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-RESEARCH ARTICLE-

Bearing and Swelling Properties of Randomly Distributed Waste Jute Reinforced Soil

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Abstract

In this study, waste jute, which was provided from textile companies, was investigated to define effect of waste jute on swelling and bearing behavior of the sand used. Three different water content (17, 19 and 21%) and four different waste jute addition amount at different percentages (0, 1, 2, and 3) by mass of dry soil were selected as design variables. With defined variables Swelling Ratio and California Bearing Ratio (CBR) tests were conducted. According to test results it is concluded that minimum swelling ratio was observed in the test containing 3% jute with 19% water content and the highest value of CBR was observed in the sample containing 2% jute with 16% water content. In addition to that, CBR values of unreinforced samples were decreased when water content increased from 16% to 21%. However, CBR values of reinforced samples increased with increasing water content from 19% to 21%.

Keywords:

Waste, Jute, CBR, Swelling

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Introduction

In recent years, as a result of urbanization, industrialization and technological developments there has been an environmental concern about finding a new reuse applications for different waste materials (Zhuang et al., 2008; Cheng et al., 2007). Reusing the waste materials is not only a way

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for protecting environment, but also diminishes production costs and more reusing of waste materials offers a solution for disposing (Zhang et al., 2010).

Currently soil reinforcement with discrete, randomly oriented fibers has been found attractive by researches worldwide. Most of the investigations were performed on the strengthening of soft clays and expansive clays using different additives like lime, cement, chemicals and fibers (Maliakal et al., 2012, Pradhan et al., 2011). (Mir., 2015) studied effect of fly ash and lime on physical and mechanical properties of expansive clay; he added different percent fly ashes to a highly expansive soil. According to his findings addition of fly ash improved engineering characteristics of the soil used. In another study Nanometer magnesium oxide (NM) was investigated as an additive and according to their findings addition of 6% NM to clay soil could effectively develop the strength and stability behaviors of the soil (Gao et al., 2015).

Fiber reinforced soil is described as composite soil which contains randomly distributed fibers that provide mechanical improvement in the reinforced soil (Jamshidi et al., 2010). Because of relatively high tensile strength of the jute fibers; soil containing jute behaves like a composite material. Mainly, near the surface of the soil the effective stress is low and fibers behaves like roots of the plants so that randomly distributed jute fibers contributes stability to soil by its relatively higher strength (Wu et al.,1988; Greenwood et al., 2004). Because of this, laboratory and in-situ test outcomes led scientist to study on fiber reinforcing soils (Jewell et al., 1987; Wang et al., 2008; Al-Refeai, 1991; Consoli et al., 1998).

Although there are several researches about reinforcing materials, there is no research about using waste jute fiber as a soil reinforcement material. The current work investigates the effect of waste jute fiber that is waste of carpet companies in Gaziantep on swelling and bearing ratio of well-graded clayey sand, which is provided from İskenderun/Hatay.

Materials and Methods

Materials and mixture design

Materials used in the current investigation are soil and jute fibers as reinforcement. The soil used was provided from İskenderun/Hatay. The gradation curve was made by plotting the weight percentage that passes each sieve versus the corresponding sieve size. Figure 1 illustrates the gradation test results the soil used. The soil used in the investigation was well graded clayey sand designated by Unified Soil Classification System (USCS) and was classified as SW-SC. Atterberg limits and physical properties of soil were tested and reported in Table 1. In addition to that optimum moisture content of the soil used was determined as 19%.

The waste jute used in this study was gathered from the textile companies in Gaziantep. Different lengths (20–25 mm) of jute fibers in different percentages (0, 1, 2 and 3%) by weight of dry soil were used to reinforce the soil.

Table 1. Atterberg limits and physical properties of soil

Jute Reinforcement (%)	Water content (%)	Jute Length (mm)
0	16	-
0	17	-
0	19	-
1	16	25
1	17	25
1	19	25
2	16	25
2	17	25
2	19	25
3	16	25
3	17	25
3	19	25

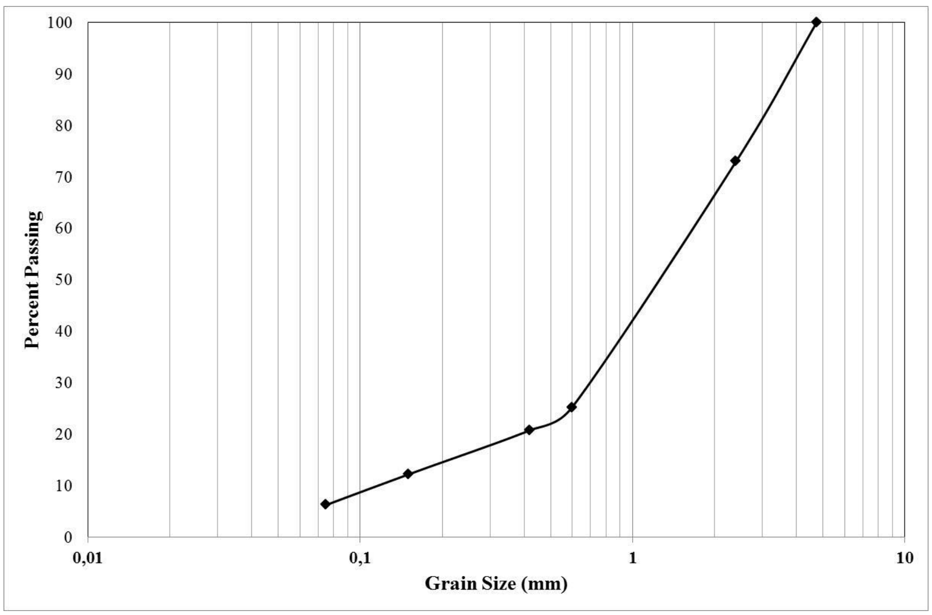

Figure 1. Size gradation curve of the soil

Mix design

Twelve different mixtures of jute reinforced soil (JRS) were prepared in consideration of fallowing

- Three different water contents (17, 19, 21%) by weight of total mass
- Four different waste jute amounts (0, 1, 2 and 3%) by weight of dry weight of soil

Details of the mixtures are given in Table 2. Twelve cylinders (152x178 mm^3), specimens were prepared. The specimens were soaked in the water tank for 96 hours then CBR and SR values were recorded.

Table 2. Properties of the specimens

Jute Reinforcement (%)	Water content (%)	Jute Length (mm)
0	16	-
0	17	-
0	19	-
1	16	25
1	17	25
1	19	25
2	16	25
2	17	25
2	19	25
3	16	25
3	17	25
3	19	25

Test methods

This study investigates effects of addition of waste jute on bearing and swelling ratio characteristics of well-graded clayey sand. Series of CBR tests were done to determine bearing and swelling capacity of the soil. Investigations were done on the samples with 17, 19 and 21% water content and 1%, 2%, 3% (by weight of dry soil) jute fibers.

The experimental study concluded conducting a series of laboratory CBR tests on the randomly distributed waste jute reinforced soil specimens. The inside diameter of mold was 152 mm and a height was 178 mm. In order to force the penetration piston with a diameter of 55 mm into the sample a digital loading machine accoutered with a movable base that slides at a uniform rate of 1.2 mm/min and a calibrated load-indicating device was used. At the same time, loads versus penetrations values were carefully recorded to a total penetration of 5 mm. The details of the soaked state CBR test can be reached in ASTM D1883.

To determine the swelling ratio of the specimens, these steps were fallowed; firstly, an adjustable metal swell plate was placed on top of the filtration disk, with the desired number of weights (for the case of the 18.143 kg surcharge weights, the collar should not be used. Instead, the 9.071 kg weight should be placed directly over the stack of 2.267 kg weights). After that the tripod assembly with the swell dial gauge was placed on top of the collar of the assembly. Finally, the dial gauges adjusted to zero then the specimens were completely submerged in the water tank at constant humidity for 96 hours.

Results and Discussions

Waste jute gathered from textile companies was used to replace partially with the well-graded clayey sand. 0, 1, 2, and 3% waste jute containing and 17, 19, 21% water containing JRS specimens were prepared and CBR and SR tests of these specimens were carried out.

California Bearing Ratio (CBR) Test

To establish the CBR values, equation 1 and 2 were used then the stress-penetration curves were drawn and the CBRs were determined. Table 3 summarizes these results as well as the moisture contents for each sample. Normally, only CBRs 2.5 millimeters are reported. But the CBR at 5 millimeters was higher than at 2.5mm (Guido et al., 1995). According to ASTM specifications higher of the two must be used. Should that the CBR at 5 mm be higher, the tests should be rerun. Due to the impracticality of rerunning every single test, randomly chosen two tests have been repeated. The results were consistent. Thus, the higher one was reported. And also, the samples with different percentages of jute and different amount of moisture contents are examined and presented in Figure 2 and Figure 3.

Table 3. CBR results of the specimens

Jute Reinforcement (%)	Water content (%)	CBR @.2,5 mm (%)	CBR @.5 mm (%)
0	16	0,455	1,185
0	17	0,625	0,749
0	19	0,227	0,426
1	16	1,777	1,782
1	17	0,682	0,787
1	19	0,554	0,559
2	16	1,834	1,939
2	17	0,967	0,9
2	19	0,739	0,824
3	16	1,72	1,934
3	17	0,497	0,692
3	19	0,739	0,938

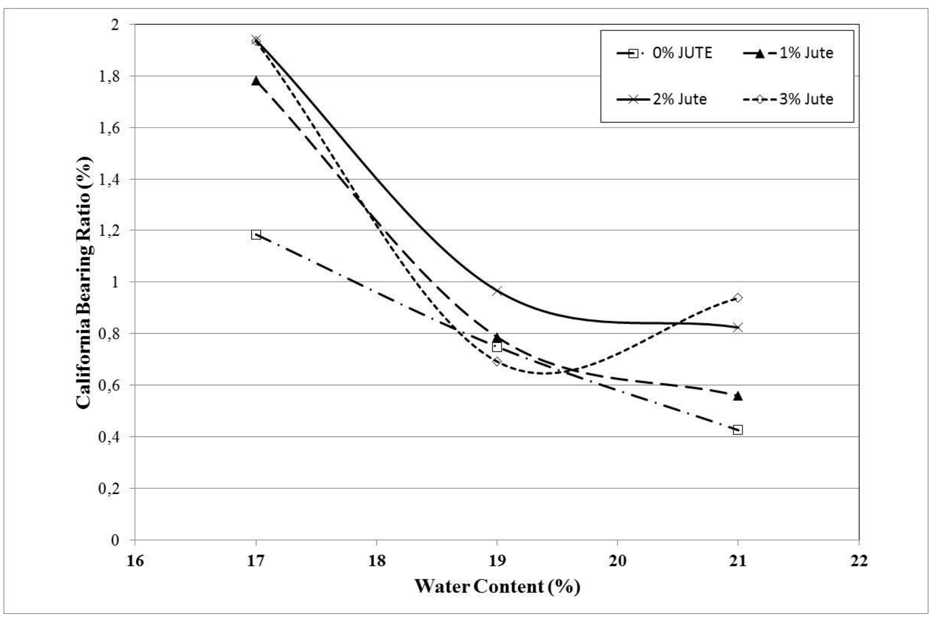

Figure 2. Water content-CBR behavior of the specimens.

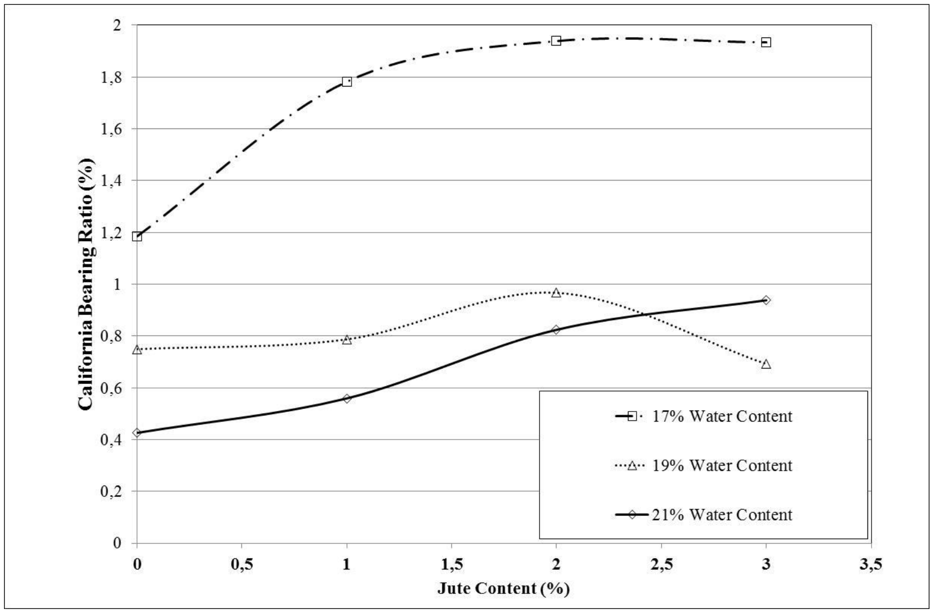

Figure 3. Jute content-CBR behavior of the specimens

CBR2.5mm = Corrected Stress at 2,5mm /70,31kg/cm^2 x 100% Eq. (1)
CBR5mm= Corrected Stress at 5mm/ 105,46kg/cm^2 x 100% Eq. (2)

According to test results shown in Figure 2, increasing water content in the JRS specimens resulted diminish in CBR values. These decreases were about 60 % for all specimens. This results are in agreement with the previous studies (Blotz et al., 1998; Horpibulsuk et al., 2009). Because the CBR values of the samples are controlled by densification of the soil (relative unit weight has effect on the CBR value). Figure 3 shows the effect of jute content of well-graded clayey sand mixed in different proportions of water content. According to results, increasing jute content caused increase in CBR values of the samples. The results obtained from the tests were also consistent with literature. It is known that adding fiber to soil increases bearing capacity of the ground (Sarbaz et al., 2013). This approach proves the results recorded.

Swelling Ratio (SR) Test

To obtain the swelling behavior of the JRS specimens, after 96 hours waiting in the water tank the specimens were removed from the tank. Then the new values of the dial gauges were recorded. Figure 4 shows the effect of waste jute content on swelling behaviors of well-graded clayey sand mixed in different proportions of water content. As it is seen in the Figure 4, increasing jute amount caused decrease in swelling ratio. This outcome is in agreement with other researches. Studies showed that soil improvement with fiber resulted decrease in swelling potential and swelling pressure (Mousavi et al., 2014; Malekzadeh et al., 2014).

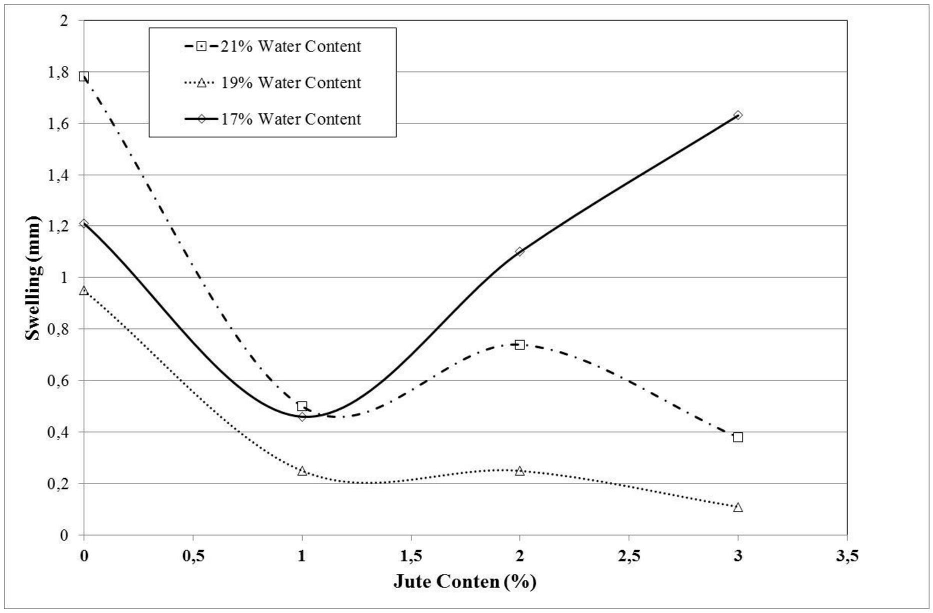

Figure 4. Jute content-Swelling behavior of the specimens.

Figure 5 shows the effect of water content of well-graded clayey sand mixed in different proportions of waste jute fiber. As it is concluded in the Figure 5, minimum swelling was observed at 19% water content which is OMC and at max jute content (3%). There are many factors that govern the expansion behavior of soil. The primary factors are a change in water content and the amount, type of clay size particles and additives in the soil (Fattah et al., 2010).

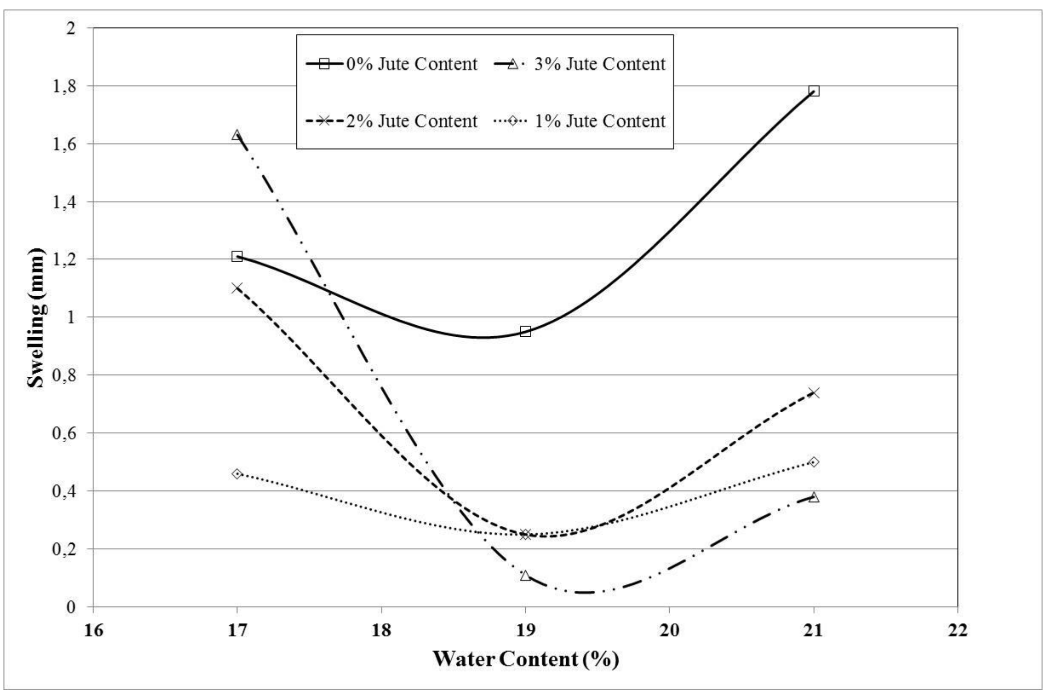

Figure 5. Water content-Swelling behavior of the specimens

Conclusions

Jute is widely used material in Gaziantep textile industry. Any jute that is not recycled is taking up valuable space and polluting environment. Limited studies have been done to reuse waste jute. However, it is important to make research about reusing that material effectively. This would provide economically and environmentally solutions.

Not only effect of waste jute content also water content effect on CBR value and swelling ratio had been researched in this study. Both waste jute content and moisture content had significant effect on CBR and SR properties.

Results from the studies revealed that increasing waste jute has positive effect on increasing CBR value. Peak CBR value has been observed at 17% moisture content, which is not OMC (19%) of SW-SC soil. The reason could be that adding jute in the soil decreased OMC from 19% to 16%.

Researches also revealed that minimum swelling has been observed at near 19% moisture content, which is OMC of SW-SC soil. But as mentioned above maximum CBR value was observed at 16% water content. Reason of observing minimum swelling ratio with 19% water could be that waste jute inside the compacted soil may absorb 2% of water then became more stable so that it resists more affective then the sample containing 17% water.

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