Soil Stabilization Using Waste Fiber Materials

SATYAM TIWARI
Research Scholar
Department of Civil Engineering
Acropolis institute of Technology & Research
Bhopal

NISHEET TIWARI
Assistant Professor
Department of Civil Engineering
MANIT, Bhopal

Abstract: The main objective of this study is to investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained are compared for the two samples 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.

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 behavior. 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. EXPERIMENTAL INVESTIGATION

Scope of Work

The experimental work consists of the following step

- Specific gravity of soil
- Determination of soil index properties (Atterberg Limits)
- Liquid limit by Casagrande’s apparatus
- Plastic limit
- Particle size distribution by sieve analysis
- Determination of maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
- Preparation of reinforced soil samples.
- Determination of the shear strength by: Direct shear test (DST)
  Unconfined compression test (UCS).

Materials

I. Soil sample-1

II. Reinforcement: Short PP (polypropylene) fiber.

Table No. 1 Index and strength parameters of PPF

<table>
<thead>
<tr>
<th>Behavior parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber type</td>
<td>Single fiber</td>
</tr>
<tr>
<td>Unit weight</td>
<td>0.91 g/cm³</td>
</tr>
<tr>
<td>Average diameter</td>
<td>0.034 mm</td>
</tr>
<tr>
<td>Average length</td>
<td>12 mm</td>
</tr>
<tr>
<td>Breaking tensile strength</td>
<td>350 MPa</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>3500 MPa</td>
</tr>
<tr>
<td>Fusion point</td>
<td>165°C</td>
</tr>
<tr>
<td>Burning point</td>
<td>590°C</td>
</tr>
<tr>
<td>Acid and alkali resistance</td>
<td>Very good</td>
</tr>
<tr>
<td>Dispersibility</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Preparation Of Samples

Following steps are carried out while mixing the fiber to the soil-

i) 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

ii) Content of fiber in the soils are herein decided by the following equations

\[
\text{Where, } p_f = \text{ratio of fiber content}
\]

\[
W = \text{Weight of the air-dried soil}
\]

iii) The different values adopted in the present study for the percentage of fiber reinforcement are 0, 0.05, 0.15, and 0.25

iv) 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.

Brief Steps Involved In The Experiments

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. Weight of bottle + 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

Liquid limit The Casagrande’s 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

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 (Ip) was also calculated with the help of liquid limit and plastic limit;

\[
\text{Ip} = \text{WL} - \text{WP}
\]

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 (Cu), which in turn is a measure of the particle size, range.

II. RESULTS AND DISCUSSION

The tests results are summarized in Table 2. The variation in the Optimum moisture contents,
Maximum dry density, California bearing ratio, unconfined compressive strength and Differential free index are shown in Figures 1 to 3.

Table 2: Summary of Results

<table>
<thead>
<tr>
<th></th>
<th>Sample 01</th>
<th>Sample 02</th>
<th>Sample 03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity Of Soil</td>
<td>2.631</td>
<td>2.65</td>
<td>2.684</td>
</tr>
<tr>
<td>Without Fiber</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Specific Gravity Of Soil</td>
<td>2.64</td>
<td>2.655</td>
<td>2.689</td>
</tr>
<tr>
<td>With Fiber</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Liquid Limit Of Soil</td>
<td>40.33</td>
<td>47.05</td>
<td>45.31</td>
</tr>
<tr>
<td>Without Fiber</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Liquid Limit Of Soil</td>
<td>43.89</td>
<td>36%</td>
<td>41.80</td>
</tr>
<tr>
<td>With Fiber</td>
<td>%</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Plastic Limit Of Soil</td>
<td>28.68</td>
<td>29.67</td>
<td>29.72</td>
</tr>
<tr>
<td>Without Fiber</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Plastic Limit Of Soil</td>
<td>22.35</td>
<td>28.14</td>
<td>27.03</td>
</tr>
<tr>
<td>With Fiber</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Shrinkage Limit Of Soil</td>
<td>3.029</td>
<td>2.97</td>
<td>2.94</td>
</tr>
<tr>
<td>Without Fiber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrinkage Limit Of Soil</td>
<td>5.65</td>
<td>6.1</td>
<td>5.46</td>
</tr>
<tr>
<td>With Fiber (Ppf)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IV. CONCLUSION

[1]. Based on Specific gravity of a soil- With mixing of 0.5% fibers (PPF) specific gravity of the soil increases by 0.3%. (From table no 3 and 4) Strength of the soil is directly proportional to specific gravity, more is the specific gravity more will be the strength of soil.

[2]. Based on liquid limit of a soil - Soil without reinforcement and with reinforcement have liquid limit difference of 18.18%.

[3]. Based on plastic limit of a soil - As similar to liquid limit the plastic limit of soil is also reduces. It reduces from 29.35% to 25.8% . % decrease in plastic limit is 12% (From table no 7 and 8) , This result shows increase in shear strength , Cohesiveness and consistency of soil mass.

[4]. Based on liquid limit of a soil - The value of the shrinkage limit in reinforced soil is less than that of unreinforced soil. Hence with the use of polypropylene fiber shrinkage reduces.

[5]. The value of shrinkage limit is used for understanding the swelling and shrinkage properties of cohesive soil. lesser is the shrinkage more will the suitability of material for foundation , road and embankment as more will be the strength.

V. REFERENCES


[2]. “Method of Test for Specific Gravity of Soils” published by “Department of Transportation Engineering Service Center, California”.


[4]. Akbar Pashazadeh1, Mahmood Ghazavi2 , and Morteza Chekaniazar3 presented in there paper entitled “Experimental study of
the effect of polyethylene fibers with random distribution on the engineering behavior of the mixture of flimsy sand with clay soils” (2011)


