Geotechnical Properties of Silty Sand Reinforced with Polypropylene Woven Bags

Moiz Ali[1], Zaheer Almani[1], Aneel Kumar Hindu[1], Umair Hussain Memon[1], Nazim Nisar Memon[1]

[1]*Civil Engineering Department, Mehran-UET, Jamshoro, Pakistan*

***Abstract*: In today's world, there is growing concern about environmental pollution, overflowing landfill sites and rising depletion of non-renewable materials. More than ever, there is the need for effective waste management and recycled materials to be used that are eco-friendly. At present, plastic waste is considered as one of the major pollutants of environment as most of the plastic waste is non-biodegradable and requires a huge amount of effort and energy for its disposal. To overcome the problem, efforts are being employed by civil engineers to utilize plastic waste in the geotechnical field. During the recent years, untraditional methods are being used for soil stabilization which include different plastic waste such as Polyethylene Terephthalate (PET), Poly Propylene (PP), High/Low Density Polyethylene (HDPE/LDPE) etc. Their use as a stabilization agent is one of the solutions to recycle these materials in a useful and effective manner. This paper aims to assess the potential of Plastic Woven Bags (for packing of sugar, fertilizers etc.) as a reinforcement material for soil. For this, silty sand (A-2-4 soil) is selected as base soil and 10 different plastic bags varying in weight are utilized and placed in layers to prepare the soil-plastic composite specimens. The tests employed to analyze the behavior of plastic reinforced soil are Modified Proctor Compaction tests and California Bearing Ratio tests under un-soaked and soaked conditions. From the obtained results, it is observed that the inclusion of plastic bags can improve the strength of soil.**

***Keywords*: Renewable Materials, Silty Sand, Modified Proctor, Plastic Woven Bags, CBR.**

I. INTRODUCTION

Rapid growth in engineering technology globally has improved the lifestyle of human being, but on the other hand it has also augmented risk in the surrounding environment at the same rate [1]. One of the major examples of this is the daily consumption of plastic products. Disposal of such plastic waste materials pose a serious challenge, since most of the plastic waste is non-biodegradable and its disposal requires a great amount of energy and effort. In order to control the problem, efforts are being made to utilize the plastic wastes in engineering applications without causing hazards to the environment. In the Civil Engineering field, the utilization of different plastic wastes has increased during recent years [2][3]

Every civil engineering structure is supported by foundation. So, the foundation should be strong enough to carry the load of entire structure. And for the foundation to be strong enough, soil plays a vital role [4]. In many situations, it is required to build the structure over the weak soil. Then to overcome the situation, ground improvement techniques are restored by geotechnical engineers to modify the soil properties. These ground improvement techniques include vertical drains, soil replacement, grouting, geosynthetic reinforcement, chemical stabilization using different admixtures etc. [5]. During the recent years, untraditional methods are being used for soil stabilization which include different plastic waste such as Polyethylene Terephthalate (PET), Poly Propylene (PP), High/Low Density Polyethylene (HDPE/LDPE) etc. Their use as a stabilization agent is one of the solutions to recycle these materials in a useful and effective manner without causing any harm to the environment. Further from the previous studies, this method is proved to be eco-friendly and economical as compared to different admixtures employed in soil stabilization [6][7]. This research aims to study the effect of plastic woven bags for packing of fertilizers and seeds etc. as a reinforcement material on basic geotechnical properties of the silty sand.

II. LITERATURE REVIEW

During the recent years, various studies have been conducted on reinforcement of soil by using different types of plastic waste. Some of them are discussed in below. S. Peddaiah, A. Burman, S. Sreedeep (2018**)** this study investigated the engineering behavior of plastic (PET) bottle strips used as a stabilizing agent in silty sand. Different tests such as compaction test, direct shear test and CBR test were performed both on the virgin soil as well as reinforced soil with varying plastic content and also size of strips. From the laboratory test outcomes, it was observed that the soil exhibited higher improvement in its engineering properties up to certain limit. Beyond the limit it began to show the decreasing pattern. It concluded that there are various factors affecting the quantum of improvement of plastic reinforced soil. These factors included the nature of surface and size of plastic strip, plastic type and content, and type of soil. Further it was added that expensive methods for soil stabilization e.g. using cement and lime etc. as a stabilizing material may be replaced by plastic reinforcement which will reduce the cost of stabilization and will be useful to recycle the plastic wastes in an efficient manner.

Nicoleta-Maria Ilies, Alexadru-Petru Circu (2016) this research includes comparing the two methods of soil stabilization to improve the soil basic geotechnical properties. The first method is to improve the soil by using cement as stabilization agent. And the second method is to use the plastic waste material (used polyethene waste material) to improve the soil properties. It mainly focused on the influence of shear parameters on the addition of cement or polyethene waste material at the rate of 2%,

4%, 6% and 8%. From the results it is observed that though the improvement is higher in case of cement as compared to polyethene. But the former method has a higher carbon footprint than the latter one, and thus it is less eco-friendly.

Muske Srujan Teja (2016) This research aims to determine the effect of Poly Propylene (PP) Fiber materials on the shear parameters of unsaturated soil by carrying out a series of direct shear test and unconfined compression strength test on two different soil samples and comparative analysis was made for the samples. From results, it was concluded that the fiber reinforced soil can act as a substitute for deep or raft foundation, minimizing both the energy and cost.

PRAGYAN BHATTARAI, A.V.A BHARAT KUMAR (2013) In this research, locally available plastic waste such as shopping bags and other materials are used as a reinforcement of subgrade soil while mixing randomly to perform the CBR studies. The results and conclusions are summed up which shows that if the plastic strips as a reinforcing material is used in right proportion, it really helps in improving the CBR value of subgrade material and improves other strength related properties. Moreover, it can be used for stabilization of embankment, subgrade and various applications according to need or suitability.

AK Choudhary, JN Jha and KS Gill (2010**).** This study aims to evaluate the improvement in strength of subgrade soil reinforced with High-Density Polyethene (HDPE) strips obtained from plastic waste. As the CBR value of soil can be regarded as indirect measure of its strength. A series of CBR tests were conducted on the soil reinforced with randomly oriented HDPE strips with different lengths (12mm, 24mm and 36mm), aspect ratios (AR=1, 2 and 3) and also varying percentages of strips (0%, 0.25%, 0.5%, 1.0%, 2.0% and 4.0%). From the tests it was observed that on reinforcing soil with reclaimed HDPE strips, increase in resistance of soil to deformation and its strength is substantial. This research concluded that an increase in waste strips content and length increases the strength of soil. It was found that maximum CBR value of a reinforced soil was approximately 3 times higher than that of a natural soil. Further it was added that the HDPE strip reinforced soil if used as subgrade material can reduce the subbase or base course thickness significantly.

III. RESEARCH METHODOLOGY

Base Soil The soil which is selected for this study is silty sand. The purpose of choosing this soil is that, as it is available in the vicinity of Mehran University of Engineering & Technology, near Almanzar Jamsohro, it can be easily collected and transported to the laboratory for various tests.
Different standard tests are done to determine the basic geotechnical properties of soil. The results of the tests are presented in Table 1.

Table 1. Basic Geotechnical Properties of Bentonite

Property	Value
Liquid Limit	20%
Plastic Limit	17%
Plasticity Index	3%
Specific Gravity	2.64
Maximum Dry Density	1.71 g/cc
Optimum Moisture Content	14.16%
CBR (Un-Soaked)	18.44%
CBR (Soaked)	11.23%

Experimental Program The soil is reinforced with 10 different Poly Propylene Woven Bags varying in weight. Each of the sample is tested for moisture-density relationship and California bearing ratio test. Each test is repeated for three times to ensure reliability in the results.

Moisture-density relationship is determined by performing Modified Proctor Test according to ASTM D1556 – 12 ε1. First the untreated soil is compacted on modified compacting effort then the soil is reinforced with plastic bags in layers and the maximum dry density and optimum moisture content is determined for each sample.

California bearing ratio (CBR) of the reinforced soil have been done by using standard CBR test procedure under un-soaked and soaked conditions. For each sample, the compaction energy is 56 Blows and each sample is compacted to O.M.C obtained from moisture-density relationship of particular sample. In case of un-soaked condition, each specimen is placed on CBR test machine and the values of load and penetration are obtained. In case of soaked condition, the molds are dumped in a tub containing water for a period of 96 Hours. After soaking period, molds are placed on CBR test machine to know the value of Load and Penetration. All the tests have been performed as per ASTM D1883-07.

Fig. 1. CBR Test Machine

IV. RESULTS AND DISCUSSION

Moisture Density Relationship Moisture-density relationship of each sample is determined to know the effect of Poly Propylene (P.P) woven bags on the maximum dry density and optimum moisture content. The results are shown below.

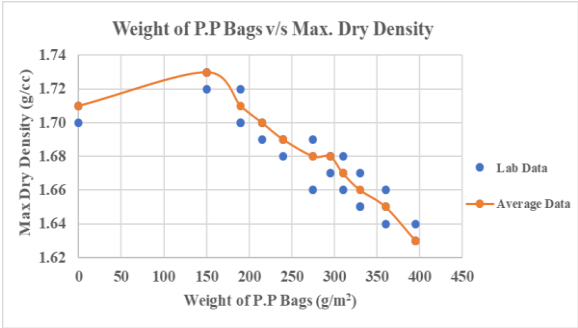

Fig. 2: Effect of P.P Bags on Maximum Dry Density of Soil

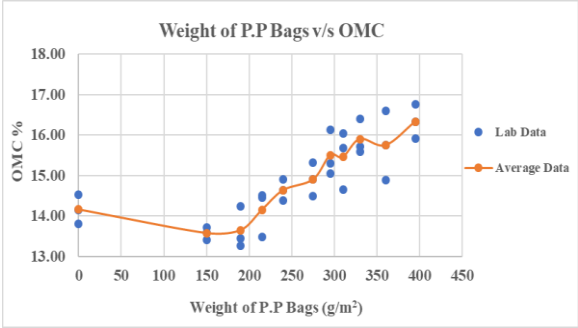

Fig. 3: Effect of P.P Bags on Optimum Moisture Content of Soil

From figure 2. it is found that as the weight of plastic bags increases, maximum dry density increases to little extent and then decreases. From Figure 3, it is observed that optimum moisture content of soil increases with increase in weight of plastic bags. California Bearing Ratio Results of CBR tests under un-soaked and soaked condition are shown in Figure 4. and Figure 5. respectively. The addition of plastic bags increases the CBR of soil to some limit and then it decreases with addition of plastic bags of higher weights. The maximum un-soaked CBR is obtained at a plastic bag of weight of 150 g/m^2. However, under soaked conditions, the highest value of CBR is achieved at 190 g/m^2.

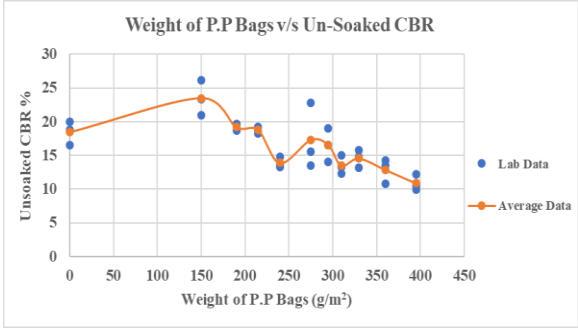

Fig. 4: Effect of Plastic Bags on Un-Soaked CBR of Soil

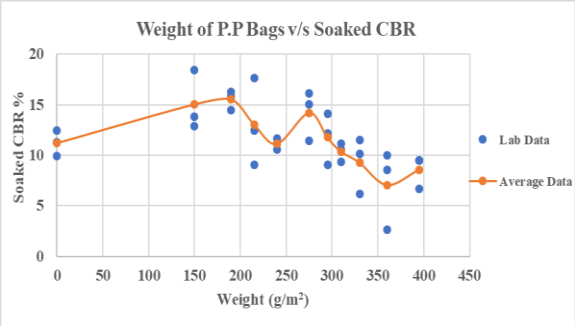

Fig. 5: Effect of Plastic Bags on Soaked CBR of Soil

V. CONCLUSIONS

From this research, the conclusions made are outlined below.

1. From Moisture-Density Relationship of all the specimens, it is observed that as weight of P.P Bags increases, the optimum moisture content increases and maximum dry density decreases.
2. From the results of Un-Soaked CBR tests, it is found that the sample with P.P bags of weight of 150 g/m^2 gives maximum value. After this point, decreasing trend starts.
3. Under Soaked Condition, it is observed that the value of CBR increases with increase in weight of weight of P.P Bags. The highest value is obtained at 190 g/m^2.

VI. RECOMMENDATIONS

In this research, an effort is made to determine the effect of silty sand reinforced with P.P woven bags in layers. However, there is need of further work to get better understanding of plastic waste as a reinforcement material for soil.

1. It is recommended that various types of soil need to be checked to understand the reinforcement behaviour with plastic bags.
2. There is a further need to understand the effects of layering technique. For this, the position and the number of layers should be changed to get the broad view. However, mixing technique should also be applied to determine the behaviour on reinforcement.
3. In this research, the effect of plastic bags on strength characteristics of silty sand has been analyzed. Further research should be undertaken to evaluate and understand the effect of plastic bags on shear and consolidation characteristics of silty sand.

REFERENCES

[1]. Jasmin Varghese Kalliyath, Jithin Thomas Joy, Jeny Merin Paul, Antony Mathew Vadakkel "Soil Stabilization using Plastic Fibers", IJSTE - International Journal of Science Technology & Engineering, Volume 2, Issue 12, June 2016
[2]. Agus Setyo Muntohar, Anita Widianti, Edi Hartono, and Wilis Diana "Engineering Properties of Silty Soil Stabilized with Lime and Rice Husk Ash and Reinforced with Waste Plastic Fiber", Article in Journal of Materials in Civil Engineering, 2013
[3]. B SURESH, N VENKAT RAO, K ARUN KUMAR, DMV PRANEETH, "Soil Stabilization using Plastic Strips of Varied Sizes by enhancing the Bearing Capacity", International Journal of Advance Engineering and Research Development, Volume 4, Issue 12, December -2017
[4]. R. H. Mohankar, M. D. Pidurkar, R.S. Bute, Y.D. Chintanwar "Behaviour of Soil Reinforced with Plastic Waste", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue VI, June 2017
[5]. Baraja M. Das, a book on "Principles of Geotechnical Engineering" 7th Edition, 2010
[6]. Maha Hatem Nsaif. "Behaviour of Soils Strengthened by Plastic Waste Materials", Journal of Engineering and Development, Vol 17 (4), 2013.
[7]. Kalumba, D. & Chebet F.C., "Utilization of polyethylene (plastic) shopping bags waste for soil improvement in sandy soils", Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering, Paris, 2013
[8]. S. Peddaiah, A. Burman, S. Sreedeep, "Experimental Study on Effect of Waste Plastic Bottle Strips in Soil Improvement," 2018
[9]. Nicoleta-Maria Ilies, Alexandru-Petru Circu, Andor-Csongor Nagy, Vlad-Costel Ciubotaru, Zsombor Kisfuladi-Bak, "Comparative Study on Soil Stabilization with Polyethylene Waste Materials and Binders," 10th International Conference Interdisciplinary in Engineering, INTER-ENG 2016
[10]. Muske Srujan Teja, "Soil Stabilization Using Polypropylene Fiber Materials,", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 9, 2016
[11]. Pragyan Bhattarai, A.V. A Bharat Kumar, K.Santosh, T.C Manikanta & K.Tejeswini "Engineering Behavior Of Soil Reinforced With Plastic Strips," International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD), Vol. 3, Issue 2, Jun 2013, 83-88
[12]. A.K. Choudhary, J.N. Jha and K.S. Gill, "A Study on CBR Behaviour of Waste Plastic Strip Reinforced Soil," Emirates Journal for Engineering Research, 15 (1), 51-57 (2010)
[13]. M. Kimura, Y. Fukubayashi "Rural road maintenance using geotextile available in developing countries", Proc. of the 2nd International Conference on Transportation Geotechnics, Hokkaido, 2012-9