Experimental study of the effect of polyethylene fibers with random distribution on the engineering behavior of the mixture of flimsy sand with clay soils

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Abstract: In this research, the shear resistance parameters of mixture of reinforced sand-kaolinite were determined with random distribution of polyethylene fibers (PEF). All samples were compressed to a certain density and then the direct shear test was done. The dimensions of direct shear set were 10×10×2 cm. Different materials such as sand, Kaolinite and polyethylene were used in the experiments. In these experiments, moisture content, amount of polyethylene (PEF), fiber size and speed of shear stress were variable. Test results show that by increasing fiber ratio the shear resistance parameters of sand-kaolinite mixture increase. Also, in reinforced mixture of sand-kaolinite the shear resistance increases by increasing the speed of shear stress.
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Key words: Sand-Kaolinite, Reinforced soil, Fibers, Direct shear test, shear stress speed

1. Introduction

Natural soil in the project site is not always suitable to use and may cause significant settlements due to loading on poor soil. To prevent these settlements or other poor mechanical properties, specific techniques should be used to improve these properties. To increase the soil resistance, designers always use mechanical processes such as compression, drainage by sand wells and consolidation and chemical processes such as reform and stabilization by the use of reinforcing elements (Nataraja and McManis, 1997). So far, different elements such as fiber glass, zinc coating steels and polymers such as geo-textiles, the geo-grades and fibers cut from polyethylene, polyester, and polypropylene has been used to reinforce the soil (Almansa and Cánovas, 1999). Gary and Ohashi (1983) have provided a model for the soil and fibers behavior in the shear zone. They determined the amount of fiber needed for optimal conditions of shear resistance by testing a large number of sand samples reinforced with plastic and fiber plant and a copper wire in direct shear set and analyzing the results. Nataraja and McManis (1997) carried out experiments on compression, direct shear, single-axis and CBR to investigate the behavior of (steel-fibre) reinforced clay and sand by synthetic fibers, and reported an increase in shear resistance, single-axis compressive resistance and particularly an increase in the CBR. The increase in impact resistance for steel-fibre reinforced concrete has been studied in several experiments, e.g. by Nataraja *et al.* (2005), Luo *et al.* (2000), Almansa and Cánovas (1999).

In the investigation done by Naeini and Sadjadi (2008), the waste polymer materials has been chosen as the reinforcement material and it was randomly included in to the clayey soils with different plasticity indexes at five different percentages of fiber content (0%, 1%, 2%, 3%, 4%) by weight of raw soil. CBR tests are conducted by Kalantari *et al.* (2010) and their experimental findings are analyzed with the point of view of use of waste plastic fibers in soil reinforcement. Effects of Random Fiber Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and Desiccation Cracking of Clays (Abdi et al., 2008) point to the strength and settlement characteristics of the reinforced soil and compared with un-reinforced condition.

Using polymer waste in the soil reinforcement reduces these waste materials and prevents environmental degradation, which is considered as one of today's industrial problems. Therefore, in this study the waste of mineral water bottles were used. Investigating Topic History has shown that till now studies were with constant shear stress speed, but the effects of earthquake on soil has always been of importance thus in this research, the effect of increasing shear stress speed has been analyzed.

2. Material and Methods

Soil and fiber characteristics: In this study, the polyethylene fiber taken from half-liter bottles of mineral water has been used to reinforce the soil. The used soil is a mixture of loose sand and kaolinite. Characteristics of sand and kaolinite are shown in Tables 1 and 2, and figure 1 demonstrates the aggregation curve of sand.

Table 1. Characteristics of tested sand

Special weight of sand in the loose state (g/cm)	1.39
Interior friction angle of sand in the loose state (degree)	30
Density (g/cm)	2.55

Table 2. Characteristics of tested Kaolinite classification

Classification(USCS)	Plastic Index (%)	Liquid Limit (%)	Plastic Limit (%)
CH	37	58	23

3. Results and Discussion

Proctor standard density test and the results: These experiments on different mixing ratio of sand with kaolinite performed and the results represented in Table 3 shows that engineering mixture of 25 percent kaolinite and 75 percent sand, has the optimal mode.

Table 3. Density Test Results

	Amount of Kaolinite (%)	Amount of Sand (%)	Optimum moisture percentage	Maximum special dry weight (kN/m3)
1	10	90	14.5	16.60
2	17	83	13	17.15
3	25	75	12.5	18.20
4	33	67	12.5	18.20

Direct shear test: This test used 10×10×2 cm mold on reinforced soil with three different weight percentage one, two and three and dimensions 16 × 4 and 12 × 4 mm

Direct shear test results: In this section results obtained from direct shear tests are offered.

Table 4. Direct shear test results of four different ratios of sand with kaolinite.

	Amount of Kaolinite (%)	Amount of sand (%)	Shear resistance (kPa) with 28 (kPa)vertical stress
1	10	90	21.72
2	17	83	23.30
3	25	75	31.78
4	33	67	29.56

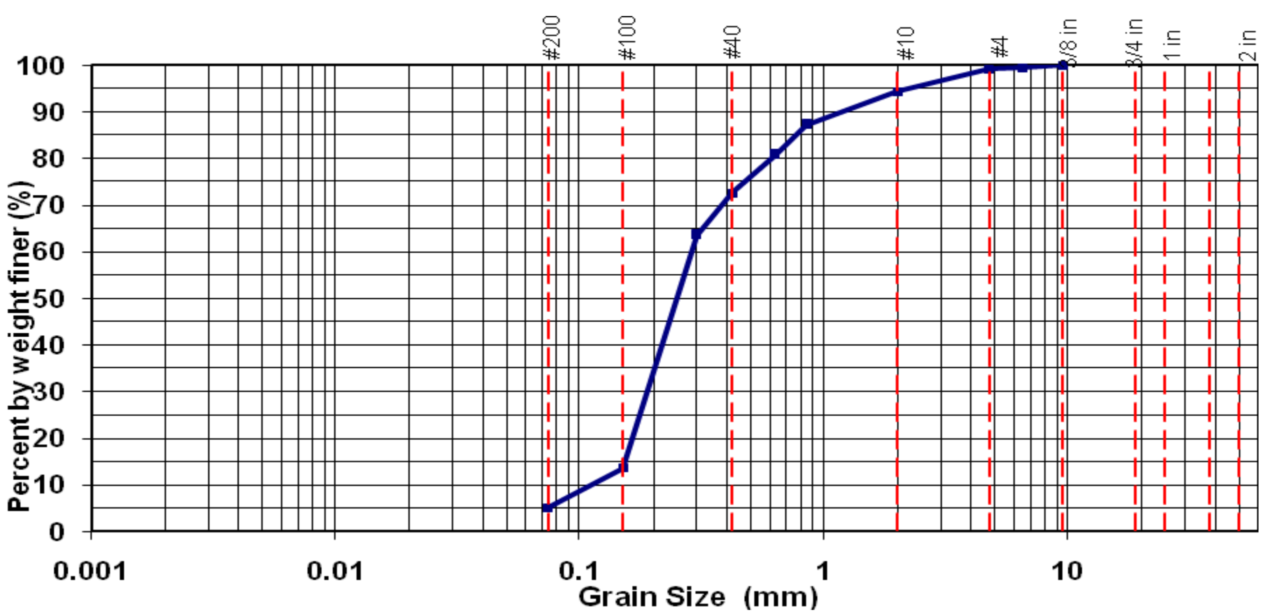

Figure 1. Sand aggregation curve

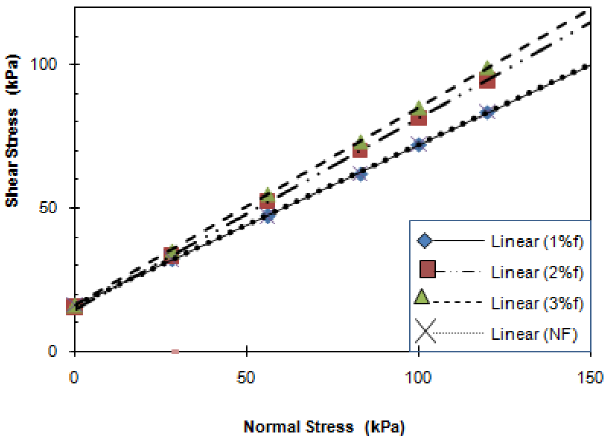

Figure 2. Changes in shear stress on the vertical stress on mixture 4 × 16F-K25-S75 with different weight percentages than optimum moisture content (NF = No Fiber)

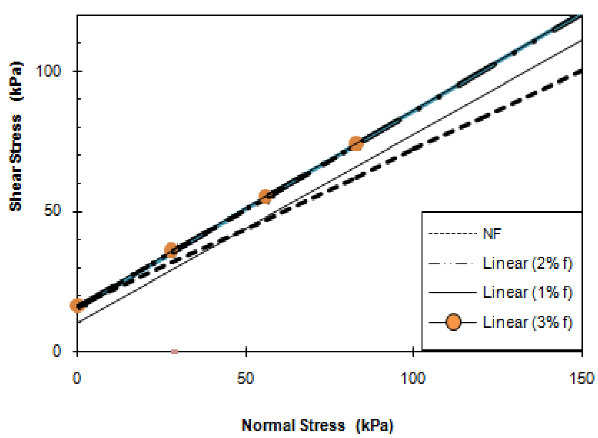

Figure 3- Changes in shear stress on the vertical stress on mixture 4 × 12F-K25-S75 with different weight percentages than optimum moisture content (NF = No Fiber)

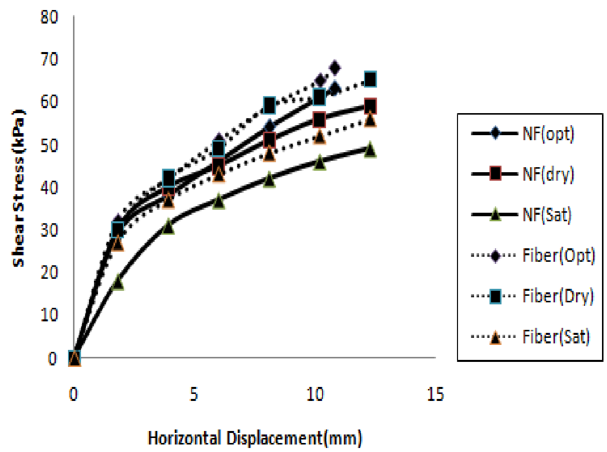

Figure 5. Comparison chart of changes in horizontal displacement against shear stress on the fiber reinforced soil mixture 12 × 4 and naked in different scenarios optimum moisture content, dry and saturated

4. CONCLUSION

1 - The Table 4 indicated that in state 1 than 3 highest resistances to shear has been made.

2 - In accordance with the second image fibers 16 × 4 are observed with increasing fiber, shear resistance value of the number kPa62 mode fiber free reaches the 73 kPa with 3 percent of the fibers and shows 17 percent increase.

3 - according to the image 3 with fibers 12 × 4 it is observed affected by different stress, vertical Shear stress level 83 kPa reaches the number 74 kPa and it shows 15 percent increase compared to the case without the fiber with the same vertical stress.

4 - As seen in Picture 4 the highest shear resistance is in a state of optimum moisture content and the least resistance has been made in saturated state

Table 5. Results in terms of changes in shear stress on the horizontal displacement mixing 4 × 12F2-K25-S757 optimum moisture content in a state with a loading speed 1, 2 and 3 mm/min

	Shear stress speed (mm/min)					
	1 mm/min		**2mm/min**		**3 mm/min**	
Vertical stress (kPa)	**Horizontal displacement (mm)**	**Shear stress (kPa)**	**Horizontal displacement (mm)**	**Shear stress (kPa)**	**Horizontal displacement (mm)**	**Shear stress (kPa)**
28	10.2	35.8	10.2	37.3	11.7	38.6
56	13.2	55.13	13.2	55.13	12.9	56.2
83	14.1	71.2	13.8	72.2	14.1	72.76

5 - As seen in Picture 5 the highest shear strength with a maximum shift in the shear mode has been made in the optimum moisture content and the least resistance is in saturated state.

6 - In accordance with image 5 broken loose soils cannot be seen, but with increasing horizontal force (shear) the amount of shear stress increases to its optimal value to achieve rupture shear stress, and after reaching the maximum, whatever the shear force increased no horizontal shift is observed and the numbers remain constant maximum numbers.

7 - Results of Table 5 show the amount of shear resistance with increasing shear stress velocity shows a 10 percent increase.

8 - Generally, mixing soil and fibers with constant shear stress speed, increase friction angle and reduce adhesion.

9 - Shear resistance of soil reinforced depends on the dimensions, fibers weight percentage and vertical stress.

10- Dimensions and weight percentage of reinforces will vary in accordance with different profiles of soil.

11 - With increase in shear stress velocity, horizontal displacement in the soil sample will happen less, so samples will be broken with further stress, and shear resistance will increase.

12 - Generally, mixture saturation decreases the shear resistance.

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