IOP Conf. Series: Materials Science and Engineering **758** (2020) 012075 doi:10.1088/1757-899X/758/1/012075

Improved mechanical properties of a high plasticity clay soil by adding recycled PET

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Abstract. To the problems posed by clay soils of high plasticity, such as vulnerability to variations in volume, producing differential settlements causing damage to structures, it is due to factors such as this it was decided to seek an alternative enhancement to parameters such as increased resistance, friction angle and cohesion of a high plasticity clay soil (CH). In the execution of civil works, these parameters generally do not conform to the requirements of the project, for that reason should seek a solution for the stability of the soil involved in any construction. The constant search for improving environmental conditions has led to the use of waste plastic to reinforce the soil and improve its mechanical and physical properties. That is why according to our proposal we try to increase data for the use of this alternative material as a soil improvement proposal, obtaining interesting and different results to that found in other investigations that used similar materials. We chose crushing polyethylene terephthalate (PET) obtaining a recycled PET 3-5 mm length as a reinforcing material to stabilize and improve the mechanical properties of the soil. According to standard proctor assays and direct shear, it was determined that the optimum percentage to be added is from 1% to study the soil because of better behaviors were observed study material with respect to the other mixtures.

1.Introduction

Techniques soil improvement introduced by geotechnical engineering have been developed to continuous with the passage of time, one of these inputs to soil improvement with the addition of natural fibers (twigs, grass, leaves). According to studies a major problem worldwide is the production of plastic materials such production of non-biodegradable has been increasing and thus waste the same as polyethylene terephthalate (PET). This residue, in the world of engineering, is commonly used in the manufacture of geosynthetic materials for which is multes, filtered and extruded into fibers polyester smooth appearance, good tensile strength and low absorption capacity water, with which geotextiles type and reinforcing geogrids are made. On the other hand, with the addition of this residue seeks to mitigate the environmental impact, so it is expected that the use of the same is an option as soil improvement technique to ensure stability and useful life of the structures.
S Peddaiah [1] This paper presents a detailed study on the behavior and the use of plastic waste in improving the soil, experimental research on the ground, results reinforced plastic showed that plastic can be used as an effective stabilizer in order to find a problem of waste disposal, as well as an economical solution for stabilization of weak soils. M Mirzababaei [2] on the basis of the experiments carried out in this study, the optimal fiber to be added to increase the shear resistance of the clay soil with an initial vacuum ratio of e0 = 0.64 was found to be 0, 25% with 140%, 81% and 23% increase in the ratio of the tension on the ground without problems in the normal effective tensions of 50, 100 and 200 kPa, For all soil samples tested in this study, it found that the stress ratio at 200 kPa of normal effective stress is in the ranges of 0.45 and 0.60. Thus J Hoseein [3]It aimed to analyze the use of plastic materials waste for reinforcing clay soils, which is why to investigate the compressibility and behavior

to the undrained shear clay soil mixed with plastic waste mixed study material with various amounts of plastic waste (0, 0.5, 1.0, 1.5 and 3.0% by dry weight). According to the results, the waste plastics do not affect the characteristics of clayey soil compaction considerably. Addition of waste plastics exceeding a specific value (1.0% in this investigation) changes the behavior of undrained samples from dilatative contraction. Also, B Mishra [4] was based on the effect of soil properties to performing the addition of polyethylene terephthalate (PET) in combination with fly ash applied to a base of flexible pavement, it is why the properties studied were the resistance to the cutting module cutting using clayey soil. The proportions ranging from 0% to1.6% by weight of the earth with an increase of 0.4% from PET fibers while 0% to 20% by weight of the soil with a 5% increase in if fly ash. The optimum amount to be found, recycled fibers 1.2% with 15% fly ash by weight of the floor, which showed improved strength parameters of the sub-base soil. Finally, Zukri [5] discloses that many countries are concerned about the problems caused by polyethylene terephthalate (PET) and polypropylene (PP), this economic and population growth development is due. For this reason the authors presented results of an investigation into the use of fiber products such as PET bottles and PP products in order to improve the engineering properties of clay soil Pekan. Finally concluded that the fibers of PET and PP can be used successfully as reinforcing materials for stabilizing clay soils, the use of these compounds waste as alternative materials for stabilizing clay soils is reasonable and cost effective because it they are constantly available.

2. MATERIALS

2.1 High plasticity clay soil (CH)

A clay soil high plasticity which has the physical characteristics required for continued research was obtained.

2.2 PET crushed

Furthermore, the PET factory Gexim SAC, which was ground to have dimensions between 3 -5 mm was obtained.

3. EXPERIMENTAL PROCEDURE

3.1 Elaboration of soil mixtures

For this investigation five mixtures were made, which is presented in Table 1:

Table 1. Names and mixtures nomenclatures

Name	Nomenclature
Natural soil	S100 + 0% PET
Natural soil + 0.5% PET	S100 + 0.5% PET
Natural soil + 1.0% PET	S100 + 1.0% PET
Natural soil+ 2.5% PET	S100 + 2.5% PET
Natural soil+ 3.5% PET	S100 + 3.5% PET

3.2 Physical characterization

3.2.1 Grain size by sedimentation

Because our soil is very fine sought to make a distribution of particle size distribution by testing by hydrometer.

3.2.2 Atterberg limits

To determine if the soil with which you are working is a high plasticity clay chose to find the LL, LP and IP.

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3.2.3 *Specific gravity (Gs)*

This test is responsible for determining the specific gravity of the solids in a soil sample the particles are less than 4.75mm.

3.3 Mechanical characterization

3.3.1 Standard Proctor

Assay Proctor standard for the 5 mixtures because it seeks to make a computer data about the material, which is why the compaction test is not performed by testing modified Proctor, which is done trials have performed high demand loads.

3.3.2 Direct Shear

The direct shear test was performed for the five mixtures, in order to determine their friction and cohesion parameters of the above.

4 Results and Analysis

4.1 Granulometry

In Figure 1 the granulometric curve shown hidrometer, obtaining the percentages of materials found 200 mesh before and after it. The results were the following:

Table 2. Percentage composition of materials in the sample.

RESULTS	
Gravels (%)	0.00
Arenas (%)	13.52
Silts (%)	42.50
Clays and Colloids (%)	43.98

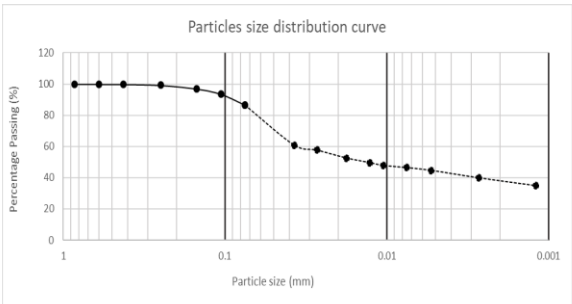

Figure 1. Particles size distribution curve

4.2 Atterberg limits

Table 3. Summary of Atterberg limits

Atterberg limits	Percent
Liquid limit	57.52
Plastic limit	18.41
Plasticity index	39.11

Note: the liquid, plastic and plasticity index of the study material was determined limit.

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After obtaining the values obtained, we proceeded to enter the plasticity chart the liquid limit and plasticity index. Thus determining that it is a high plasticity clay (CH).

4.3 Rating Gs

Of assay specific gravity was obtained as result a value of 2.71, thus being this value is compared with a table of average values according to ASTMD 854 standard being verified for the second time is a clay of high plasticity as study material.

4.4 Standard Proctor Test

Table 4. Results Standard Proctor Test

Nomenclature	Max. Dry Density (g / cm3)	Optimal cont. hum. (%)
S100 + 0% PET	1,618	20.25
S100 + 0.5% PET	1,612	21.70
S100 + 1.0% PET	1,606	22.23
S100 + 2.5% PET	1,495	26.00
S100 + 3.5% PET	1,477	26.75

Note: We determined the maximum dry density and moisture content for each optimal mixture.

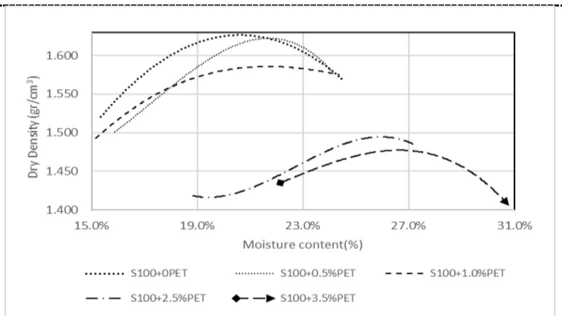

Figure 2. Compaction curves

A progressive decrease is evidence of the maximum dry density of the samples with additions of PET, this occurs because the moisture content increase as the percentage of PET reinforcement are added to the soil samples. This occurs because the particles of the material, which are waterproof, do not allow the passage of water is so retained. Also, the addition of progressively higher percentage of reinforcement there is a separation of the particles of the ground which causes the decrease maximum density of the samples dry.

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4.5 Direct shear test

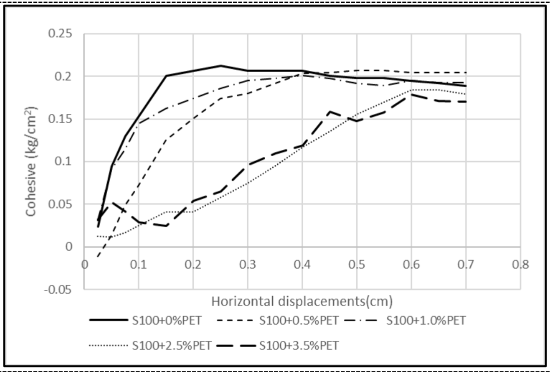

Figure 3. Cohesive Parameters

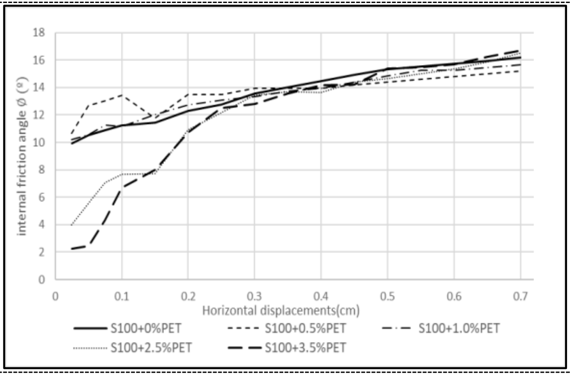

Figure 4. Parameters friction angle

It is observed in Figure 3 that for the S100 + 0% PET the cohesive is increasing at least to 0.25 cm horizontal displacement and then reduced to 0.18885 and seek constant trend C. To S100 + 0.5%PET a progressive increase is observed of the cohesive which gives signs of great improvement of the study material added to the PET, surpassing the cohesion of the S100 + 0%PET residual stress. Finally, the S100 + 3.5% PET is observed discontinuities in the graph and verifying that the particles of the mixture have failed the cohesive than the S100 + 0% PET, can say that it is not an optimal mix.

Also in Figure 4 to S100 + 0%PET, the angle of internal friction for displacing 0.25 cm is 12.73º indicating that this value is increasing until 16.18º angle is achieved through displacement of 0.80 cm. Furthermore, for other mixtures is noted that the graph does not change much because all friction angles have similar values in shift of 0.70 cm, just variations observed at the start of the assay these being smaller in the mixtures S100 + 2.5% PET and S100 + 3.5%PET.

4.6 Volumetric analysis

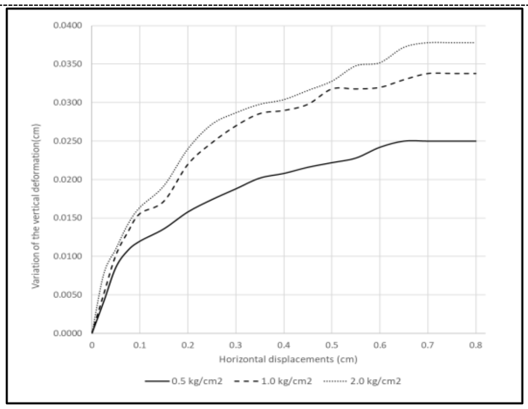

Figure 5. Volumetric analysis of the S100 + 0% PET

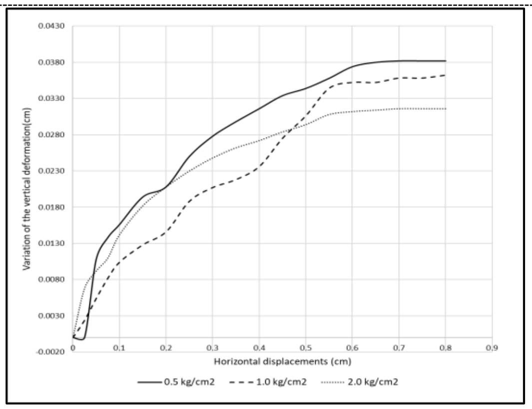

Figure 6. Volumetric analysis of S100 + 1.0% PET

To Figure 5 the mixture S100 + 0% PET shows that for 0.5 kg/cm^2 there is a constant volumetric change also to 1.0 kg / cm^2 are observed slight bumps that can be a rearrangement of the particles of the study material, culminating in 2.0 kg / cm^2 is also evidence constant volumetric change according to the horizontal displacement.

According to Figure 6 for mixing S100 + 1.0% PET in the effort of 0.5kg / cm2 at the beginning of the test the contraction of the material to then follow constant is observed until the end of the test, to the effort of 1.0 kg/cm^2 is evidenced a volumetric uniform behavior compared to other levels of confinement, however for the horizontal displacement of 0.4 centimeters expansion of the study material is slightly more pronounced and comes to exceed the expansion of the sample to a level of containment of 2.0 kg/cm^2. However, for this level of confinement a constant expansion is evident, but with less variation of vertical deformation, thus showing that this effort regarding S100 + 0%PET there is a significant improvement to the addition of recycled PET.

CONCLUSION

1. It was achieved characterize the soil as a materialinorganic red clay with high plasticity white (CH), medium high compressibility and expansion characteristics of permeable drainage. To themselvesand it found that polyethylene terephthalate was ground to about 3 to 5 mm. Also, 98.57% of the material passes No. 8 mesh which meet the requirements set for the completion of the investigation.
2. Obtaining curves compaction made with assay Proctor standard, according to ASTM D 698 standard, evidenced a progressive decrease of the maximum dry density of the samples with the additions of PET, this is logical because the content humidity (%) increased as the percentages are added to PET reinforcing soil samples.
3. The comparison of the mechanical parameters obtained from the direct shear test, it is concluded that there are improvements with regard to cohesion and decreased friction angle as claimed [3] these analyzed at each time instant in which they occur the horizontal displacements.
4. Of the direct shear test it determined that both parameters cohesion and angle of friction, their leakage resistances of the different mixtures approximate horizontal displacements larger.
5. It was determined that the volumetric analysis for levels of greater confinement as 2.0 kg/cm^2 a considerable improvement is observed in the S100 + 0% PET as this develops a more uniform behavior and less normal deformation compared to theS100 + 0% PET. Also, to levels lower confinement as 0.5kg/cm^2 a significant increase is observed in the normal strain of the S100 + 0%PET compared to the S100 + 1.0%PET.
6. It was determined that the optimal addition of reinforcement is 1.0% PET because this adopts a better performance, more uniform and less vertical variation.

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