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Study on Sand and paper reinforcement

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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. Reinforcing subgarde in pavement systems has always been an issue. This study focuses on effect of paper inclusion on the modulus of elasticity of subgrade material. Paper was used for this investigation. Paper contents and aspect ratio have been changed during these tests. The paper percentage varied from 0 % (for unreinforced samples) to 20%. Sand was used as sub grade material. Unconfined compression tests were carried out to investigate behaviour of the composite under different condition. The paper reinforcment length and paper reinforcment content found to play important rule on the modulus of elasticity of paper reinforced samples. Effect of paper content found to be more signifcient compare to paper length.**

***Keywords*— Reinforced soil, Unconfined, Strength, paper.**

I. 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 (Chegenizadeh and Nikraz,2011), 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. This idea can be a start point for using other material such as waste material in soil. 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 (Chegenizadeh and Nikraz, 2012) therefore research on reinforced systems in pavement structure needs to be more performed.

As in pavement engineering modulus of elasticity has considerable effect on the design procedure, this study is mainly focused on changes in this parameter due to random paper reinforcment inclusion.

II. Material

Composite materials 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.(Chegenizadeh and Nikraz,2012)

Soil Type

The soil type in this study was Western Australian Sand. The Particle Size Distribution (PSD) of used sand is presented in Figure 1. This type of sand is widely used in industrial project and research activities in Western Australia.

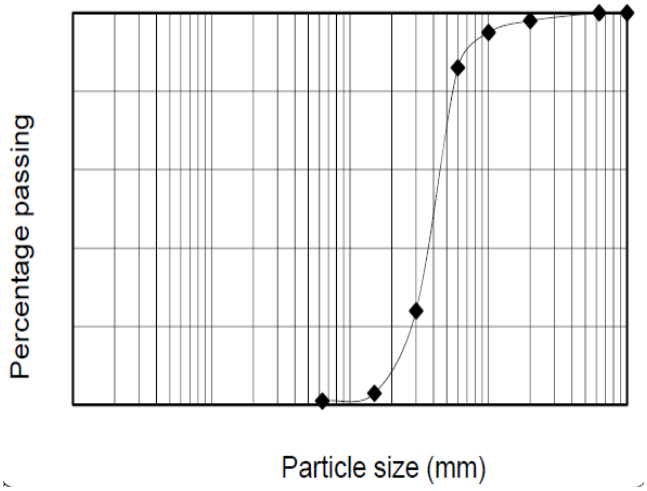

Fig. 1 PSD of used sand (Chegenizadeh and Nikraz,2011)

Reinforcement Type

Paper has been used as reinforcement in this investigation. Figure2 shows the template of used paper. This paper can be prepared by waste material and helps the environment to reduce the landfills.

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Fig. 2 Used paper template(online source,2012)

III. Test Program

A series of unconfined compression tests have been conducted to verify effect of paper reinforcement content on elasticity modulus.

Unconfined Compression Test Principle

Aim of Unconfined Compression test is to obtain unconfined compressive strength of soil. This can be applied to fine grade and cohesive soil and will represent very fast response in practical condition as the test time is very quick in respect to confined one. This test is widely used for slope stability and embankment dam applications.

Equipments

- Unconfined compression testing machine (Triaxial Machine) as shown in figure 3
- Specimen preparation equipment
- Sample extruder
- Balance

Fig. 3 Triaxial machine(Chegenizadeh and Nikraz,2011)

Sample Preparation

The samples were prepared according to Chegenizadeh and Nikraz research by mixing sand and three percentage of paper reinforcement. Specimen preparation method was the standard compaction method, which was used in an ongoing experimental research on fiber-reinforced soil 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 papers was performed mostly by hand rather than using the mixer. The paper-soil mixture was placed in a closed container for 24 hours after mixing was completed. A split mold and a specific hammer were used to compact the specimen. The specimens were prepared in different paper reinforcement content (i.e. 4%, 8%, 20%) and different paper reinforcement length (aspect ratio) which were 5mm, 10mm, 25mm.

IV. Test Procedure

1. The specimens were prepared in the laboratory with 90% compaction effort, special care was taken during this process
2. The size of samples were checked to be suitable for the test purpose
3. The samples were put for 24 hours in geotxtile and packed
4. Special attention was applied for preventing any moisture loose
5. The samples were put in trixial base without any confinement pressure
6. According to ASTM 1.27 mm/min were applied through the tests
7. The data was collected automatically
8. The stress-strain curve plot used for modulus elasticity investigation

V. Results And Discussion

The unconfined compression tests were performed in order to determine the modulus of elasticity (E-value). The E values were calculated based on the initial tangent of the stress-strain curve. The tests were conducted on cylindrical specimen of 60 mm diameter and 170 mm height.

Table 3 provides values of elastic modulus of soil with and without paper reinforcement. The maximum E-value of sandy soil was 7522 kPa obtained at the aspect ratio of 25mm and paper content 20% percent. Figure 4 shows the graphical change in modulus due to paper inclusion in soil.

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It was observed that modulus of elasticity was increased with increasing in paper reinforcement length and paper reinforcement content. However, the paper length parameter found to be less effective compare to paper content.

TABLE 3
E-VALUES (KPA) FOR REINFORCED AND UNREINFORCED SOILS

Paper reinforcement length(mm)	paper reinforcement content %	E value
-----	0.00	6000
5	4	6320
	8	7085
	20	7430
10	4	6332
	8	7097
	20	7442
25	4	6412
	8	7177
	20	7522

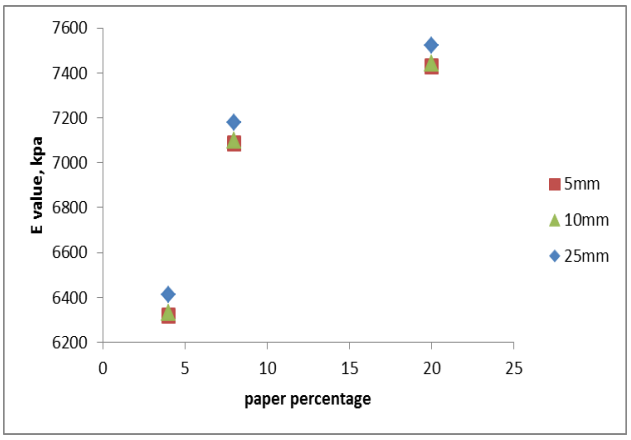

Fig. 4 Effect of paper percentage and length on modulus of elasticity

VI. CONCLUSION

A series of Unconfined Compression tests were performed and conclusions can be summarized as:

- Increasing in paper reinforcement percentage increased modulus of elasticity
- Increasing in paper reinforcement aspect ratio slightly increased modulus of elasticity
- During the test, it was observed that ductility behavior of reinforced sand increased because of paper reinforcement inclusion.
- The comparison between results of 10mm paper reinforcement and 25mm doesn't show significant effect on modulus.
- Short and randomly paper reinforcement inclusion showed to be reliable solution to enhance strength of the composites.

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