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Laboratory Evaluation of Fibre-Composite

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Abstract-Reinforced soil has been among the most effective soil modification materials. Its use has been expanded rapidly into civil engineering, geotechnical engineering and pavement engineering. This study focuses on effect of fiber inclusion on the unconfined compressive strength of composite soil. Plastic fiber was used for this investigation. Fibers were put in composite in random orientation. Fiber contents and aspect ratio have been changed during these tests. The fiber percentage varied from 0 % (for unreinforced samples) to 2%. Kaolin Clay was selected as soil. Unconfined compression tests were carried out to evaluate the behaviour of the composite under different loading condition. The results showed that the unconfined compressive strength of fiber reinforced composite soil was increased by increasing in fiber content and fiber aspect ratio. The fiber aspect ratio and fiber content found to play important rule on the strength of fiber composite clay.

Keywords- *composite; soil; strength.*

I. Introduction

The paper presents the effect of fiber inclusion on unconfined compressive strength of clay composite. Applications of soil strengthening or stabilization range from the mitigation of complex slope hazards to enhancing the subgrade stability. Together with the many applications for improving soil, there are several widely varied methods. Chemical stabilization by cement or lime is a proven technique for improving the performance (strength and stabilization) of soil (Ismail et al., 2002; Aiban, 1994; Huang and Airey, 1998; Basha et al., 2005; Kolias et al., 2005; Sherwood, 1993; Al-Rawas, 2002; Tremblay et al., 2002; Lima et al., 1996; Thome, 1999). However, these chemical additives usually result in a high stiffness and brittle behavior (Wang et al., 2003; Basha et al., 2005). The mixing of randomly oriented fibers to a soil sample may be considered same as other admixtures used to stabilize soil. Materials which are used to make fibers for reinforcement may be obtained from paper, metal, nylon, polyester and other materials having widely varied physical properties. There have been numerous past papers published on the topic of fiber strengthening of soils. Examples include Lee et al., 1973, Hoare,1979, Andersland and Khattac,1979, Freitag,1986, Gray and Ohashi, 1983, Gray and Rafeai, 1986, Maher and Gray 1990, Maher and Ho, 1994, Michalowski and Zhao 2002, Ranjan et al. 1996, Kaniraj and Havanagi 2001, Consoli et al. 2009. All of the papers listed above indicated that; strength of the soil was improved by fiber reinforcement. The investigation on clay composite is very limited. The purpose of this survey is to evaluate clay behaviour induced by fiber inclusion.

II. Materials

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

A. *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

B. *Fiber Type*

The plastic fiber has been used for this investigation. Fig1 shows the used fiber. The used fiber has good potential to absorb energy and good adhesion with soil particle.

Fig. 1 Plastic fiber

Fig. 2 Trixial Base

III. TEST PROGRAM

A series of unconfined compression have been performed on reinforced clay composite.

A. Unconfined Compression Test

The unconfined compression test applies uniaxial stress conditions on a sample of soil, and is therefore a special case of the trixial test with no confining stress. The unconfined compression test has a considerable cost advantage over triaxial test due to the simpler testing requirement. The limitation of this test can be named as: preparing stable sample for cohessionless material and undrained estimation due to quick test.

B. Main Equipments

To run the test, tools are needed as:

- Unconfined compression testing machine (Triaxial Machine)
- Specimen preparation equipment
- Sample extruder
- Fiber
- Balance

Fig 2 shows the triaxial base which was used to run the UCS test. The device is fully automated so the results easily transferred without any user interference.

IV. SAMPLE PREPARATION

The samples were provided by mixing clay and three percentage of fiber. Specimen preparation procedure was the standard compaction method, which was used in an ongoing experimental research on fiber-reinforced clay at Curtin University. The soils were first oven-dried. The dry soils were then crushed using a hammer. A mixer was used to thoroughly mix the soils with water to obtain the desired water moisture content for compaction. The mixing of soil with fibers was performed mostly by hand rather than using the mixer because the mixer caused the fibers to tangle or break. The fiber-soil mixture was placed in a closed container for 24 hours after mixing was completed. (Chegenizadeh and Nikraz,2011) A split mould and a specific hammer were used to compact the specimen. The specimens were prepared in different fiber content (i.e. 1%, 1.5%, and 2 %) and different fiber length (aspect ratio) which were 10mm, 20mm.

V. TEST METHODOLOGY AND PROCEDURE

The test procedure can be listed as:

- The specimens were prepared in the laboratory with 90% compaction effort, special care was taken during this process
- The size of samples were checked to be suitable for the test purpose
- The samples were put for 24 hours in geotextile and packed
- Special attention was applied for preventing any moisture loose
- The samples were placed in trixial base without any confinement pressure
- According to ASTM 1.27 mm/min were applied through the tests
- The data was collected automatically

The stress-strain curve plot used for strength behavior investigation.(Chegenizadeh and Nikraz,2011)

VI. Results and Discussions

The unconfined compression tests were conducted in order to determine effect of fiber inclusion on Unconfined Compressive Strength (UCS). The tests were included two parts. First part was to consider the effect of fiber inclusion on pure kaolin clay. Effect of fiber on pure clay

The tests were conducted on cylindrical specimen of 60 mm diameter and 170 mm height. Fig 3 showed the stress-strain curve obtained from the tests. The results in Fig 3 proved that strength of the composite increased with increasing in fiber content. It should be noted that the results in Fig 3 is at fiber length 10mm.

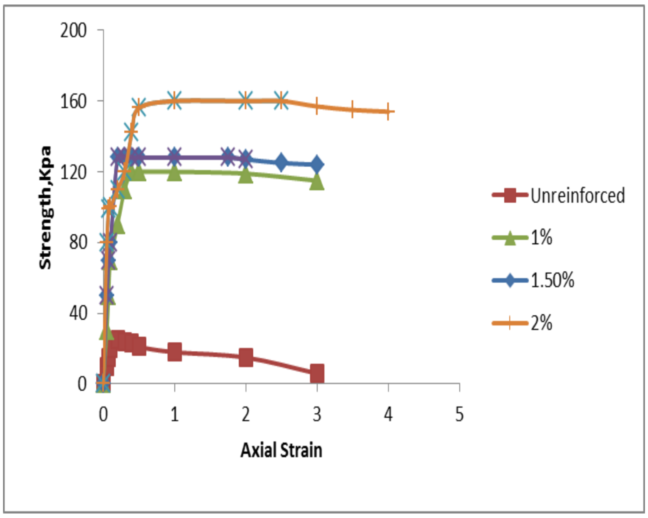

Fig. 3 UCS results with different fiber content (at 10mm fiber length)

The presented results in Fig 4 are at fiber content of 1%. Fig 4 shows effect of fiber length on composite samples. As can be found from the results, with increasing in fiber length, strength of composite was increased.

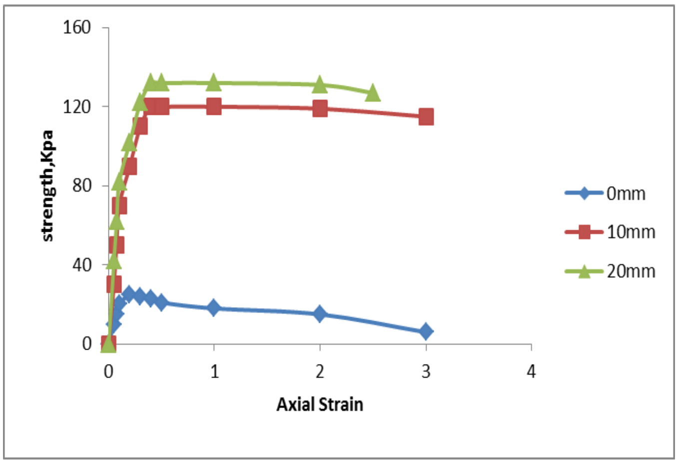

Fig. 4 UCS results with different fiber length (at fiber content of 1%)

VII. Conclusion

A series of Unconfined Compression Test were performed to evaluate the effect of fiber inclusion on strength behaviour of composite material. The following results were derived:

- Increasing in fiber percentage increased strength in clay samples
- During the test, it was observed that ductility behaviour of reinforced clay increased because of fiber inclusion.
- The results proved that with increasing in fiber length, the UCS of composite clay was increased.
- Short and randomly Fiber inclusion showed to be reliable in industry projects as it helps to minimize the cost of projects.

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