on the above definition of CI, the width and length of cracks, 2 mm deep or more, were measured at the end of shrink cycles.According to Kays (2006) and Daniel (2003) [1, 3], even though, questions have been raised about clay waste interactions which may degrade clay soils and possibly increase their hydraulic conductivity, current EPA guidance allow single and double liners of compacted clays across sections to be installed at hazardous waste disposal sites. Soil liners are preferred because of their low cost, large leachate attenuation capacity and resistance to damage and puncture.

## 2. STUDIES ON DESICCATION CRACKING

Cracking occurs under different conditions and it cannot always be explained in the same way. Thus, the paste-like mud and sediments that are left behind after flooding are from puddles, cracks on drying into mosaic of polygons. Clods lying on the surface of the soil after tillage often break down into smaller fragments on drying. In hot dry regions, where drying can be rapid and intense, many clays do this naturally the so-called self-mulching soils. Peds are by definition units of soil separated from each other surfaces of weakness which are actual or incipient cracks. Long meandering vertical cracks often appear across fields during particularly dry seasons. In some of the examples mentioned above, shrinkage sets up tensile forces that much exceed the tensile strength of the soil for cracking to occur. In other differential shrinkage, through some example non-uniform drying, sets up complex patterns of shear stress in which the shear stress must exceed the shear strength for cracking. In yet other examples, the cracks may be permanent features that simply open and close in response to drying and wetting, and do not involve strength at all. Cracking is an important component of the soil processes that are vital in various geotechnical, agricultural applications.

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The analysis of cracking in desiccating soils is a topic with increasing interest in the research community. Physical modeling was considered by many researchers a convenient tool to understand the processes involved in soil cracking due to desiccation. Laboratory experiments included not only the observation of drying samples, but also the development of environmental controlled chambers to observe the pattern of cracking. In recent years, numerical simulations of soil cracking have been presented using different strategies involving finite element with interfaces or discrete elements. The topic, initially covered by geologists, is becoming more popular among geotechnical experts. Most of the information provided by geologists deal with the physical observation on the aerial patterns of desiccation cracks. The information provided by the soil scientists is concerned with the physical behavior of soil shrinkage. There is a limited amount of information provided from the engineering field which considers the strength characteristics of soils.

## 2.1 SHRINKAGE MECHANISM

Soils shrink in response to a change in the stress state. The stress state depond on various environmental factors such as, land use and annual climatic conditions. Haines (1923) studied blocks of soil moulded from a paste and distinguished three main phases of soil shrinkage that accompanied water withdrawal: normal, residual and no shrinkage as shown in Fig. 1. Normal shrinkage occurs when the change in soil volume equals to the water lost. Residual shrinkage occurs when air enters the soil and the reduction in soil volume is less than volume of water lost.

At the no shrinkage phase, soil does not shrink upon further drying. Large volume changes due to shrinkage (i. e., up to 34.0% of original soil volume) on compacted clayey soils have been reported by various researchers (Stirk (1954) and Chang and Warkentin (1968). The actual amount of shrinkage due to drying depends on factors such as type and amount of clay minerals, soil fabric arrangements, initial water content and confining pressure (Mitchell, 1976).

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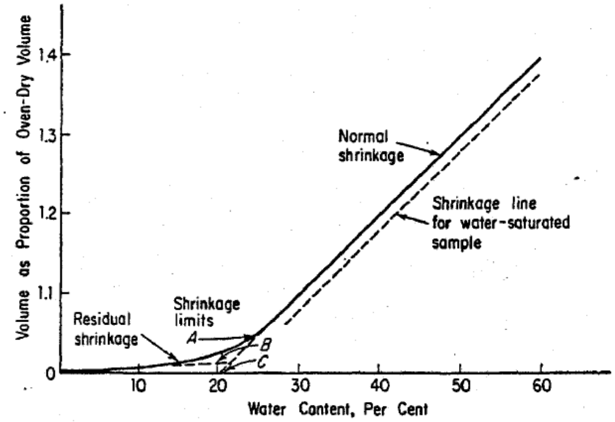


Fig. 1 Shrinkage curve for typical soils

### 2.2 PHYSICS OF CRACKING

There are other phenomena that may produce soil shrinkage and cracking. Skempton and Northey (1952) have suggested that, *in* London Clay, "fissures developed as a result of syneresis, a colloidal process whereby the particles draw themselves together under the action of attractive forces and expel some of the pore water". White (1961) also noted that cracks can be formed in a sedimenting clay through "syneresis". Lachenbruch (1962) studied the crack patterns in permafrost regions and contended that tensile stresses set up due to thermal contraction of the surficial frozen soils during winter causes fracture. Water then fills these cracks during summer thawing, becomes frozen, and builds up vertical ice-wedges of a considerable thickness after manyseasonal cycles. Burst (1965) noticed *in* laboratory tests that swelling clays under water can crack because of shrinkage in response to increases in salinity. Barbour (1986) suggested osmotically induced and/or osmotic consolidation as the cause of the volume change of clay soils that were exposed to brine solutions. This kind of volume reduction may ultimately cause cracking in soils. Hamilton (1966) noticed that freezing of compacted clay samples composed of mostly montmorillonite and illite, caused a reduction in soil volume for degrees of saturation less than 90%. Samples with degrees of saturation over 90% expanded. Reduction in volume ranged from 2.0% to 10.0%. Presumably, this type of shrinkage could lead to cracking as well.

### 2.3 DESICCATION CRACKING

As a result of volume reduction due to sub-aerial drying or desiccation, cracks would be induced in cohesive in sediments such as alluvial and lacustrine deposits, flood plain clay or dried-out lake (i. e. ,

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playa) deposits. The joints in flood plain clays can be accounted for by seasonal variations in water content which cause alternating expansion and contraction (Terzaghi, 1955). vertical joints in tills have been attributed to shrinkage during drying out by Boulton and Paul (1976) Desiccation cracks have been observed in playa (Longwell, 1928, and Willden and Mabey, 1961), in clayey till deposits after heavy rain in varved sequence of lacustrine clays and silts and in dried out hydraulic fill of intermixed and interlayered silty fine sand and moderately to highly plastic clayey silt (Fig. 2). Desiccation cracks are characterized by their aerial patterns, spacings and depths of the cracks. Despite this significance, more research is needed to understand cracking pattern and geo-mechanical properties associated with material anisotropy and inhomogeneity, stress non-uniformity and the boundary shape (Blight1997, Blight 2009 and Cui et al. 2013)

Fig. 2 Uneven desiccation cracking

## 2.4 CONCLUSIONS

It is concluded that factors that affect the amount of water contained in the soil include soil properties and compaction condition. Soil with higher clay content and higher plasticity index generally have a greater volume of water and thus are more prone to large volumetric shrinkage strains during drying. Thus volumetric shrinkage strain is a direct function of the volume of water and nature of soil subject to desiccation.

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