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Experimental Study on the Effect of Crumb Rubber on Shear Strength of Sandy Soil

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Abstract

Nowadays, soil reinforcement using polymer elements have been investigated by a number of researchers in order to increase the load capacity of soils. Reinforcing soils using fibers is a method of soil improvement, which offers a homogenous mixture in combination with soils, regarding their tensile strength. This combination maintains pressure loading capacity and properties in mutual resistant tensile. The present research investigates the effect of crumb rubber bearing the size of $5^{mm} \times 5^{mm}$ and 10%, 25% and 40% volume on sandy soil behavior using large-scale direct shear test ($300^{mm} \times 300^{mm} \times 150^{mm}$) under the vertical stresses of 50, 100 and 150kPa. Results showed that the optimum volume percentage of crumb rubber for maximum shear strength is between 20% and 25%.

Keywords: Soil reinforcement, rubber, large-scale direct shear test, shear strength, vertical stress.

1. Introduction

Reinforced soil is composed of two different materials in which compressive and tensile stresses are tolerated by soil and reinforcing elements, respectively.

Soil reinforcing can be used as an effective and reliable method to stabilize soil layers, to increase bearing capacity and shear strength and also to decrease settlement in the surface beds, embankments and pavements.

It has been experimentally observed from the ancient times that roots of trees or plants play effective role in soil improvement [1].

In fact, reinforced soil is a type of composite building materials in which the elements bear tensile strength, acting as a reinforce element in soil [2-4].

From the beginning of the process for reinforced soil creation and development, a wide range of experimental efforts performed for replacing natural and even metal reinforce element using polymer reinforcement factors. In comparison with the other reinforcement factors, the soil reinforced with polymer fibers bear high ductility and tensile strength [5-7].

Gray and Ohashi (1982) performed a small scale direct shear test on dry sand reinforced with polymer fibers and found that addition of fibers result in increasing strength and ductility for this type of soil [8].

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Nowadays, soil reinforcement has been applied as an effective and economic way to increase strength and stability of soils [9-11]. The main objective of this paper is to examine the impact of crumb rubber on sandy soil shear strength. In order to perform main tests, we applied large-scale direct shear test ($300^{mm} \times 300^{mm} \times 150^{mm}$).

2. Used materials

2. 1. Soil

This study used sandy soil with classified silty sand (SM); its grading curve and features are summarized in Figure 1 and Table 1.

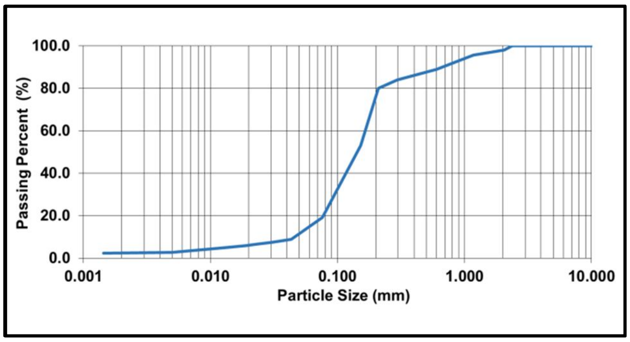

Figure 1: Grading Curve of the studied sandy soil

Table1: Physical and mechanical parameters studied sandy soil

Soil Type	Test Type	ASTM Standard	Value
SM	Optimal Moisture	ASTM D2216	8.34 %
	Special Density	ASTM D854	2.70
	Minimum dry density	ASTM D698-78	14.8 (kN/m^3)
	Maximum dry density	ASTM D698-78	16.9 (kN/m^3)

2. 2. Reinforcement Elements

The elements used in the reinforcement applied crumb rubber in the dimensions of $5^{mm} \times 5^{mm}$. Crumb rubber is provided from cut out old car rubbers with specific gravity of $G_s = 1.17$.

3. Research Methodology

The present research investigates the effect of crumb rubber bearing the size of $5^{mm} \times 5^{mm}$ on sandy soil behavior. In order to perform this, large-scale direct shear test ($300^{mm} \times 300^{mm} \times 150^{mm}$) on sandy soil reinforced with crumb rubber with 10%, 25% and 40% volume. It is to be noted that large-scale direct shear test performed under the vertical stresses of 50, 100 and 150kPa and with speed of 1 millimeter per minute.

4. Experimental studies on the effect of rubber crumb on shear strength of sand

Figures 2, 3 and 4 show the results of shear stress versus horizontal displacement of regular sand and rubber crumb reinforced sand with 10%, 25% and 40% volume under the vertical stresses of 50, 100 and 150kPa.

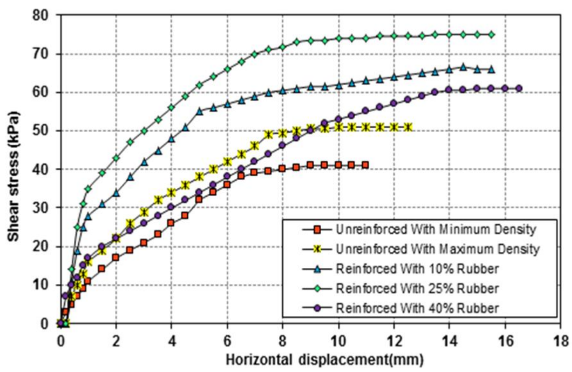

Figure 2: Horizontal displacement variations-shear stress of regular sand and reinforced sand under the vertical stress of 50kPa

As seen, application of crumb rubber increases the shear strength of reinforced sandy soil than the regular sand. The results indicate that under the vertical stress of 50kPa, the maximum shear strength at the rupture moment of crumb rubber reinforced sample with 10%, 25% and 40% volume under the vertical stress of 50kPa increases with the values of 29.41%, 43.14% and 19.6% than regular sand with maximum compression.

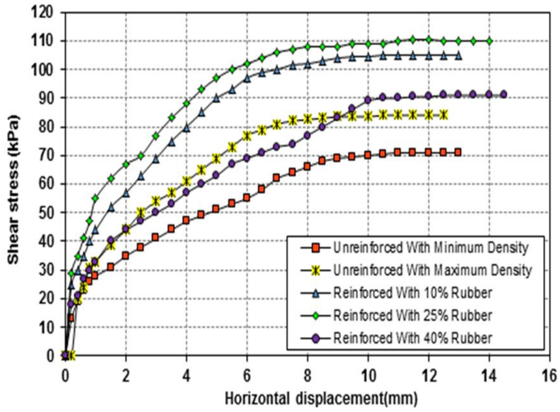

Figure 3: Horizontal displacement variations-shear stress of regular sand and reinforced sand under the vertical stress of 100kPa

The maximum shear strength at the rupture moment of crumb rubber reinforced sample with 10%, 25% and 40% volume, under the vertical stress of 100kPa, increases with the values of 22.61%, 31.73% and 9.63% than regular sand with maximum compression.

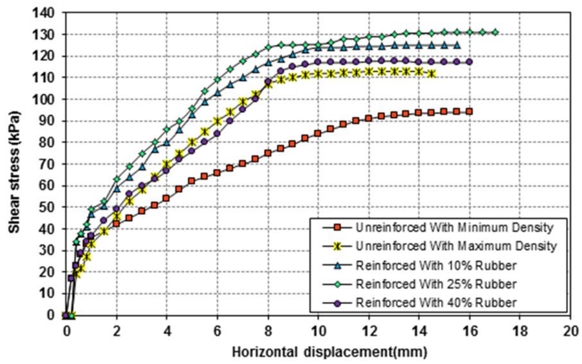

Figure 4: Horizontal displacement variations-shear stress of regular sand and reinforced sand under the vertical stress of 150kPa

The maximum shear strength at the rupture moment of crumb rubber reinforced sample with 10%, 25% and 40% volume, under the vertical stress of 150kPa, increases with the values of 11.61%, 16.96% and 4.5% than regular sand with maximum compression.

5. Determination of Optimum crumb rubber on the maximum shear strength of sand

Figure 5 shows maximum shear strength results versus different volume percentages. To find the optimum volume percentage of crumb rubber, the results were fitted with a quadratic function. As observed, the optimal volume percentage of crumb rubber for overhead of 50, 100 and 150kPa is approximately 20% to 25%.

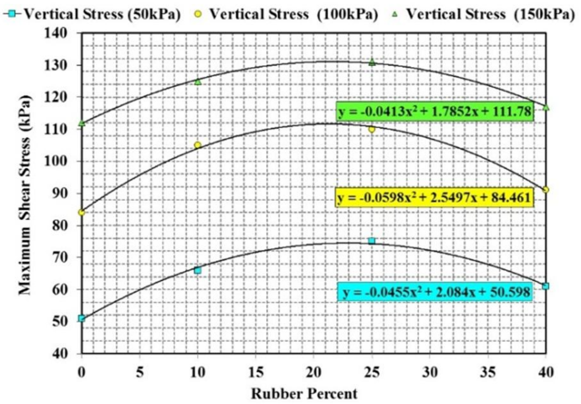

Figure 5: Graph of maximum shear strength of sand with different percentages of crumb rubber

6. Conclusion

1. Toward this research, shear strength of all samples of sand composites with different volume percentages of rubber significantly increased in comparison with dense and loose sands.

2. Addition of crumb rubber to sandy soil improved ductility of sample and reduced fragility feature and became softer. This mode increases rupture strain and reduces maximum elastic modulus.

3. Increasing crumb rubber from 10% to 25%, maximum shear strength of the sample increased and it decreases from 25 to 40 percent.

4. Maximum increase of shear strength of 43.14% relates to the terms that the sample is constructed using sand combined with 25% crumb rubber, placing the sample under vertical stress of 50kPa.

5. Toward this research, the process of increasing shear strength percentage decreases than pure sand for all composite sand samples with different percentages of crumb rubber with increase in vertical stress.

6. The optimum volume percentage of crumb rubber for increasing maximum shear strength is between 20 to 25 percent.

7. References

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