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Granular Soil Bearing Capacity Improvement Using Waste Plastic Materials

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ABSTRACT: Reinforcement is the improvement of total resistance with reinforcing materials (with suitable performance in tension) in soil (with fairly compressive strength and weakness in tension). In the recent years, there have been numerous studies on the application of reinforced soil and bearing capacity of granular soils. Generally, it has been seen that studies are limited to reinforced embankment by geosynthetics and metal stripes and pulleys or even plastic parts and wastes so using plastic waste in embankment has not been considered. Therefore, in this research the effect of using plastic wastes to improve bearing capacity of granular soils has been investigated. The variables are using one type of disposal plastic wastes in different weight percentages in irregular (random) reinforcement and regular reinforcement (with specified layers) in granular embankment. The research was carried out in small laboratory scale using CBR. According to results, placing plastic waste parts in sandy soil increases the bearing capacity remarkably. The optimum values were obtained at 2-2.5 weight percent of plastic parts to sand and also the required energy conditions to attain optimum percentage were examined. In this regard, the strain-stress behavior of soil was studied. The results showed that increasing weight percentage of plastic parts to 2-2.5 in the condition of irregular and regular distribution, respectively, raises the soil elasticity coefficient to 234 and 152%.

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1- Introduction

The natural loose soil in the site of projects is mostly unsuitable and there may appear some settling in soil due to the load. Strengthening the weak soils to use in foundations, road beds and dams is the most important aspect in civil engineering projects. Some of the methods of soil improvement are compacting, pre-loading and soil reinforcing .The idea of using reinforced soil has recently been paid attention to.

Babu and Chouksey (2011) investigated the strain-stress behavior of a mixture of soil and plastic wastes. Their reinforcing material was in crispy obtained from plastic waste of bottles. With the increase of plastic waste percentage, unconfined compressive strength increases remarkably resulted from the increase of friction between soil and plastic wastes and development of tensile stresses in plastic waste [1].

Dutta and Sarda (2007) used waste plastic stripes and volcanic ash to reinforce soil. These stripes were used in different values and sizes and the effect of size was investigated. They concluded that increasing plastic stripes in saturated clay increases bearing capacity and secant module. Increasing the number and length of these stripes causes more increase. This increase in bearing capacity continues to optimal value of 2% but there is no change in bearing capacity after increasing plastic stripes [2].

Fauzy et al. (2016) examined the properties of the broken glass as the additive to improve the sub-structure using standard compact, bearing capacity and triaxial tests from different regions and plastic percentages to show that engineering properties of clay soil, bearing capacity and shear strength of reinforced samples are improved. With the increase of wastes, the paste limit value decreases and soil compressive value increases. Increasing the value of plastic wastes reduces the optimum moisture content and increases friction angle. It can be concluded that using glass wastes reduces the great expenses of using other additives in paving and removes environmental issues remarkably [3].

Muntohar et al. (2013) studied the effect of random distribution of waste plastic fiber using un-confined and triaxial un-drained compressive strength tests on engineering and strength properties of clay soil strengthened with lime and ash of rice shield. They showed that soil engineering properties are dependent on fiber type. The optimal value of plastic fiber in the mixed soil was 0.4 to 0.8 of weight percentage. They concluded that increasing the plastic fiber in the mixture reduced the friction angle and adhesion first increases and the decreases when the value of fiber increases. Therefore, the optimum value of this fiber was 0.4% [4].

2- Method and materials

2- 1- Soil

In this research, a type of silicate soil was used to make samples. Based on the uniform classification system of soils (ASTM D 2487-06) this soil is named badly granular sand as SP. Table 1 show the grading size curve and characteristics of sandy soil respectively.

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Table 1: Sand characteristics

Soil type	Dry specification weight (kN/m^3)	Internal friction angle (degree)	Cohesion (kg/cm^2)
Sand	13.6	21	0.01

2- 2- reinforcing materials

Plastic wastes of polyethylene-terephthalate obtained from fluid containing bottles were used as reinforcing elements. The 3D nature of these wastes provides the suitable confining conditions in soft grain sand and loose soil. One of the most widely used plastics is polyethylene-terephthalate known as PET used in making water containing bottles .In Table 2, the physical characteristics of plastic wastes are presented. To prepare the reinforced samples two method is used (irregular and regular contributions of plastic waste, Figures 1 and 2). To investigate the bearing capacity of reinforced soil samples, CBR apparatus is used.

Table 2: Physical characteristics of wastes in this research

Type	Specific density	Height (mm)	Diameter (mm)	Tnsile strength (MPa)	Young module (MPa)
Poly ethylene wastes	1.31	15	30	55- 75	2800- 3100

Figure 1: Preparing reinforced sample with random combination

Figure 2: Preparing reinforced sample with layer combination

3- Results and Discussion

3- 1- The effect of reinforcing element percentages on bearing capacity at regular placement

Figure 3 shows bearing capacity of reinforced samples versus vertical displacement for regularly placed plastic waste.as reinforcement materials with different percentages of waste materials.

It is seen that increasing the percentage of plastic parts to 2.5% , increases the applied force and after that the applied force decreases due to less locks of plastic parts in higher percentages.

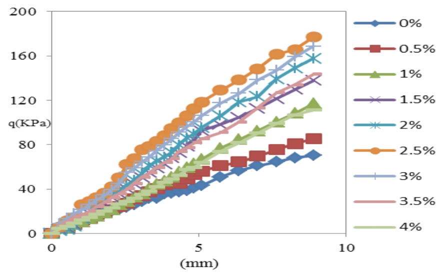

Figure 3: Force-displacement diagram for reinforced sand sample in regular form with different reinforcing material percentages

3- 2- The effect of reinforcing element percentages on bearing capacity at irregular placement

Figure 4 shows bearing capacity of reinforced samples versus vertical displacement for irregularly placed plastic waste as reinforcement materials with different percentages of waste materials. It is explained that the mixing of more than 3 percent plastic parts is not possible in irregular case. It is seen that increasing the percentage of plastic parts to 2%, increases the applied force and after that the strength of reinforced soil.

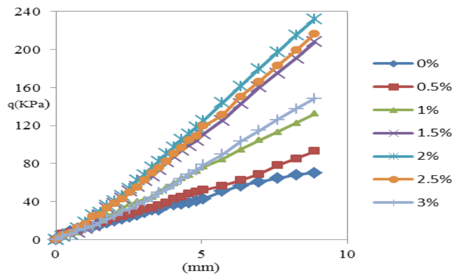

Figure 4: Force-displacement diagram for reinforced sand sample in irregular form placement with different reinforcing material percentages

4- Conclusion

In the present research, waste plastic parts (plastic bottle lids) were used as the 3D reinforcing element of loose sand soil and the following results were obtained.

1. Increasing the plastic parts up to 2% in irregular case and 2.5% at regular case, increases the strength and with the increase of number of parts, the strength decreases.
2. The reinforcement percent of 2-2.5% is introduced as the optimal value of plastic parts to reinforce sand soil. Also, using these plastic parts imposes little costs to provide materials.
3. In comparison of soil strength in regular, irregular and non-reinforced cases, it can be seen that using the reinforcing elements irregularly can increase the strength more than that of two other cases with more feasibility of application.
4. Increasing the percentage of plastic parts to optimal value increases the elasticity module of reinforced soil.

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