Effect of clay layer thickness on desiccation and cracking

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ABSTRACT: Clay materials are usually part of geotechnical projects such as slopes, embankment dams and landfills. Crack problem in clayey soil is one of the most destructive phenomenon as can affect the stability and efficiency of geotechnical projects. Thermal, mechanical and volume changes which lead to stress in soil can be cause of cracking. A series of desiccation tests were carried out to investigate effect of thickness of clay layer in crack pattern. Circular container selected with 150 mm diameter. Soil thickness was changed during the tests (i.e. 10mm, 15mm, and 30mm). Kaolin clay was used as soil part. The container material selected as metal. The results from the tests proved that thickness of soil is a significant parameter in desiccation tests and with increasing in thickness crack pattern is moved to orthogonal manner. During the tests also effect of fibre inclusion observed and showed that fibre inclusion had significant effect on crack density of the sample.

KEYWORDS: Desiccation; clayey soil; cracking, fibre

1 INTRODUCTION

In conventional application of reinforcement in soil, the inclusion of tire, bars, grids etc are usually in a preferred orientation. The advances of these materials have usually been considered by an increase in their applications. The randomly discrete fibers are easily added and mixed randomly with soil part, the same way as cement, lime or other additives. Some researches have been done on cement additive (Consoli et.al. 2009; Cai et.al 2006; Lorenzo and Bergado, 2004) and can be used as a pattern of additive usage in soil. Fibre reinforced composite shows more ductility and small losses of peak strength i.e. in compared to unreinforced material. Therefore, fiber-reinforced soil composite is a practical solution in civil engineering projects. The main application of composite soil can be in embankment, subgrade, subbase, and slope stability problems. However, the data concerning the effects of fiber inclusion on the characteristics of compacted native or virgin soils are limited, (Maher and Ho, 1993). This shortage is more considerable in pavement engineering and landfill systems in terms of crack control. Limited attempts have been made to control clay cracking by fibre reinforcement (Allan and Kukacka, 1995; Al Wahab and El-Kedrah, 1995; Ziegler et al., 1998). Miller and Rifai (2004) studied the effects of fibre reinforcement on the development of desiccation cracking in compacted clay samples. Therefore, the significance this study is to evaluate the effect of fibre inclusion on crack propagation in clayey soil. The application of controlling crack cause significant improvement in land fill systems and pavement engineering as cracking which lead these systems to be failed in the real civil projects.

2 MATERIAL

Composite soils consist of two parts. The first part is soil part which can be dealt as normal soil. The second part is reinforcement part which can be made up of any material which helps soil to have better performance.

2.1 *Soil Type*

The soil type in this study was kaolin clay. The properties of clay are presented in table 1. This type of kaolin clay is widely used in industrial project and research activities in Western Australia.

Table 1. Clay properties

No.	Size (cm)	
1	Soil type	Clay
2	Liquid Limit	49
3	Plastic Limit	23
4	Pl. Index	26

2.2 *Fiber Type*

The plastic fiber has been used for this investigation. Figure1 shows the used fiber. The used fiber has good potential to absorb energy and good adhesion with soil particle.

Figure. 1 Plastic fiber

3 TEST PROGRAM

Test program in this study includes a series of cracking test were conducted to investigate the effect of thickness of sample ad fibre inclusion on cracking phenomenon.

3.1 *Main Equipments*

- Metal container and glass container for cracking test
- Electrical light for cracking test
- Balance for cracking test

Figure 2 shows the metal container which was used to run the crack test.

Figure 2. Metal Container used for cracking test

4 SAMPLE PREPARATION FOR CRACK TEST

The soil was passed through a 4mm sieve in order to obtain a consistent mixture once water had been added. The cured soil would be sealed in a couple of plastic bags to prevent moisture loss. When placing soil at 45% moisture content into containers, they were continuously tapped to surface any trapped air bubbles in the soil. Cling wrap was used to smoothen the surface of each sample as well as provide a cover to prevent moisture loss when allowing the soil to settle over night. The surface of the sample was a circle with 150mm and thickness was 10mm, 15 mm and 30mm.

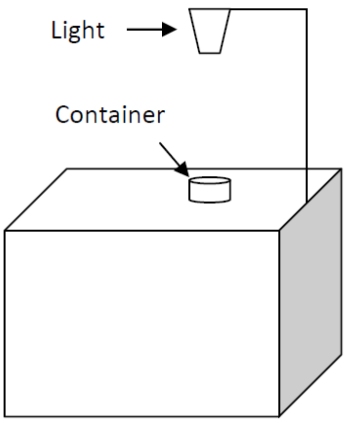
5 TEST METHODOLOGY AND PROCEDURE

5.1 *Cracking test*

To run the cracking test following steps were taken:

- Putting soil into container
- Making sure that moisture content is as what required (i.e. 45%)
- Setting up the height of light faced to sample precisely on 1m
- Using digital camera to record image of soil specimen every hour
- Extracting of images to analysis of crack pattern
- Crack Intensity Factor is considered as ratio of crack area to total surface of sample.

The figure 3 shows the sketch of experimental set-up which used to run the cracking tests. As previously mentioned the flood light used to run cracking test. The soil in metal container is directly faced to flood light.



dure sketch

6 RESULTS AND DISCUSSIONS

In this section the results of cracking tests are presented.

6.1 *Cracking test on clay without fibre*

The results form caking test for different thickness proved that with increasing in soil thickness the pattern moved to orthogonal behavior. Figure 4 shows the sample with 10 mm.

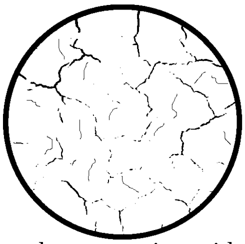


Figure 4. The crack propagation with 10mm thick

Figure 5 shows the crack pattern for 15mm thickness.

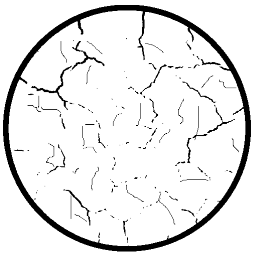


Figure 5. The crack propagation with 15mm thick

Figure 6 shows the crack pattern for 30mm thickness.

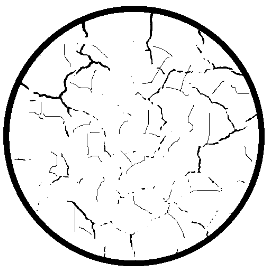


Figure 6. The crack propagation with 30mm thick

6.2 *Effect of fibre in cracking test*

A series of cracking tests were conducted and following results obtained. Table 2 shows the crack density with different fibre content and length. Crack density factor was computed based on image processing and obtaining the ratio of crack to total surface area. Crack Intensity Factor (CIF) is the ratio of the crack area to total area of the sample surface.

Table 2. Crack density versus fibre content

No.	Fibre	CIF
1	No fibre	5.28
2	1%	3.7
3	2%	1.2

Figure 7, 8 and 9 show the images from different fibre contents. The results proved that with increasing in fibre content and length crack density decreased rapidly.

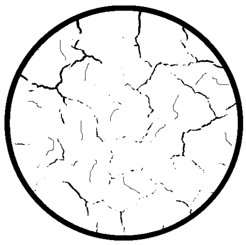


Figure 7. The crack propagation without fibre

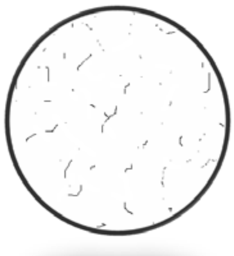


Figure 8. The crack propagation pattern with 1% fibre with 25mm length

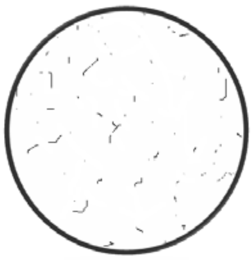


Figure 9. The crack propagation pattern with 2% fibre with 25mm length

The results from cracking test proved that increasing in fibre content and fibre length decreased the Crack Intensity Factor (CIF). Therefore, fibre inclusion is good solution to solve the cracking problem of clayey soil.

7 CONCLUSION

A series of cracking on cylindrical clayey soil with 150 mm diameter and 10 mm, 15mm and 30 mm thickness, were conducted and following results obtained:

1- Using fibre caused huge decrease in crack intensity factor
2- Increasing in fibre length and content directly decreased the crack
3- Image processing proved that can be used as useful tool in further crack analysis
4- Image analysis proved that with increasing in soil thickness the crack pattern moved to orthogonal shape.

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