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Evaluation of Shear Strength Behaviour of Anzali Port Sand Reinforced with Polyethylene terephthalate (PET)

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ABSTRACT: Due to the increasing production of plastic materials, there is an international concern about disposal or recycling of plastic waste in the world. One of the ways to reuse plastic waste is to use it in the engineering works to modify mechanical properties of loose soils. The purpose of this research is to find a way to reuse a particular kind of plastics (bottles of dough, soft drinks, mineral water, etc.) in geotechnical works to improve soil.

In this paper, the mechanical behavior of Anzali Port sand, reinforced with 1×1 cm polyethylene terephthalate crumbs and 1×5cm strips, to 0, 0.1 , 0.5 , 1 and 2% and polyethylene terephthalate fibers to 0 and 0.1 and 0.5% of the dry weight of the soil which were arranged separately, was evaluated. Samples were prepared at the relative density of 75%. The effects of parameters such as dimensions, the weight percentage of reinforcers in the soil and vertical stress were investigated. The results of the experiments showed that although the polyethylene terephthalate crumbs and strips improve the mechanical behavior of sandy soil, but the effect of fiber reinforcers on soil mechanical properties has been much higher. Also, the optimum percentage of polyethylene terephthalate crumbs and strips reinforcers was 1% of sand dry weight. The comparison between reinforced and unreinforced samples showed that reinforced specimens had more ductility and resistance.

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1. INTRODUCTION

The effects of different types of fibers on soil properties have been studied in the past decades. Environmental and economic issues have attracted the interest of many researchers to develop alternative materials that can fulfil design specifications.

Experimental researches (e.g. Khattak & Andersland. 1979[1]; Ohashi. 1983[2]; Maher & Ho. 1994[3]; Wang & Youjiang. 1999[4]; Tan & Park. 2005[5]; Tang. 2007[6]; Akbulut. 2007[7]; Consoli et al. 2009[8]) have shown that compressive strength, failure strain, ductility & shear strength of samples are increased when discrete fibers are mixed with the soil. Several investigations have been conducted specially on the influence of plastic fiber inclusion on the mechanical behavior of different soils. Maher and Ho (1993) performed static and cyclic

triaxial compression and splitting tension tests to study the mechanical behaviour of artificially cemented sand reinforced with randomly distributed fibers. They concluded that the introduction of fibers considerably increases the compressive, splitting tensile and also cyclic strength of cemented sand[3]. Consoli et al. (2002) evaluated the effect of randomly distributed PET fiber alone or combined with Portland cement on the engineering behaviour of uniform fine sand using unconfined compression tests, splitting tensile tests and saturated drained triaxial compression tests. They reported that PET fiber enhanced the peak and ultimate strength of both cemented and uncemented soil and decreased the brittleness of the cemented sand[9]. Babu and Chouksey (2011), investigated the stress-strain response of plastic waste-soil composite, with fibre inclusion percentage ranging from 0% - 1.0%. In this research, red soil and sand having particles ranging from 425μm to 75μm were mixed together with plastic fibres of length 12mm, and width of 4mm. Furthermore, unconfined compression, consolidated undrained, triaxial compression tests, and one dimensional compression test were performed on the fibre-soil composite to determine their stress-strain responses. It was concluded that in the unconfined compression test results, there was a 73.8% increase in unconfined strength for 1% plastic waste mixed with soil compared to unreinforced soil[10]. Botero et al. (2015) studied the mechanical behavior of a silty soil that was reinforced with aleatorily distributed PET fibers. To meet this objective, UU triaxial laboratory tests were performed on soil specimens with fiber contents of 0.0 to 1.0% of the soil dry weight. The test results indicated that the reinforced specimens presented an increment of shear strength that was

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associated with the increasing quantities of the PET fiber. Furthermore, the laboratory tests indicated that the reinforced soil had a greater deformation capacity, which can be a positive characteristic in some cases because the deformation capacity can reduce the risk of crack formation in certain soil layers for specific geotechnical problems[11].

2. In this study, the effect of size and weight content(%) of PET on the shear strength parameters and ductility of Anzali sand has been investigated.

2- METHODOLOGY

Sandy soil was provided from the shores of the Caspian Sea (in Anzali city located in northern Iran, Guilan province). The basic properties of the soil are presented in Table 1.

In order to simulate the effect of size and weight content(%) of PET on the shear strength parameters of soil, 3 different sizes of PET (chips, strips and fibers) were used with different range of contents(0,0.1,0.5,1 and 2% of the dry weight of the soil), and direct shear tests were performed on soil samples under normal pressures of 50, 100 and 150 kPa. Furthermore, the effect of size and content of reinforcers were evaluated on the rate of shear strengths. In this study direct shear tests were performed according to ASTM D3080 standard.

3- DISCUSSION AND RESULTS

Firstly, the direct shear tests were conducted on soil samples without reinforcers. Results showed that maximum shear strength, normalized shear displacement at failure, friction angle and cohesion for unreinforced sand under the pressure of 150 kPa were 120 kPa, 2.5%, 32 degree and 15 kPa respectively.

Moreover, direct shear tests were conducted on reinforced samples and all the results are shown in Figures 1, 2 and 3.

As fig.1 shows, by increasing reinforcers up to 1% for chips and strips and 0.5% for fibers, the maximum shear strength and also normalized shear displacement increased. In addition fibers played the best rule in increasing shear strength and normalized shear displacement of samples.

The direct shear tests results on shear strength parameters for unreinforced and reinforced samples with different percentages and sizes of PET are shown in Figures 2 and 3. The results demonstrated that by increasing PET chips and strips up to 1% and fibers up to 0.5% internal friction angle and cohesion increased . On the other side, the effect of fibers on improving shear strength parameters of samples was the most.

Finally the bearing capacity was calculated for all samples. Calculations showed that adding 0.5% of fibers to the soil resulted in the most improvement in bearing capacity by 191%.

Table 1. Geotechnical properties of soil sample

USCS	Gs	e_{min}	e_{max}	$(\gamma d)_{min}$ gr/cm3	$(\gamma d)_{max}$ gr/cm3	D50, mm	Cu	Cc
SP	2.65	0.65	1.12	1.25	1.6	0.17	1.25	1.07

4- CONCLUSIONS

5. 1) Direct shear test results demonstrated that by increasing reinforcers up to 1% for chips and strips and 0.5% for fibers, the maximum shear strength and also normalized shear displacement increased

6. 2) By increasing PET chips and strips content up to 1% and fibers up to 0.5% internal friction angle increased.

7. 3) By increasing PET chips and strips content up to 2% and fibers up to 0.5% cohesion increased.

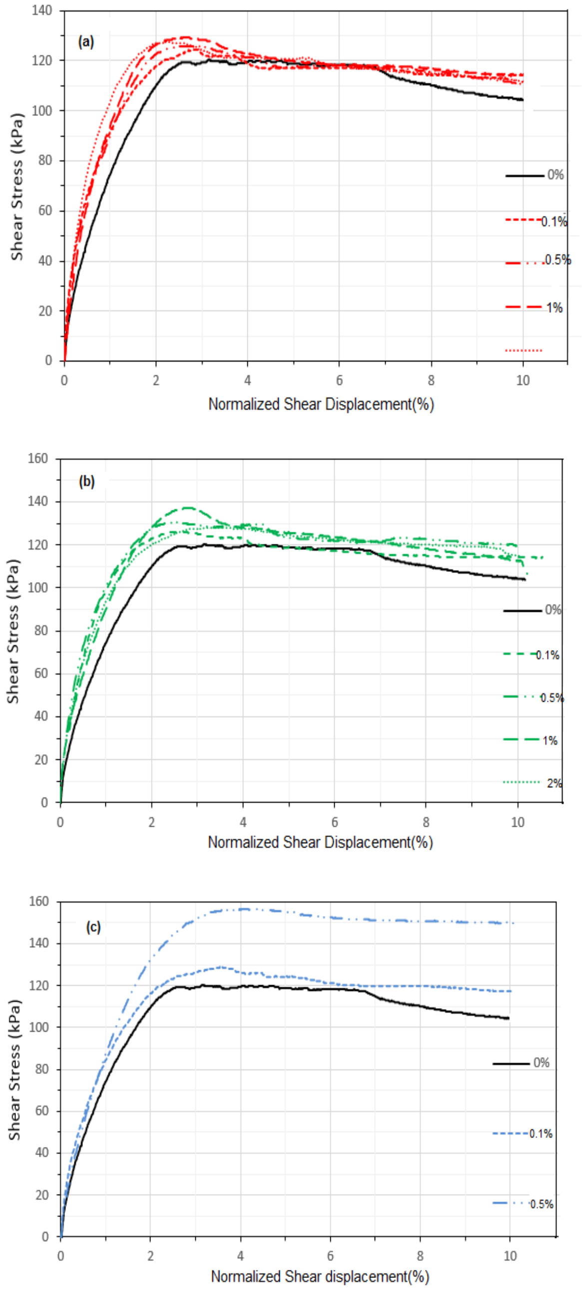

Fig. 1. Variation of shear stress with normalized shear displacement for unreinforced and (a) chips-reinforced (b) strips-reinforced (c) fiber reinforced sand at NP=150 kPa

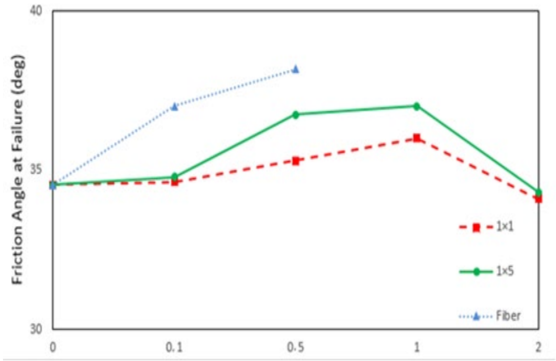

Fig. 2. Variation of friction angle with PET content

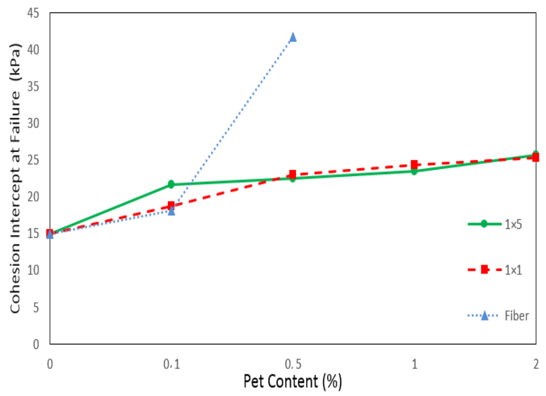

Fig. 3. Variation of cohesion intercept with PET content

8. 4) Calculations showed that adding 0.5% of fibers to the soil resulted in the most improvement in bearing capacity by 191%.

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