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Reinforcement of High Density Polyethylene Strips and Fibers

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Abstract: ***The amount of wastes has increased year by year and it is necessary to utilize the wastes effectively. This study presents a simple way of using the recycled plastic waste in the field of civil engineering as reinforcing material. This study describes a comparison on the inclusion of recycled high density polyethylene (HDPE) in the form of strips and fibers with clayey soil at different mixing ratios in percentage by weight respectively. A significant improvement in the strength is observed due to the inclusion of HDPE strips and fibers.***

Keywords: Clayey soil, HDPE (High Density Polyethylene), Reinforcement, Strength improvement

1. Introduction

In recent years, plastic containers and bags made of high density polyethylene (HDPE) have been used with increasing frequency for various purposes like storage of materials including food, detergents etc. These containers have only a short span of life since they are often disposed after regular use. As a result, landfills have been continuously filled with an alarming rate of waste plastic. This should be avoided so as to prevent the soil strength degradation and low permeability of soil caused due to the presence of excess plastic waste present in the soil. Nowadays, used HDPE is often collected for reusing and recycling techniques. However, recycled HDPE has a major disadvantage. Since HDPE can be melted at very low temperatures, it is prohibited from manufacturing products that are used for storing food items, drugs or cosmetics. However, these reclaimed HDPE after recycling can't be discarded hence new methods are being adopted to reuse the recycled plastic wastes so that it can be used in an efficient way. Thus, recycled plastic wastes are therefore used to reinforce weak soils and soft clays.

1.1 Objective of the Study

- Determination of the properties of clayey soil used for the study.
- Study the effect of varying percentage of high density polyethylene strips on the geotechnical properties of clay sample and determination of optimum percentage.
- Study the effect of varying percentage of high density polyethylene fibers on the geotechnical properties of clay sample and determination of optimum percentage.
- Evaluate the influence of HDPE strips and fibers on CBR value of clayey sample.
- Evaluate the unconfined compressive strength of clayey sample reinforced with HDPE strips and fibers.
- Analyze the influence of equal optimum percentage mixtures of HDPE strips and fibers by weight on strength characteristics of reinforced soil.

2. Materials and Methods

2.1 Soil

The soil sample necessary for the thesis work was collected from Akkulam region, Trivandrum. "Fig.1" shows the soil sample.

Figure 1: Clayey soil

Table 1: Properties of clayey sample

Sl No	*Property*	*Value*
1	Sand content	18.1%
2	Silt content	48.7%
3	Clay content	33.2%
4	Specific Gravity	2.46
5	Liquid Limit	62%
6	Plastic Limit	32.8%
7	Plasticity Index	29.2
8	Optimum Moisture Content (OMC)	32%
9	Maximum Dry Density(MDD)	1.26g/cc
10	Void Ratio(e)	0.44
11	Unconfined Compressive Strength	3.03kg/cm²

2.2 High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) or polyethylene high density (PEHD) is a polyethylene thermoplastic made from petroleum. With a high strength to density ratio, HDPE is

used in the production of plastic bottles, corrosion resistant piping and geomembranes.

Table 2: Properties of HDPE

Parameters	*Value*
Resin Identification code	2
Density	0.94g/cm³

(a) High Density Polyethylene strips

High Density Polyethylene strips are prepared from cutting down of plastic bags after they are being collected and recycled. The materials are prepared in the form of small strips of width 0.5cm and with varying lengths of 2cm, 4cm and 6cm respectively. The lengths are determined with respective to aspect of ratio of 4, 8 and 12 with respect to the width size.

Figure 2: HDPE strips

(b) High Density Polyethylene fibers

Reclaimed waste plastic bottles made up of high density polyethylene are reprocessed in the form of fibers which can be used for reinforcing soil. Fibers used for the reinforcement possesses a diameter of about 1mm was added to the soil in the ratio of about 0,1,2,3 and 4 percentages by weight and the increase in strength was determined.

Figure 3: HDPE fibers

3. Results and Discussion

After the determination of the basic physical and chemical properties of the soil, tests like Standard Proctor test and California bearing Ratio test were performed to determine the strength parameters for reinforced and unreinforced samples.

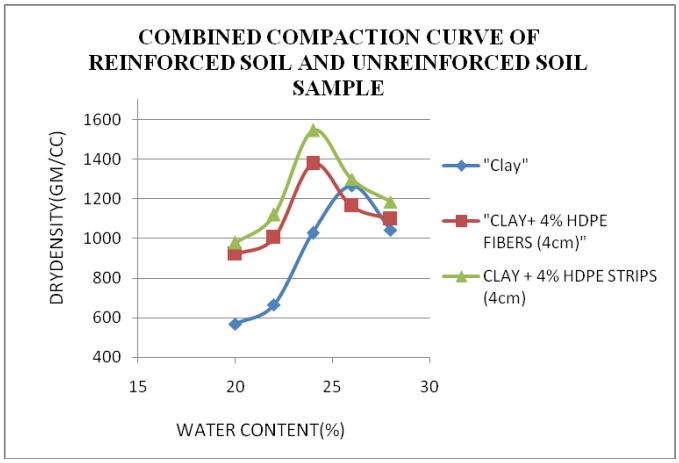

Figure 4: Combined Standard Proctor test results

'Chart 1' shows the effect of addition of HDPE in the form of strips and fibers on the maximum dry density and optimum moisture content of the clayey sample. The maximum dry density was observed to possess a hike of about 22% in case of HDPE strips and 8.7% in case of HDPE fibers when they are included to the soil. A decrease in optimum moisture of about 2% is observed due to the inclusion of HDPE strips and fibers to the clayey sample.

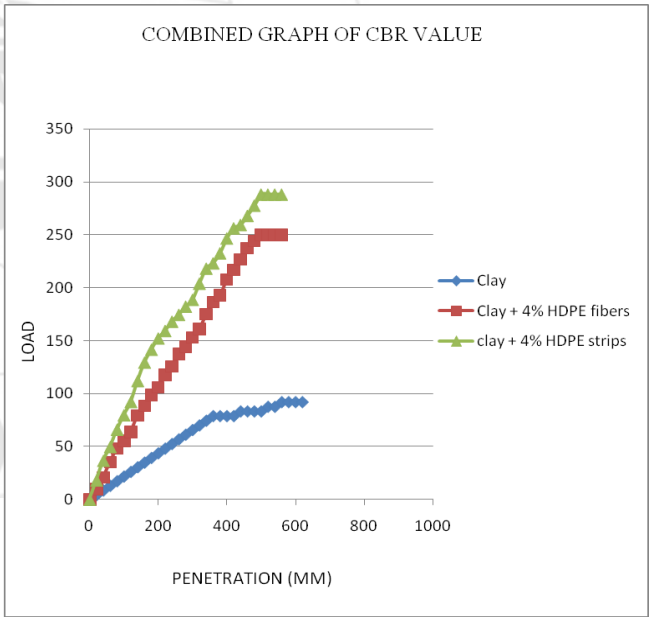

Figure 5: Combined California Bearing ratio test results

'Chart 2' shows the effect of HDPE strips and fibers on the California Bearing ratio of the clayey sample used with and without reinforcement. The test results shows an increment in the CBR value of about 4.6 times in the case of HDPE strips and about 4.03 times in the case of HDPE fibers.

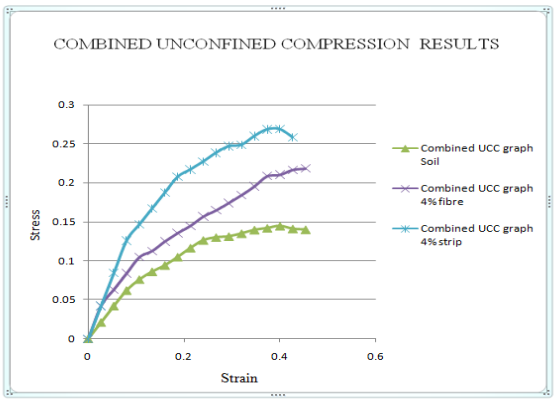

Figure 6: Combined Unconfined Compression test results

'Chart 3' shows the increment in the unconfined compressive strength of the clayey sample when they are included with High Density Polyethylene strips and fibers. An increment of about 1.85 times in case of HDPE strips and 0.28 times in the case of HDPE fibers is observed from this test.

However, the inclusion of both HDPE strips and HDPE fibers of same length and of equal proportions by weight into the clayey soil, the following test results were obtained. This is mainly due to the fact that the higher tensile loads were carried by the strips and lower tensile loads were taken up by the fibers. The results obtained are listed below:

Table 3: Test results due to inclusion of 2% HDPE strips and 2% HDPE fibers

Parameters	Value
Standard Proctor	1.64gm/cc
California Bearing Ratio	10.42
Unconfined Compression	30.38kN/m²

The test results provide us with the information that the best results are obtained due to the inclusion of equal proportions of HDPE strips and HDPE fibers to the soil sample.

4. Conclusions

When soil is reinforced with HDPE strips and fibers, an increase in dry density of about 22% in the case of HDPE strips and 8.7% in the case of HDPE fibers were observed.CBR value of soil reinforced with HDPE strips was observed to possess an increment of about 4.62 times and about 4.03 times in the case of HDPE fibers when compared to soil without any HDPE. UCC value was also found to possess an increase 1.85 times when HDPE strips were added and 0.28 times increment was recorded for HDPE fiber inclusion to clayey soil. A new concept of including an optimum value of both HDPE strips and fibers were undergone and the results were promising. Maximum dry density is recorded of about 1.64g/cc which is about an increase of 30.15% compared to unreinforced clayey soil. CBR values also shows a hike when the optimum percentages were added to the clay. An increase of 4.96 times is obtained when compared to unreinforced clay. 2.18 times increase is found out when the optimum percentages of HDPE strips and fibers were added to the sample while performing unconfined compression test

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