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Laboratory evaluation of the effect of polymer carpet waste on geotechnical properties of Bandar Anzali sandy soil

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Abstract

Reinforcement of soil with polymer waste materials is one of the new and practical methods for improvement and stabilization of soil. The purpose of soil reinforcement is to improve shear strength, increase ductility, increase stability, increase bearing capacity, increase the slope stability, safety factor and reduce the settlement. One of the common types of polymer waste used in soil reinforcement is waste from textile and carpet production factories. In this paper, the effect of reinforcing the soil with carpet waste by randomized distribution, has been studied. Laboratory study program includes the effect of parameters such as weight percentage (0.5, 1, 1.5 and 2% of soil dry weight) and the ratio of sides (1, 2 and 5) of carpet waste under overheads of 100, 200, and 400 kPa in dense conditions and the moisture obtained from a proctor standard compaction test is on the shear strength of the samples. The results of direct shear and standard compaction tests, reveal that the addition of carpet waste to sandy soil improves the shear strength parameters, reduces the maximum dry unit weight and increases the optimum moisture content. Thus, due to the recyclability of this type of material, their use in civil engineering and geotechnical projects is both economically viable and reduces the environmental problems caused by the accumulation of these wastes in nature.

***Keywords**: soil Reinforcement, Carpet waste, shear strength, soil compaction.*

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Extended Abstract:

1. Introduction

Soil reinforcement is one of the practical methods for improvement and resilience of land. Soil Reinforcement with Geotextile, a well-proven technology, is widely used for soil reinforcement and stabilization. On the other hand, in recent years, the use of waste materials to reinforce soils has been widely considered by researchers. Using of these waste materials, such as rubber waste , in addition to improving the engineering properties of soils due to the addition of recycled materials, can be used as filler materials in civil engineering. (Akbarimehr et al., 2020, Khosh et al., 2020). Researches has been conducted to investigate the effect of waste polyester and nanosilica composition, the results of which showed that the addition of the combination of these two materials has improved soil shear strength (Sarli et al., 2020; Changizi and Haddad, 2015). In addition, another waste material that is effective in improving the mechanical properties of soils is carpet waste, which is used both as a filler in the soil and to improve the shear strength parameters of the soil. A study evaluated the effect of carpet fibers on damping properties and shear modulus of silty sand that carpet fibers were randomly distributed in the soil and the results showed that in high percentages of carpet fibers the damping ratio is increased (Ghiassian et al., 2010). In another study, the effect of calcium nanocarbonate and carpet waste on clay was investigated. The results of its experiments show that the simultaneous use of calcium nanocarbonate and carpet waste fibers almost doubles the undrained cohesion and adding the recycled fibers of carpet to soil has increased the hardness of the tested samples (Janalizadeh Choobbasti et al., 2019). The purpose of this study is to evaluate the effect of carpet waste on sandy soil to investigate the compaction characteristics of the samples and also to investigate the shear strength parameters of the samples.

2. Materials and methods

The sand used in this research is prepared from Bandar Anzali city located in northern Iran and is poorly graded.

Also, the reinforcing element used in this research is carpet waste made of polypropylene synthetic fibers, which has been prepared by cutting and scissoring the excess strips of carpet waste.

Then, in order to evaluate the effect of carpet waste on the studied sandy soil to determine the compaction characteristics as well as the shear strength parameters of the samples, the standard compaction test according to ASTM D-698 and the large scale direct shear test according to ASTM D-3080 standard are used, respectively,

Also, laboratory tests with different percentages of carpet waste (0, 0.5, 1, 1.5 and 2% of dry soil weight) were performed in 3 different ratio of sides (1, 2 and 5). In direct shear test, each test was performed under three overheads of 100, 200 and 400 kPa to check the shear strength parameters.

3. Result

In this study, after performing standard compaction test, direct shear test was performed on the samples and the results of these tests are given in Table (1). As the results show, the addition of carpet waste to the sandy soil has improved the shear strength of the samples and also a specific optimum point or peak has been obtained by adding 1% by weight and a ratio of 5 sides for the samples in this study.

In the compression profile section, it can be seen that the addition of carpet waste has reduced the maximum unit weight and increased the optimum moisture in the samples.

Table 1. Effect of carpet waste on compaction characteristics and soil shear strength parameters (S:Sand, CW:Carpet Waste)

NO	Name of specimens	L/B	Carpet Waste (%)	Direct Shear Test		Standard Proctor Test	
				Φ (Degree)	C (kPa)	γ_d (kN/m^3)	ω (%)
1	S0%CW	0	0	37.7	1.42	1.53	10.6
2	S0.5%CW	1	0.5	38.5	4.5	1.52	16.9
3	S1%CW	1	1	39	4.8	1.52	17.3
4	S1.5%CW	1	1.5	37	9	1.51	18.2
5	S2%CW	1	2	36.4	9.6	1.5	19.2
6	S0.5%CW	2	0.5	39.3	4.7	1.51	17.5
7	S1%CW	2	1	40.1	5	1.5	18.6
8	S1.5%CW	2	1.5	37.9	8.8	1.49	19.5
9	S2%CW	2	2	36.5	10	1.48	20
10	S0.5%CW	5	0.5	39	2	1.51	17.9
11	S1%CW	5	1	40.3	5.5	1.49	19.3
12	S1.5%CW	5	1.5	38	9.5	1.48	20.2
13	S2%CW	5	2	36.7	11	1.47	20.9

4. Conclusion

Due to the appropriate effect of recycled materials on soil geotechnical characteristics, reinforcement with this type of material can be considered as practical and executive method in civil engineering projects. Also, the results of this research have been extracted and expressed as follows:

-In exchange for adding different amounts of carpet waste in different side ratios, the maximum amount of soil unit weight decreased, with the largest decrease due to the addition of 2% by weight of carpet waste at 5 side ratio, which is about 4% of natural sand. The reason for this can be found in the low specific gravity of the reinforcement compared to natural sand, which due to the replacement in soil particles, causes lightening of the samples.

- By adding the amount of carpet waste in the different ratio of sides, the optimal moisture content of the sample has increased. More reinforcing water causes more water to be retained and absorbed in the samples, thus increasing the optimum moisture content.

- Addition of carpet waste with different side ratios in overheads of 100, 200 and 400 kPa increased the maximum shear stress and the highest increase occurred in the ratio of 5 sides by adding 1% by weight of carpet waste in all overheads, which is increased about 19, 14 and 10 percent compared to natural sand, respectively. It is also observed that at lower overhead, it had a higher growth rate.

It is noteworthy that the shear stresses created in the sample are due to the mobilization of tensile strength of carpet waste and have increased the shear strength in the samples.

- The tensile force mobilized in the reinforcement practically has two vertical and tangential forces on the surface. The vertical component on the surface increases the normal stress and consequently increases the friction between the grains on the cutting surface. The internal friction angle increases with addition of up to 1% reinforcement, then deacreses which is followed by the largest increase compared to natural sand in the ratio of the sides of the 5 carpet scraps , that is about 7%.

- In all the proportions of the studied ratio of sides, the maximum shear stress and the internal friction angle increase up to 1% by weight of the reinforcement, and after that, the trend is decreasing, in

other words, an optimal point can be obtained for all samples or A specific peak in the ratio of 5 sides and the addition of reinforcement up to 1% by weight to the sand used in this study was considered.
- The amount of cohesion of reinforced samples in all proportions of carpet waste was always upward and the greatest increase in the ratio of sides 5 by adding 2% by weight of carpet waste to the soil sample and haas increased about 8 times compared to natural sand.

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