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Investigation of Shear Strength of Clay Soil – Geotextile by Adding the BCF Waste Fibers

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ABSTRACT: By placing the reinforcing elements, the shear strength of the soil improves. Several studies have been carried out on reinforcing of coarse grained soils, and less has been done on fine-grained soils. Researches show that the shear strength of fine grained soil-geosynthetics is weaker than the coarse soils and should be to improve soil interaction with reinforcing elements. In this research, soil with about 80% passing the No.200 sieve and two types of non-woven geotextiles have been used. Shear strength of soil was considered by adding BCF waste polypropylene fibers with 0.2%, 0.7% and 1.2% by weight of dry soil. Shear strength of soil–geotextile determined by large direct shear machine and several tests were done in vertical loading–reloading conditions. Experimental results showed that vertical loading– reloading conditions increase interface shear strength. Addition of 0.7% fibers increase interface shear strength up to 15% and 9% in usual loading and loading-reloading conditions, respectively. Also increasing of normal stress in loading step, application of geotextile with higher tensile strength and reduction of moisture content are the factors improving shear strength of soil-geotextile in this study.

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1.INTRODUCTION

Using different type of geosynthetics is one of the most useful methods for improving the shear strength of soil, in geotechnical engineering. The interaction between soil and geosynthetics is of the utmost importance in design of reinforced soil structures. The soil-geosynthetics interaction can be very complex because it is affected by various factors such as physical and mechanical properties of soil, structural, geometry, and mechanical characteristics of the geosynthetics, [1]. Many studies have been done on the effect of these factors on shear strength [2-4].

In the soil reinforcing studies, less attention has been paid to fine-grained soil. In clay soil, because of a weak interaction between soil and geosynthetics, it is necessary to investigation the possibility of improving the interface shear strength.

Studies show that using of fibers, increase the shear strength of soils [5-9]. In this research, by using large direct shear machine, the effect of BCF waste fibers on shear strength of clay-nonwoven geotextile have been investigated.

2.METHODOLOGY

Clay soil with about 80% passing the No.200 sieve, two types of non-woven geotextiles and BCF waste fiber are materials used in this research. Properties of soil, fiber and geotextile are presented in table 1-3.

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For preparing test samples, fiber adding to the moist soil and mix until homogeneous mixture is achieved. Samples are kept in closed bag for 24 hours to moisture is distributed well. Shear strength of soil–geotextile determined by large direct shear machine and some of these tests were done in vertical loading–reloading conditions. In this conditions, samples are loaded to 200 or 300 kPa for 24 hours and then reloaded to 100kPa. In loading-without reloading condition, normal stress was 50,100 and 150 kPa. Direct shear tests were conducted at a constant displacement rate of 1.5 mm/min. Maximum shear displacement in these tests is 30 mm. Fig 1 shows the schematic of geotextile placement in direct shear box.

3.RESULT AND DISCUSSION

Shear strength parameter of clay-geotextile1 in loading-without reloading conditions are presented in table.4. Results show the addition of fibers has increased clay-geotextile interface friction angle. According to Fig.2, addition of fibers also increased interface shear strength in loading-reloading condition. Also, increasing normal stress increases density and interface shear strength. In table.5 and table.6 the effect of moisture content of soil and tensile strength of geotextile have been investigated. It is observed that increase of tensile strength and decrease of moisture content increase interface shear strength. These results are in accordance with previous studies [2-3, 10].

Table 1. Properties of the soil

Test	Standard No	Value
Specific gravity of soil solids	ASTM D-854	2.63
Shrinkage limit (%)	ASTM D-427	12.4
Plastic limit (%) Liquid limit (%)	ASTM D-4318	15 34
Optimum water content (%) Maximum dry density (gr/cm3)	ASTM D-698	17 1.9

Table 2. Properties of BCF fibers

Property	Value	Unit
Density	0.91	(gr/cm^3)
Diameter	45	µm
Length	1-2	cm
Tensile strength	100	MPa

Table 3. Properties of two types of geotextile used

characteristics	Unit	Direction	Type1	Type2
Mass per unit area	g/m^2	-	250	400
Thickness	mm	-	3	4
Tensile strength	kN/m	Machine direction	16	26
Tensile strength	kN/m	Cross direction	13	26
Max tensile strength	%	Machine direction	55	55
Max tensile strength	%	Cross direction	50	50
Puncture resistance	kN/m	-	3	4.1
Trapezoid tearing strength	N	Machine direction	340	310
Trapezoid tearing strength	N	Cross direction	320	505

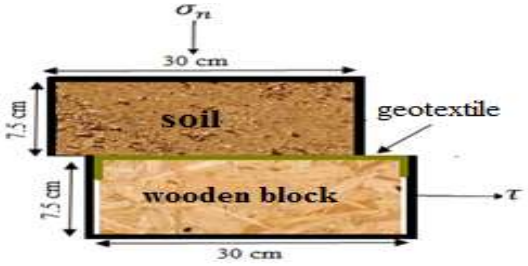

Fig 1. Schematic of wooden block and geotextile placement in direct shear box

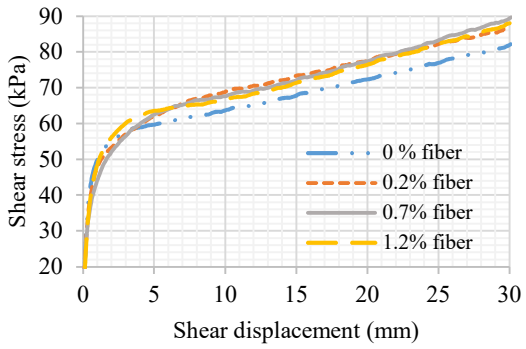

Fig 2. Effect of fibers on soil-geotextile type1 interaction (ω=17% and normal stress =200 kPa)

Table 4. Shear strength parameters of soil – geotextile type1

Fibers content	Cohesion (kPa)	Friction angle (degree)
0	14.68	22.83
0.2	8.6	26.54
0.7	13.06	26.28
1.2	5.85	27.25

Table 5. Shear strength of mixture of soil- fiber with different moisture content

Fiber percent	Shear strength (kPa)	Moisture %
0	82.17	16.53
0	78.57	18.48
0.2	86.79	16.25
0.2	79.2	20.27
0.7	89.68	16.81
0.7	86.24	17.41

Table 6. Effect of geotextile orientation on shear strength

Fiber content	Shear in machine direction	Shear in cross direction
0	88.26	82.17
0.2	90.53	86.79
0.7	92.19	89.68

4.CONCLUSION

Soil-geotextile interaction is one of the factors influencing the design of reinforced soil structures. Hence, effort to improve interaction is necessary. In this research, BCF waste fibers are used to improve the interaction of clay-geotextile.

All tests have been done by large direct shear machine and part of them have been in loading-reloading conditions. The results show the addition of fibers and application of loading-reloading conditions increase interface shear strength. The tensile strength of geotextile, normal stress and moisture are parameters studied in this research. Results show increasing of normal stress, application of geotextile with higher tensile strength and reduction of soil moisture increases clay-geotextile shear strength. Also, in loading-reloading conditions, dilation has been observed because of more density and better interlocking between soil particles and geotextile fibers.

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