

Stabilization of Waste Soil at Pallipalayam Dump Yard by using Polypropylene Fiber

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ABSTRACT: This project deals with the basic engineering and geotechnical properties of poor subgrade soils using Polypropylene fibre to improve its strength. The main objective of this study is to investigate the use of fiber materials in geotechnical applications. To evaluate the effects of polypropylene fibers on shear strength of unsaturated soil by carrying out California Bearing Ratio (CBR) test, and unconfined compression tests on pallipalayam dump yard soil sample. The different values adopted in the present study for the percentage of fiber reinforcement are 0.2%, 0.4%, 0.6%, 0.8% and 1.0%. Overall it can be concluded that fiber reinforced soil can be considered to be a good ground improvement technique especially in engineering projects on weak soils. The results obtained from soil sample and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach.

KEYWORDS: polypropylene fibers, unconfined compression tests, and California bearing ratio tests, cost effective approach.

I. INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement. Here, in this project, soil stabilization has been done with the help of randomly distributed polypropylene fibers obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement.

II. SCOPE OF WORK

The experimental work consists of the following steps:

1. Specific gravity of soil
2. Determination of soil index properties (Atterberg Limits)
 - i) Liquid limit by Casagrande's apparatus
 - ii) Plastic limit
3. Particle size distribution by sieve analysis



4. Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
5. Preparation of reinforced soil samples.
6. Determination of the shear strength by:
 - i) Unconfined compression test (UCS)
 - ii) California bearing ratio test (CBR).

III. MATERIALS AND PROPERTIES

- Soil sample
 - Location: Pallipalayam dump yard
- Reinforcement: Short PP (polypropylene) fiber

TABLE-1 Index and Strength Parameters of PP-Fibre

Appearance	Polypropylene Fibre
Specific Gravity	0.91 g/cm ³
Alkali Content	Nil
Sulphate Content	Nil
Air Entrainment	Air content of the concrete will not be significantly increased
Chloride Content	Nil
Aspect Ratio	100
Constituents	Virgin Polypropylene C3H8
Fibre Thickness	6 Denier
Young's Modulus	5500-7000 MPA
Tensile Strength	360 MPA
Melting Point	160° C
Compatibility with other Admixtures and Cements	KEM FIBRE 84 can be used with all types of cement and is compatible with other admixtures
Fibre Length	6mm
Aggregate Size	Max. 32mm

3.1 PREPARATION OF SAMPLES

Following steps are carried out while mixing the fiber to the soil. All the soil samples are compacted at their respective maximum dry density (MDD) and optimum moisture content (OMC), corresponding to the standard proctor compaction tests. Content of fiber in the soils is herein decided by the following equation:

$$\rho_f = (W_f/W) \text{ ----- (1)}$$

Where, ρ_f = ratio of fiber content
 W_f = weight of the fiber
 W = weight of the air-dried soil.

The different values adopted in the present study for the percentage of fiber reinforcement are 0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1%. In the preparation of samples, if fiber is not used then, the air-dried soil was mixed with an amount of water that depends on the OMC of the soil. If fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

IV. TEST PROCEDURE

4.1 Specific gravity of the soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water.

$$\text{Specific Gravity } G = (W_2 - W_1) / (W_4 - W_1 - W_3 - W_2)$$

Where,

- W1- Weight of bottle in gms
- W2- Weight of bottle + Dry soil in gms
- W3- Weight of bottle + Soil + Water
- W4- Weight of bottle + Water

Specific gravity is always measured in room temperature and reported to the nearest 0.1.

4.2 Liquid limit

The Casagrande tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to 25 blows from the graph.

4.3 Plastic limit

This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil which crumbles on reaching this diameter. Plasticity index (I_p) was also calculated with the help of liquid limit and plastic limit;

$$I_p = w_L - w_P$$

Where,

- wL- Liquid limit
- wP- Plastic limit

4.4 Particle size distribution

The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the abscissa with logarithmic axis and the percentage passing as the ordinate gives a clear idea about the particle size distribution. From the help of this curve, D10 and D60 are determined. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D10 and D60 gives the uniformity coefficient (C_u) which in turn is a measure of the particle size range.

4.5 Proctor compaction test

This experiment gives a clear relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of (i) cylindrical metal mould (internal diameter- 10.15 cm and internal height-11.7 cm), (ii) detachable base plate, (iii) collar (5 cm effective height), (iv) rammer (2.5 kg). Compaction process helps in increasing the bulk density by driving out the air from the voids. The theory used in the experiment is that for any compactive effort, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is achieved when the soil is compacted at relatively high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the OMC and MDD. The equations used in this experiment are as follows:

$$\text{Wet density} = \text{weight of wet soil in mould gms} / \text{volume of mould cc}$$

$$\text{Moisture content \%} = (\text{weight of water gms} / \text{weight of dry soil gms}) \times 100$$

$$\text{Dry density } \gamma_d \text{ (gm/cc)} = \text{wet density} / (1 + \text{moisture content}) \times 100$$

4.6 Unconfined compression test

This experiment is used to determine the unconfined compressive strength of the soil sample which in turn is used to calculate the unconsolidated, undrained shear strength of unconfined soil. The unconfined compressive strength (q_u) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The experimental setup constitutes of the compression device and dial gauges for load and deformation. The load was taken for different readings of strain dial gauge starting from $\epsilon = 0.005$ and increasing by 0.005 at each step. The



corrected cross-sectional area was calculated by dividing the area by $(1 - \epsilon)$ and then the compressive stress for each step was calculated by dividing the load with the corrected area.

4.7 California bearing ratio test

The California Bearing Ratio (CBR) is the ratio of the resistance to Penetration developed by a subgrade soil to that developed by a specimen of standard crushed stone base material. The resistance of the crushed stone under standardized condition is well established. The objective of a CBR test is to determine the relative resistance of the subgrade material under the same conditions. Place the mould assembly with the surcharge weights on the penetration test machine. Place the penetration piston at the center of the specimen with smallest possible load, but in no case in excess of 3Kg so that full contact of the piston on the sample is established. Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25mm/min. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0mm. Note the maximum load corresponding penetration if it occurs for a penetration less than 5.0mm. Detach the mould from the loading equipment. Take about 20to50g of soil from the top 3cm layer and determine the moisture content.

V. RESULTS AND DISCUSSIONS

5.1 INDEX PROPERTIES

The index properties includes Specific Gravity, Liquid limit, Plastic limit, Uniformity Coefficient, Optimum Moisture content, Max dry density etc., The index properties obtained from the tests for soil sample.

TABLE-2 Index properties of Soil

INDEX PROPERTIES	SOIL SAMPLE
Specific gravity	2.8%
Liquid limit	32%
Plastic limit	26.32%
Uniformity coefficient	6.85%
Optimum moisture content	12%
Maximum dry density	1.941g/cc

The Shear strength properties includes unconfined compression strength, California bearing ratio are determined unconfined compression strength test and California bearing ratio test. The shear strength parameters obtained from the tests for soil sample for unreinforced soil and reinforced soil of various percentages of reinforcement such as 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1% are listed in the table below.

TABLE-3 Shear strength properties

Parameters	Soil sample					
	0%	0.2%	0.4%	0.6%	0.8%	1%
Unconfined compression test	56	72.80	125.08	68.65	57.92	51.70
California bearing ratio test	14.02%	16.77%	17.27%	17.27%	17.77%	18.27%

5.2 DISCUSSIONS

5.2.1 Inferences from Unconfined compression Test

Soil sample

- UCS value increases from 0% to 0.4% - 56 to 125.08, a peak value 123.35 N/mm².

5.2.2 Inferences from California bearing ratio Test

Soil sample

- CBR value shows 1% of fiber reinforced soil sample shows higher, the penetration is 18.27%.

VI. CONCLUSION

- The study investigated the application of polypropylene fibre to strengthen the weak soil.
- The Results from the UCS test for soil sample, for reinforcement 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1%. The increase in unconfined compressive values are 56 N/mm², 72.80 N/mm², 125.08 N/mm², 68.65 N/mm², 57.92 N/mm² and 51.70 N/mm² respectively.
- The Results from UCS test of soil sample is found that the value of unconfined compressive strength show increasing from 0.2% to 0.4%, then values are decreasing upto 1%, from 0% to 0.4%, 123.35 N/mm² peak value obtained, the combination of polypropylene fiber and soil, therefore maximum value is obtained in 0.4% of reinforcement. Since 0.4% of fibre reinforcement soil sample has a higher cohesion strength and compression strength than other fibre reinforced soil sample.
- The Results from CBR Test for soil sample, reinforcement 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1%. The increase the strength of soil, the values are 14.02%, 16.77%, 17.27%, 17.27%, 17.77%, and 18.27% respectively. From the values, 1% of fiber reinforced soil sample shows higher CBR value. It shows that combination of polypropylene fiber and soil help us to improve the weak soil strength.
- Overall it can be concluded that polypropylene reinforced soil can be considered to be good ground improvement technique specially in engineering projects on weak soil where it can act as a substitute to deep/raft foundation, reducing the cost as well as energy.

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