Laboratory investigation on the Effects of Coconut Fibres on Bearing Capacity Of SM Reinforced Soil

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Abstract

This article describes a laboratory study on reinforcement of SM soil using coconut fibres as an additive. Coconut fibres are biodegradable and environmentally friendly among the soil. Test specimens were prepared with varying percentages of coconut fibres (non-reinforced, 0.8%,1.8%, 2.4% and 3.2%) by the weight of dry soil and varied lengths of coconut fibres (35mm and 50mm).The Unconfined Compression Test (UCT) was performed to investigate the bearing capacity of soil.

These primary conclusions were obtained from this investigation. The first observation indicated that according to the different fibre contents, the effects of coconut fibre reinforcement provided a significantly different improvement in the soil shear strength. The second observation showed that the effect caused by the different percentages of coconut fibres was stronger than the effect caused by the coconut fibre length.

Key words: reinforcement of SM soil, coconut fibres, Unconfined Compression Test, soil shear strength

1. Introduction

Reinforcement consists of incorporating certain materials with some desired properties within other material which lack those properties (Jones 1990). Therefore, soil reinforcement is defined as a technique to improve the engineering characteristics of soil in order to develop the parameters such as shear strength, compressibility, density; and hydraulic conductivity (Kazemian et. al 2010). Mainly, reinforced earth is a composite material consisting of alternating layers of compacted backfill and man-made reinforcing material (Ola 1989). So, the primary purpose of reinforcing soil mass is to improve its stability, to increase its bearing capacity, and to reduce settlements and lateral deformation (Binici et al 2005)

Some unconventional methods of soil reinforcement achieved by the combination of randomly distributed fiber with chemical admixtures such as cement, lime and/or chemical resins. Some of the methods appeared may have the disadvantages of being ineffective and/or expensive. So, new methods are still being researched to increase the strength properties and to reduce the swell behaviors of problematic soils (Puppala & Musenda, 2000).

It is emphasized that short fiber soil composites have recently attracted increasing attention in geotechnical engineering. Studies on mechanical behavior of short fiber soil composite are comparatively new when compared to other research fields (Michalowiski & Zhao 1996). McGown et al. classified soil reinforcement into two major categories including ideally inextensible versus ideally extensible inclusions. Ideally extensible inclusions include relatively low modulus natural and/or synthetic fibers, plant roots; and geosynthetics. They provide some strengthening but more importantly they present greater extensibility (ductility); and smaller loss of post-peak strength compared to the neat soil (McGown et al 1978)

At the present time, there is a greater awareness that landfills are filling up, resources are being used up, the planet is being pol-luted and that non-renewable resources will not last forever. So, there is a need to more environmentally friendly materials. That is why there have been many experimental investigations and a great deal of interest has been created worldwide on potential applications of natural fibers for soil reinforcement in recent years. The term ‘‘eco-composite’’ shows the importance role of natural fibers in the modern industry (Hanafi & Few 1998).

One of the natural fibers used in reinforced soil is coconut fiber. These fibers are biodegradable and environmentally friendly. Additionally, coconut trees grow widely in tropical areas around the world such as Asia, Central and South America and Africa. Palm trees are grown in abundance in Brazil, the Caribbean, Venezuela, Indonesia, Thailand and Kenya among others.

SM soil generally has a low shear strength that needs reinforcement. The main purpose of this article is to reinforce the shear strength of SM soil with Coconut fiber.

2. Material

Coconut fiber

Coconut fiber is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fiber is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but also weaker. Coconut fibers are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types of fibers have different uses depending upon the requirement. In engineering, brown fibers are mostly used.
According to official website of International Year for Natural Fibers 2009, approximately, 500 000 tones of coconut fibers are produced annually worldwide, mainly in India and Sri Lanka. Its total value is estimated at $100 million. India and Sri Lanka are also the main exporters, followed by Thailand, Vietnam, the Philippines and Indonesia. Around half of the coconut fibers produced is exported in the form of raw fiber. there are many general

advantages of coconut fibers e.g. they are moth- proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean. (Majid 2010).

Coconut fibers due to weather conditions in Iran are not generated. So for the preparation of coconut fibers those coconut fruits were used which were available in Bandar abbas fruit market. Coconut fibers in both the 35 and 50 mm were prepared (Fig. 1).

Fig 1: coconut fibers lengths of 35 and 50 mm

Soil

Soil in the study area is located in Bandar Abbas, Hormozgan University, respectively. For classification of soil, Unified classification system was used. Sieve analysis and Atterberg limit was performed. Percent passing the #200 sieve was measured 20.1% and 80.4% of measured soil grains passed through the sieve #4, and based on these percent, it was concluded to sandy soil. To determine the silt from clay, percent passing through the #200 sieve was measured 20.1% and plasticity index was measured less than 7(PI=2) so it was silt. Based on the findings on the experiment, the soil was named silty sand soil (SM soil).

3. Research Methodology

To evaluate the effect of the fiber reinforcement on the shear strength of the soil, there were two options available: Triaxial Test and the Unconfined Compression Test (UCT). The UCT (ASTM D2166) was selected because the sample preparation time for this test was significantly shorter than the sample preparation time of the Triaxial Test. Even though the

UCT provides less information than Triaxial Test, the information was still sufficient to clearly establish the characteristics of the optimum soil fiber reinforcement scheme.

Test specimens were prepared with varying percentages of coconut fibres (non-reinforced, 0.8%,1.8%, 2.4% and 3.2%) by the weight of dry soil and varied lengths of coconut fibres (35mm and 50mm). Sample sizes of 5 cm diameter and 10 cm in height were built. Dried soil was mixed with various percentages of coconut fibers. Soil moisture content is 17%. Water was equally added to the samples and they were dried in the end.

The Unconfined Compression Test (UCT) was performed to investigate the bearing capacity of soil. The UCT is a strain controlled test; therefore a constant strain rate was applied to the sample throughout the test. The failure point of the soil sample was determined when the maximum loading was reached. The strain was calculated and compressive stress was applied to every loading increment, in every specimen. Then the peak stress was identified until each sample could withstand before shear failure. Figure 2 shows the device of unconfined compression test.

Fig 2: device of Unconfined Compression Test

Results and Analysis

Figure 3 illustrates the difference in soil behavior according to the different reinforcement combinations of fiber length and its various percentages based on soil weight. The height of each bar represents the maximum strength attained within all the specimens of the same fiber length. The vertical line represents the standard deviation of maximum strengths attained within each sample type.

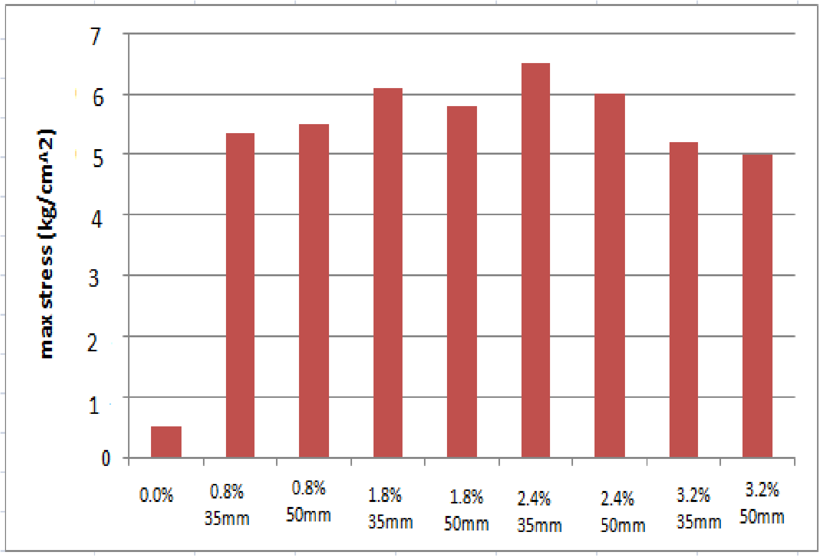

Fig 3: comparison of maximum shear strength according to the fiber content and length combinations

Figure 4 illustrates the difference in soil behavior according to the percentage by weight of the fiber reinforcement.

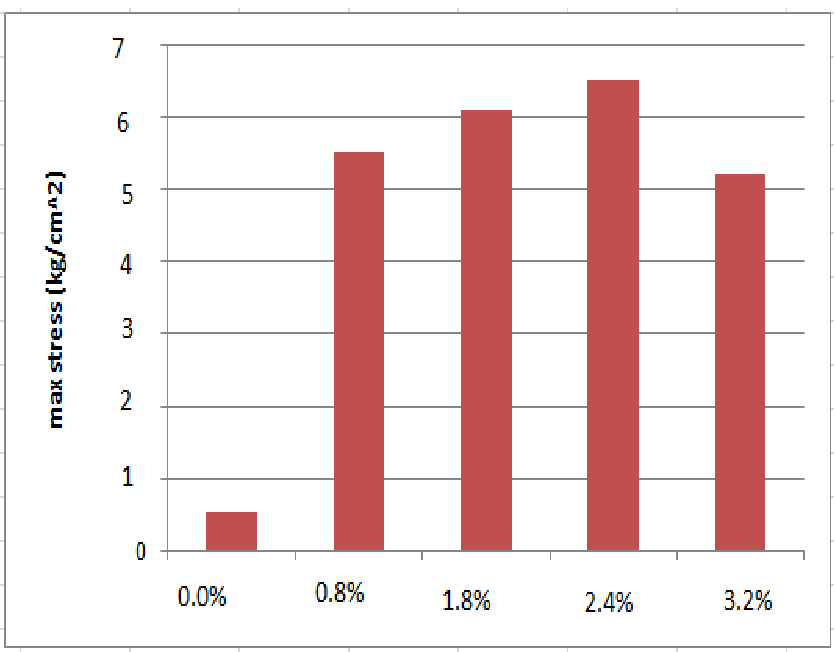

Figure 4: comparison of maximum shear strength according to percentages of fiber

Therefore the first evaluation compared the behavior presented by the un-reinforced soil to the one caused by different combinations of the fiber length and concentration parameters. The second evaluation compared the behavior caused by the fiber concentration. The evaluations were performed in this order because the first necessary step was to determine whether the reinforcement of the soil by fibers provided a scientifically valid improvement in the shear strength of the soil and whether the effect was significantly different between various combinations; and the second necessary step was to determine which of the two varied fiber parameters was the leading one: length or concentration. As the results show, none of them caused a significant effect; there is an interaction between these two parameters that this test could not determine. However, the conclusion is that the fibers dramatically improve the soil shear strength and there is an optimum combination of these two parameters.

5. Conclusions

The first observation points out that the effect of the fiber reinforcement according to the different fiber contents provides a significantly different improvement in the soil shear strength. The second observation shows that the effect caused by the different percentages of fiber is stronger than the effect caused by the fiber length.

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