Journal of Advances in Science and Technology

Vol. IV, Issue No. VIII, February-2013, ISSN 2230-9659

EXAMINATION OF DESICCATION CRACKING ACTIVITIES OF DRYING SOIL

Journal of Advances in Science and Technology
Vol. IV, Issue No. VIII, February-2013, ISSN 2230-9659

Examination of Desiccation Cracking Activities of Drying Soil

Manoj Kumar[1]* Vishal Arora[2]

[1]Lecturer in Civil Engineering, Department G.B.N. Govt. Polytechnic, Nilokheri, Karnal, Haryana

[2]Lecturer in Civil Engineering, Department G.B.N. Govt. Polytechnic, Nilokheri, Karnal, Haryana

Abstract – This paper reports various experimental observations on desiccation tests performed in the laboratory under controlled conditions over samples of 'Ganga soil', from a defence embankment along the Ganga River, India. Data has been reported on the volumetric shrinkage and desiccation cracking exhibited on samples upon air-drying. Water retention curve was obtained to analyse the material properties during shrinkage. A number of tests have been carried out to study the desiccation process; in circular desiccation plate over 5 mm, 10 mm and 20 mm soil thickness. To characterised the crack patterns quantitatively digital image analysis (DIA) techniques have been used to analyse the desiccation plate tests. Crack parameters e.g., number of crack intersections, number of crack segments, total length of cracks, average width of cracks and crack intensity factor (CIF) have been determined for this purpose.

Keywords – Drying Soil; Crack Parameters; Digital Image Analysis; Desiccation.

---------------------------♦-----------------------------

INTRODUCTION

Cracking is a complex phenomenon in materials like soils. It is a natural process involving weathering, chemical changes and biological. Desiccation cracking significantly affects soil performance. Cracks create a zone of weakness in a soil mass and reduce its overall strength and stability (Miller, 2010). Examples can be found in various geotechnical, agricultural and environmental applications e.g. irrigated land, tailing ponds for mining waste, landfill liners, earth embankment, reservoir beds, etc. (Yesiller et. al., 2010).

Considerable work has been done to study experimentally the physical phenomenon of cracking in soils. To explain the development and extent of desiccation cracking several factors are considered including clay content and mineralogy, soil thickness, surface configuration, rate of drying, total drying time etc. (Colina and Roux, 2010). As soil structure is an important property which affects water storage and movement, it is necessary to measure crack size and pattern precisely. Examples of basic crack measurements are reported on several works (Aitchinson and Holmes, 2003. Abedine and Robinson, 2011. Logsdon et. al., 2010).

Imaging techniques have also been developed to basic cracking measurement. Guidi used electro-optical determination to estimate size distribution of crack (Lima and Grismer, 2012). Lima also used photographic image analysis to determine soil surface cracking (Logsdon et. al., 2010). Photographic image analysis techniques appeared to be a useful tool to distinguish differences in crack patterns which may be useful characterising soil cracking. This study has been conducted on a soil (Bengawan Ganga Soil) from a flood protection embankment in India.

The highly dense desiccation crack network observed in this man made embankment may have an important role in the occurrence of the small progressive failure frequently detected along the embankment. It is considered that in a drying soil, drying causes shrinkage and a crack initiates when the tensile stresses exceed the soil strength.

The tensile strength is dependent on the moisture content of the soil and the associated suction. In this paper the influencing factors behind cracking behaviour of soil such as volumetric shrinkage, water retention property of Ganga soil has been investigated experimentally under proper laboratory environment. Accurate measurement of geomaterial parameters of soil shrinkage cracks is not easy by direct measurement. Large measurement error is expectable due to irregular shape and complex cracks pattern. In recent years, image analysis techniques have been used extensively to characterise the crack network with improved accuracy (Guidi et. al., 2008), (Tang et. al., 2008).

In this work an image analysis algorithm has been developed (using Matlab code) to measure the amount of cracking on the surface of the soil. This research work is an attempt of development towards standard and improved procedure of laboratory testing using modern technology of cracking behaviour of soil.

SOIL PROPERTIES TO BE USED IN THE ANALYSIS

The samples have been obtained at the depth on 0.5 m - 1.0 m from the surface. The soil has been classified as inorganic silts of high compressibility and organic clay (Yan et. al., 2012). Some basic properties of the soil are given in table 1. From the clay mineralogy of this soil (table 2), it has found that the clay is rich in Smectite minerals (montmorillonites) which makes the soil highly attracted to absorb water and causing expansion of the material. These kinds of soils develop significant change of volume (contraction) during drying. The kinds of minerals of the clay fraction play a central role on the properties of the soil, such as plasticity and strength (McCloskey et. al., 2008).

TABLE 1. PROPERTIES OF BENGAWAN SOLO SOIL.

Properties	Value
Liquid Limit	55%
Plastic Limit	36%
Plasticity Index	19%
Linear shrinkage	14.8%
Volumetric shrinkage	16.45%

TABLE 2. MINERALOGY OF BENGAWAN SOLO SOIL.

Depth	0.5-1.0 m
Total fraction	
Total Phyllosilicates	60
Quartz	18
Calcite	12
Plagioclases	9
Mg-hornblende	1
Clay fraction	
Smectite	88
Kaolinite	12

TEST METHOD AND ANALYSIS

All crack parameters were extracted accurately with program algorithm. Finally, skeletonized operation has been performed. Table shows the desiccation test condition parameters. The information extracted from crack patterns in plates is shown in table. The total length of crack was determined by calculating the distance between intersections from skeletonized image. To quantify the amount of cracking, Crack Intensity Factor (CIF) was determined, which is the ratio of the surface area of the cracks to the total surface area of the soil.

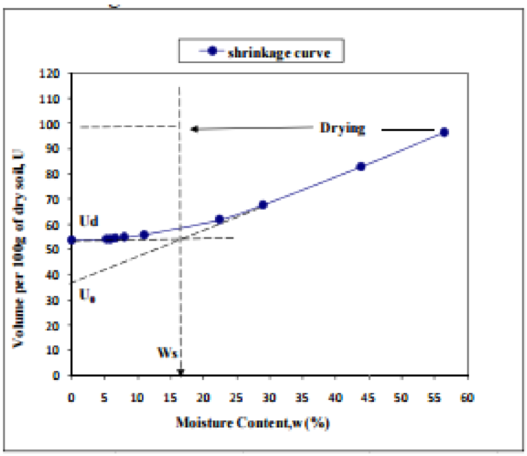

Figure 1. Shrinkage curve for Bengawan Solo Soil.

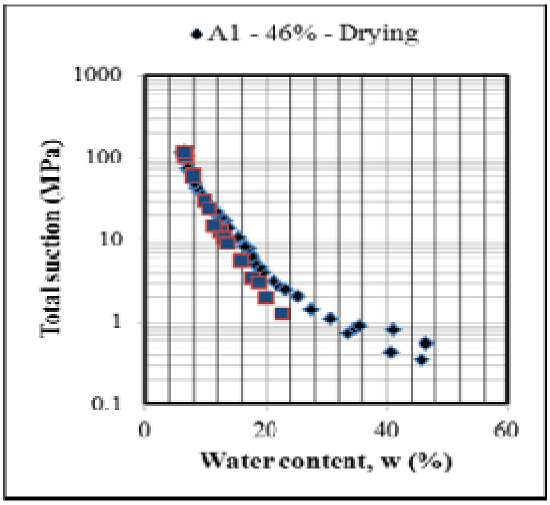

Figure 2. The water retention curve for Bengawan Solo soil.

Clayey soils are mostly used as liner material because of their low permeability. Clayey soils also follow the EPA standards as well. Sometimes, these soils cause a lot of problems for the geo-technical engineers as these soils tend to have high compressibility and poor shear Strength.

The variation in the volume is found at a very high level just because of high compressibility and hence, this variation creates a lot of problems for the engineers.

But the use of clayey soils has not decreased, it is still used for many purposes like clay liners, stabilization of bore holes etc. So while using this type of soil, its negative aspects are ignored by the engineers and only positive aspects are considered and this soil is used whenever needed.

There are many reasons because of which the variation in the volume of clayey soils is observed. One is due to the expulsion of pore water from the voids upon static surcharge. This process is known as consolidation. The other reason of variation is because of the shrinkage in the clay soils while drying. Desiccation is the process to pore water loss to a hot atmosphere.

The soil tends to shrink and the volume of the soil water decreases as a result of drying procedure. Soil tends to crack during desiccation if shrinkage is restrained. There are many applications of the desiccation cracking of clay in the performance of clayey soils.

The compressibility of the soil gets affected by the cracks formation. Cracks also affect the strength of soil to re-enter the water in it. So many kinds of applications directly or indirectly are affected by the presence of cracks in the soil.

Many type of construction work is done by using the clayey soils because of its property of swelling and drying. Clay tends to shrink during the dry time; as a consequence desiccation cracks are formed.

SUMMARY AND CONCLUSION

This work focuses on the study of some relevant factors that affect the behaviour of soils submitted to drying. The experimental research has been performed on samples from Ganga River of India. The following conclusions were derived:

1. The volumetric shrinkage of Ganga soil was found low which is 16.45%. Low shrinkage limit indicates high potential for shrinkage and swelling (Miller, 2010)..

2. The visual observation from the circular desiccation plate test was that all samples produced predominantly sequential, orthogonal crack (cracks that tends to meet at right angles) patterns leading to subdivision of the crack area into smaller cells.

3. The shapes of the crack notes at intersection was always '+' or 'T' regardless any experimental condition. Similar observations were found in the work by Tang et. al. (Guidi et. al., 2008).

4. Higher desiccation rate was observed for smaller thickness; non-orthogonal crack patterns evolved at the primary cracking stage and they occurred simultaneously and relatively fast all over the soil surface The higher the number of crack per area the higher was the length and CIF. But the opposite was found in the case of average width of crack.

REFERENCES

Miller (2010). Average length of crack and CIF was varied with the number of crack per area, 2010.

N. Yesiller, C. J., G. Inci and K. Yaldo (2010). Desiccation and cracking behaviour of three compacted landfill liner soils, Wayne State University, Department of Civil & Environmental Engineering, Detroit, USA, MI328202.

H. Colina and S. Roux (2010). 'Experimental model of cracking induced by drying shrinkage', The European Physical Journal E 1: pp. 189-194.

G. D. Aitchinson and J. W. Holmes (2003). Aspects of swelling in the soil profile. Aust. J. Appl. Sci.4, pp. 244–259.

Z. Abedine and G. H. Robinson (2011). 'A study on cracking in some vertisols of the Sudan', Geoderma 5, pp. 229–241.

S. D. Logsdon, R. Allmaras, L. Wu, J. B. Swan and G. W. Randall (2010). 'Macroporosity and its relation to saturated hydraulic conductivity under different till age practices', Soil Sci. Soc. Am. J. 54, pp. 1096– 1101.

L. A. Lima and M. E. Grismer (2012). 'Soil crack morphology and soil salinity', Soil Sci. 153, pp. 149–153.

G. Guidi, M. Pagliai and G. Petruzzelli (2008). 'Quantitative size evaluation of cracks and clods in artificially dried soil samples', Geoderma 19, pp. 105–113.

C. Tang, B. Shi, C. Liu, L. Zhao and B. Wang (2008). 'Influencing factors of geometrical structure of surface shrinkage cracks in clayey soils', Engineering Geology, 101(3-4): pp. 204-217.

A. Yan, K. Wu and X. Zhang (2012). 'A quantitative study on the surface crack pattern of concrete with high content of street fiber', Cem. Concr. Res. 32: pp. 1371-1375.

G. McCloskey, M. Sanchez, M. Dyer and R.A.A. Soemitro (2008). 'Experimental behaviour of a compacted silt used in a flood defence embankment in India', Proceedings of International Conference on Geotechnical & Highway Engineering, Kuala Lumpur, Malaysia, (ISBN: 978-983-42613-4-4) pp. 26-27.

J. K. Mitchell (2003). Fundamental of soil behaviour. New York: Wiley.

British Standards Institute (2010). Method of test for Soils for Civil Engineering purpose, Part 2: Classification of soil, BS 1377- 2.

S. Costa, J. K. Kodikara and N. I. Thusyanthan (2008). 'Modelling of desiccation crack development in clay soils', The 12th International conference of International Association for Computers Methods and Advances in Geomechanics (IACMAG), Goa, India, pp. 1099-1107.

Corresponding Author

Manoj Kumar*

Lecturer in Civil Engineering, Department G.B.N. Govt. Polytechnic, Nilokheri, Karnal, Haryana

E-Mail – vikas.pandey94@gmail.com