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STUDY OF THE PERFORMANCE OF WASTE PLASTIC IN CLAY SOIL STABILIZATION

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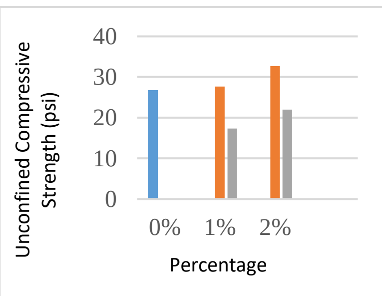
Graphical abstract



Abstract

Every year, tons of plastic garbage is produced, damaging our environment. So, recycling these waste plastic has become a need of this time. Therefore, using such materials in technical applications like soil stabilization will be advantageous. Additionally, stabilization using waste plastic is a practical option that is also easily accessible around us. In this research, the soil was stabilized with Waste Plastic. This paper describes the numerous studies performed on soil with varying aspect ratios of waste plastic. Waste Plastic and Bottle Strips were collected and used as soil reinforcement in this study to improve the engineering performance of subgrade soil. The plastic strips were cut in two distinct aspect ratios (5 mm x 5 mm) and (5 mm x 10 mm) and were prepared to add at two different weight proportions (1% and 2%). Unconfined Compressive Strength testing was then carried out. The testing findings revealed that shear strength parameters improved significantly. The current analysis yielded the following Compressive Strength values: 27.68 psi and 32.73 psi when 1.0% and 2.0% of plastic bottle strips (5mm x 5mm) were used, and 17.32 psi and 21.99 psi when 1.0% and 2.0% of plastic bottle strips were used (5 mm x 10 mm). The results demonstrate that in the instance of bottle strips, mixing smaller strip sizes created an increase in shear strength on the soil. Any additional increase in strip size has resulted in a loss in compressive strength because increasing strip size generates un-compacted weak shear planes. So, this can be concluded that using waste plastic in clay soil for soil stabilization is recommended since it helps to both reduce the cost of stabilization and protects the environment.

Keywords: clay soil, unconfined compressive strength, plastic waste, plastic strip, recycle

1.0 INTRODUCTION

Soil stabilization is a technique that was developed many years ago to make inadequate soils capable of satisfying the needs of certain engineering projects. Various methods for stabilizing weak and inappropriate soils have already been investigated. These techniques include geotextile and fabric grouting stabilization, chemical stabilization, thermal stabilization, electrical stabilization, mechanical (granular) stabilization, cement stabilization, lime stabilization, bituminous stabilization, and stabilization of the cement and other materials. Recently, researchers developed a new practice of soil stabilization that makes use of waste materials. Plastics are one of the most common waste items discovered to be useful for this function. They significantly reduce the cost of stabilization. Every day, an estimated 15.4 billion pieces of plastic garbage are produced, the equivalent of one ordinary plastic bottle. These wastes are produced in large quantities in the form of polyethylene terephthalate-based plastic bottles (PET). Polypropylene is also used to make plastic sacks and carpets (PP). Using plastic waste to stabilize soil can help improve pavement foundation layers (Khattab et al. 2011). Thus, by reducing the quantity of waste, this can solve the problem of waste management, and recycling these materials in the geotechnical sector can improve the properties of soils. One method of using plastic for soil stabilization is to use the plastic in the form of discrete fibers (Yetimoglu and Salbas 2003), because when plastic materials are merged with soils, they behave similarly to fiber-reinforced soil. The method is commonly used in highway and airport construction projects. However, they are already obscuring landfills and waterways, clogging sewers, upsetting the biological balance, providing an unpleasant atmosphere, and seriously endangering the lives of animals, plants, and people. PET bottles are a type of ubiquitous plastic bottle that are frequently used to store liquid items, including water, soft drinks, and a range of other beverages. As their demand rises, getting rid of them becomes increasingly challenging. Waste PET bottles take a very long period (more than 100 years) to degrade in nature. Due to its large consumption capacity, the construction industry is a prime option for plastic bottle recycling and reuse to stabilize expanding clay soil. In order to enhance and obtain the necessary qualities for construction works, this study covers acceptable and straightforward techniques of recycling plastic water bottles as reinforcing material for expansive soil stabilization. The experiments that were run and the outcomes that were discovered are provided.

2.0 METHODOLOGY

To begin, a soil sample was obtained from Grambhatulia, Turag, Uttara, Dhaka-1230, Bangladesh. The disturbed soil sample was obtained 10 feet below ground level. Waste plastics are collected at the laboratory's nearby shop. Following confirmation as a clay soil by particle size analysis (sieve analysis and hydrometer), the soil sample was combined with waste plastic (Bottle strips) by 1% and 2% of its volumetric weight and cut in two different aspect ratios (5 mm x 5 mm) & (5 mm x 10 mm) in the presence of a small amount of water. Then it was dried in the sun for 5 days. After 5 days, the plastic mold was removed which was 7.5cm and 3.8cm in height and diameter respectively. Subsequently, Unconfined Confined Compressive Strength Test was done on the mother soil and the whole plastic waste mixed soil. Figure 1 illustrates the mold and the prepared sample.

Figure 1: The mold and the prepared sample

3.0 LABORATORY TEST RESULTS AND DISCUSSIONS

3.1 Characterization of Soil

The soil sample was described using the particle size distribution, Atterberg limit tests (Figure 2), and specific gravity of soil tests. The soil's specific gravity was 2.65, its liquid limit was 35 percent, its plastic limit was 27.5 percent, and its plasticity index was 7.45 percent.

Figure 2: Atterberg limit tests

3.2 Testing Reinforced Soil Properties

3.2.1 Standard Proctor Compaction Test Results:

The aim of this test method is to determine maximum dry unit weight, γ_d (max) and optimum moisture content, $w_{(opt)}$ of compaction. Table 1 show that the summary of compaction test of soil and Figure 3 and Figure 4 show that the comparison bar chart of maximum unit weight and optimum moisture content correspondingly.

Table 1: Summary of compaction test

Type	% Added	Max dry unit weight, $\gamma_d(max)$	Optimum moisture content, $W_{(opt)}$
Normal soil	0	17.74	15.95
Plastic strips (5mmX5mm)	1%	17.12	17.61
	2%	17.58	14.54
Plastic strips (5mmX10mm)	1%	17.25	16.78
	2%	17.07	16.74

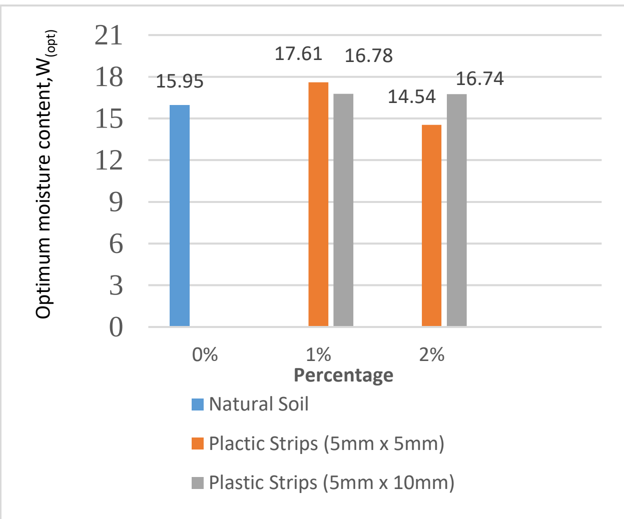


Figure 3: Summary of obtained data of max unit weight

The bar chart presented in Figure 3 depicts the relationship between the percentage of plastic strip mixed and the corresponding optimum moisture content when combined with natural soil. Notably, the data indicates that at a 1% mix of plastic strips (5mm x 5mm), there is an elevation in the moisture content value.

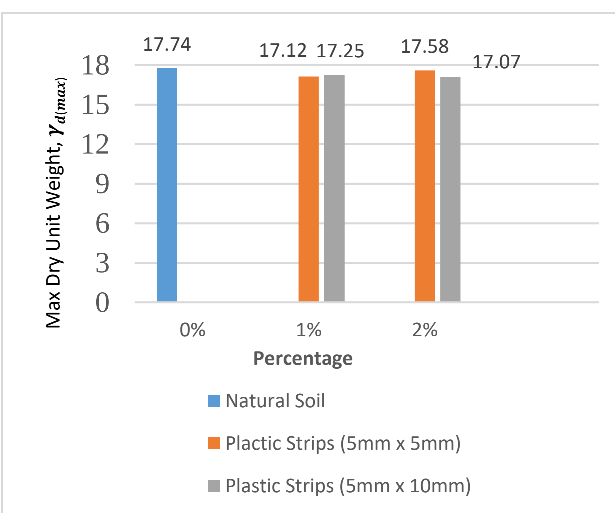


Figure 4: Summary of obtained data of optimum moisture content

In Figure 4, the bar chart illustrates the maximum dry unit corresponding to different percentages of plastic bottle strips mixed with soil. Upon examination of the provided data, it is evident that the mixture containing 2% plastic strips (5mm x 5mm) with normal soil displayed a superior value, measuring 17.78 psi.

Overall, the data reveals a positive correlation between the percentage of plastic strips (5mm x 5mm) and the maximum dry unit. However, it's worth noting that the trend is not uniform across all plastic strip mixes, as there is a decrease in the maximum dry unit with the increase in plastic strip mix (5mm x 10mm). This implies that the size of the plastic strips plays a significant role in influencing the maximum dry unit, with the 5mm x 5mm variant demonstrating an increase while the 5mm x 10mm variant shows a decrease.

3.2.2 Unconfined Compressive Strength (UCS) Test Result:

Unconfined compressive strength tests were conducted for determining the unconfined shearing strength. Table 2 show that the summary of unconfined compressive test result and Figure 5 illustrate that the comparisons by bar chart.

Table 2: Data the summary of all unconfined compressive tests

Type	% Added	Unconfined compressive strength, (Psi)			Average UCS
		Sample I	Sample II	Sample III	
Normal Soil	0	23.87	28.75	27.58	26.73
Plastic Strips (5mmX5mm)	1%	27.45	28.05	27.54	27.68
	2%	32.88	34.00	31.32	32.73
Plastic Strips (5mmX10mm)	1%	15.38	17.63	18.95	17.32
	2%	20.58	22.23	23.15	21.99

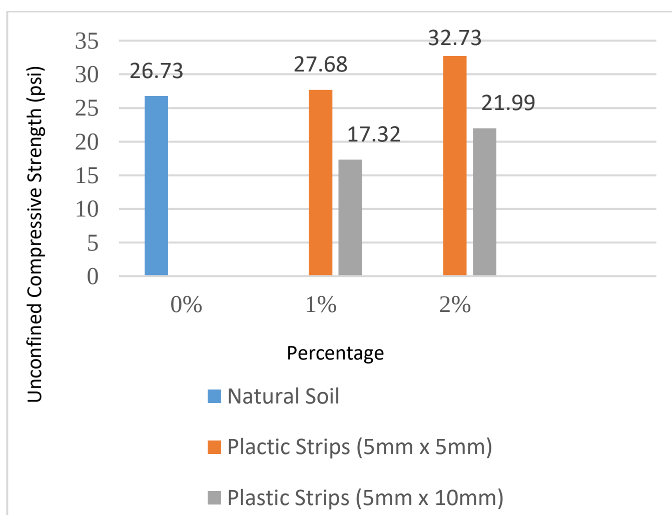


Figure 5: Data summary of unconfined compressive strength

Figure 5 depicts the unconfined compressive strength corresponding to varying percentages of plastic bottle strips mixed with soil. Upon scrutinizing the provided data, it becomes evident that the mixture containing 2% plastic strips (5mm x 5mm) with average soil exhibited a notably higher value, measuring 32.73 psi. This represents a substantial increase of 22.45% compared to the unaltered composition of 0% plastic strips or solely natural soil.

The trend observed across the data suggests a positive correlation between the percentage of plastic strips (5mm x 5mm) and the unconfined compressive strength. In essence, the results indicate a consistent enhancement in strength as the proportion of plastic strips in the mixture increases.

4.0 CONCLUSION

After accomplishing the required analysis, we found the below analysis data.

1. From this study, the maximum dry unit weight was found 17.74. however, mixing 1% and 2% plastic bottle strips of 5mm x 5mm with soil was found 17.12 and 17.58 respectively and for 5mm x 10mm bottle strips with soil it was determined 17.25 and 17.07 consequently.
2. It is observed that strips with smaller dimensions show higher unit weight with the increasing percentage while larger dimensions strips illustrate a downward trend with the climbing percentages.
3. It was found that the optimum moisture content of natural soil and contaminated soil by using 1.0% and 2.0% plastic bottle strips (5mm x 5mm) was 15.95, 17.61 and 14.54 consequently. Using 1.0%, 2.0% plastic bottle strips (5mm x 10mm) was 16.78 and 16.74. Here, it is seen that with the shooting up percentage optimum moisture content decreases. However, in 5mm x 10mm the decrement is lesser.
4. Moreover, It was found that the unconfined compressive strength (UCS) of natural soil and contaminated soil by using 1.0%, 2.0% plastic bottle strips (5mm x 5mm) was 26.73 psi, 27.68 psi and 32.73 psi consequently. So , the soil with 2% plastic waste (5mm x 5mm) aspect ratio is providing better strength then that of virgin soil.
5. In addition to this, the UCS results convey if the amalgamation percentage of strips with soil increases, the strength of the treated soil with also increases.

5.0 RECOMMENDATIONS FOR FUTURE STUDY

To secure the purpose of this research more tests data were required which could not be possible due to time constraints. Samples from other locations would have given more accurate results. The recommendation that can be made for future study is based on the fact that:

1. For further study in this field, it would be suggested to perform the California Bearing Ratio (CBR) test.
2. These experiments should be conducted using different percentages of the stabilizing agent.
3. Glass breeds, coarse and fine aggregates, lime, ceramic powder, stone dust and small pieces of facemask can be used for further experiments to get some comparisons in this regard.
4. As it is known Triaxial test provides pertinent shear strength parameters, so it is recommended to conduct this test in forward research.
5. Smaller strip size (5 mm x 5mm) should be tested to see whether it provides even better strength.

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