Soil Stabilization using Lime and Polypropylene Fiber Material

Ravi S Balagoudra1, Vamshi Krishna2, Hemappa S Yaligar3, Jayasurya T4, Shwetha G C5

Student1, 2, 3, 4, Assistant Professor5

Department of Civil Engineering
Stjit Ranebennur, Karnataka, India

Abstract:

Expansive soils are found in many parts of the world such kind of soil generally consists of active clay minerals. Geotechnical engineers face various problems while designing foundation because of clayey soil due to poor bearing capacity and excessive settlement. To overcome those problems researches concentrated on soil improvement techniques by adding fibers, lime etc. to the soil. The usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach. The various tests were conducted on Black cotton soil with increment of 0.25% polypropylene fiber (PPF) upto 1% and constant 4% lime by weight of soil. Finally the maximum strength is obtained at 0.75% PPF and by maintaining 4% lime.

Key word: Soil Stabilization, fibers, lime, raft foundation.

1. 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 its plays a very important role. So to work with soils we need to have proper knowledge about their properties and factors which affect their behavior. In order to satisfy the soil properties the soil stabilization is very important so that the addition of lime and polypropylene fiber makes soil stabilization by arresting the cracks so that it improves strength. The addition of lime and polypropylene fiber decreases the optimum water content, and increases strength and maximum dry density and reduced the swelling potential, liquid limit, plasticity index. But further addition can increases swelling in soils with high sulphate contents, decrease in plasticity of soils and excessive lime treatment contribute to brittle failure characteristics of soils that lead to rapid and great loss in strength when failure occurs. Here in this project soil stabilization has been done with the help of lime and randomly distributed polypropylene fibers, obtained from waste materials.

2. LITERATURE REVIEW

SATYAM TIWARI et al (2016): They explained the “Soil Stabilization Using Waste Fiber Materials”, and investigated 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 percentages of fiber reinforcement added are 0, 0.05, 0.15, and 0.25. Based on Specific gravity of a soil- With mixing of 0.05% fibers (PPF) specific gravity of the soil increases by 0.3%. Strength of the soil is directly proportional to specific gravity, more is the specific gravity more will be the strength of soil. Based on liquid limit of a soil without reinforcement and with reinforcement have liquid limit difference of 18.18%.

SHAILENDRA SINGH, et al (2013): They explained the “Stabilization of Black Cotton Soil using Lime”. The stabilization of black cotton soil with lime has been done in three different ratios of lime i.e. 0%, 4%, 6%. After that, the soil with lime in above percentage the various tests have been performed. They concluded that the addition of lime at 4% and 6% decreases the liquid limit by 12.1% and 17.7%. MDD is found to decrease by 2.4% and 5.6% at 4% and 6% lime content. The swelling pressure at 4% and 6% decreased by 40% and 80% respectively. ANKIT JAIN, et al (2016): They explained the “Effect of lime on the index properties of black cotton soil”. A Serious of laboratory tests conducted on black cotton soil mixed with different proportion of lime i.e. 0%, 2%, 4%, 6%, 8%, and 10% by weight of dry soil. Based on their investigation they concluded that, liquid limit of soil decreases from 67.49% to 52.01% with increase in lime content up to 8% after that there is no significant change with increase in lime content. Plasticity index of soil decreases from 37.16% to 10.43% with increase in lime content up to 8%. Differential free swelling of soil decreases from 60% to 14% with increasing lime content. Above results shows that the swelling characteristics of soil is reduced and optimum dosage of lime is found at 8%.

3. OBJECTIVES

- To evaluate the index properties of Black cotton soil.
- To increase the strength characteristic of soil by adding polypropylene fiber and lime.
- To make comparison of strength properties between Black cotton soil with fiber and without fiber.
- To identify the increasing in strength of soil by replacing fiber at various percentages.
- To increase the soil bearing capacity by adding polypropylene fibre and lime in varies percentages.
- To identify the Effect of lime on CBR value of the soil and Effect of lime on Compressive strength of soil.
- To identify the optimum % of poly propylene fiber by conducting varies strength test to various % of fibre.
4. EXPERIMENTAL INVESTIGATION

4.1 Scope of work
The experimental work consists of the following steps:
1. Determine the specific gravity of the 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 compaction test.
5. Determination of strength by;
   i. Unconfined compression test (UCS).
   ii. Direct shear test (DST).
   iii. California bearing ratio test (CBR).

4.2 Materials
4.2.1 Black cotton soil: Black cotton soil (BC soil) is a highly clayey soil. They are of variable thickness, underlain by black sticky material known as “Black soil”. Black cotton soil when comes in contact with water it either swells or shrinks and resulting in moments to the structure which are generally not related to direct effect of loading. On account of its high volumetric changes it is not suitable for construction. It swells and shrinks excessively due to present of fine clay particles. Hence black cotton soil must be treated by using suitable admixtures to stabilize it.

4.2.2 Polypropylene fiber:
Table 1: Physical and chemical properties of fibre

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Physical and chemical properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fibre type</td>
<td>Single fibre</td>
</tr>
<tr>
<td>2</td>
<td>Unit weight</td>
<td>0.91 g/cm3</td>
</tr>
<tr>
<td>3</td>
<td>Average diameter</td>
<td>0.034 mm</td>
</tr>
<tr>
<td>4</td>
<td>Average length</td>
<td>12 mm</td>
</tr>
<tr>
<td>5</td>
<td>Breaking tensile strength</td>
<td>350 M Pa</td>
</tr>
<tr>
<td>6</td>
<td>Modulus of elasticity</td>
<td>3500 M Pa</td>
</tr>
<tr>
<td>7</td>
<td>Fusion point</td>
<td>165 °C</td>
</tr>
<tr>
<td>8</td>
<td>Burning point</td>
<td>590 °C</td>
</tr>
<tr>
<td>9</td>
<td>Acid and alkali</td>
<td>Very good</td>
</tr>
<tr>
<td>10</td>
<td>Dispersibility</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

4.2.3 Lime: Calcium oxide is a white crystalline solid with a melting point of 2572°C. It is manufactured by heating limestone, coral, seashells, or chalk, which are mainly CaCO₃ to drive off carbon dioxide. By using lime in the method of soil stabilization it mainly increases strength and reduces the swells or shrinks property. But further additions may decreases the plasticity of soil and excessive lime treatment contribute to brittle failure characteristic of soils that lead to rapid and great loss in strength when failure occurs.

4.3 Preparation of samples
The following steps are carried out while mixing the fiber to the soil:
1. All the soil samples are compacted at their respective maximum dry density (MDD) and optimum moisture content (OMC) corresponding to the standard proctor compaction test.
2. Content of fiber in the soil is depends on the weight of soil we have taken for conducting tests.
3. The different values adopted in the present study for the percentage of fiber reinforcement are 0%, 0.25%, 0.5%, 0.75%, and 1% and lime is added constant about 4% for different percentages of fiber.
4. In the preparation of samples, if fiber and lime is not used then, the air dried soil is mixed with an amount of water that depends on the OMC of the soil.
5. If fiber and lime was used, the adopted content of fibers and lime was first mixed into the air dried soil in small increments b hand, making sure that all the fibers and lime were mixed...
4.4 Brief steps involved in the experiments
4.4.1 Specific gravity of the soil: The specific gravity of the soil is ratio between weight of the 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. The specific gravity is denoted by “G”.

4.4.2 Liquid limit by Casagrande’s apparatus: It is the water content of the soil between liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing against flowing. The Casagrande’s tool cuts a groove of size 2mm wide at the bottom and 11mm wide at the top and 8mm high. The number of blows used for the soil sample 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. It is denoted by $W_L$.

4.4.3 Plastic limit: The limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non-porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by $W_P$.

4.4.4 Particle size distribution by sieve analysis: The distribution of particles of different sizes determines many physical properties such as its strength, permeability, density etc. Particle size distribution is done by sieve analysis which is done only for coarse grained soils. It is followed by plotting the results on a semi log graph. The percentage finer N as the ordinate and particle diameter i.e. sieve size as the abscissa on a logarithmic scale.

4.4.5 Proctor compaction test: The compaction process helps in increasing the bulk density by driving out the air from the voids. 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. After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the MDD and OMC.

4.4.6 Unconfined compression test: The 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 is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The compressive stress for each step was calculated by dividing the load with the corrected area.

4.4.7 Direct shear test: This is the most common test used to determine the shear strength of the soil. In this experiment the soil is put inside a shear box closed from all sides and force is applied from one side until the soil fails. The shear stress is calculated by dividing this force with the area of the soil mass. This test can be performed in undrained, drained, and consolidated undrained conditions.

4.4.8 California bearing ratio test: California bearing ratio (CBR) is defined as the ratio expressed in percentage of force per unit area required penetrating a soil mass with a circular plunger of 50mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. Tests are performed out on natural or compacted soils in water soaked or unsoaked conditions and the results so obtained are compared with the curves of standard tests.

5. RESULTS AND DISCUSSION

The index properties of black cotton soil tests results are summarized in Table-2. The variation in the Optimum moisture contents, Maximum dry density, Unconfined compressive strength, Direct shear test and California bearing ratio test results are shown in Figures 4 to 8.

Table 2. Summary of results

<table>
<thead>
<tr>
<th>Specific gravity of the soil (G)</th>
<th>2.287</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid limit (W_L)</td>
<td>32%</td>
</tr>
<tr>
<td>Plastic limit (W_P)</td>
<td>22.65</td>
</tr>
<tr>
<td>Plasticity index (I_p)</td>
<td>9.35</td>
</tr>
<tr>
<td>Maximum dry density of soil (MDD)</td>
<td>1.486 g/cc</td>
</tr>
<tr>
<td>Optimum moisture content of soil (OMC)</td>
<td>25%</td>
</tr>
</tbody>
</table>

Figure 4. Optimum moisture content
IV. CONCLUSION:

[1]. The results obtained for different percentages of polypropylene fiber and constant lime (4%) as shown in figure 4. The decrement in the Optimum moisture content (OMC) as shown in figure with different percentages of addition of polypropylene fiber and constant lime (4%). The OMC decreases up to 0.75% after that OMC gradually increases with further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

[2]. The results obtained for different percentages of polypropylene fiber and constant lime (4%) as shown in figure 5. The increment in the Maximum dry density (MDD) as shown in figure with different percentages of addition of polypropylene fiber and constant lime (4%). As MDD increases strength of soil also increases. The MDD increases up to 0.75% after that MDD gradually decreases with further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

[3]. The results obtained for different percentages of polypropylene fiber and constant lime (4%) as shown in figure 6. The increment in the Unconfined Compression strength as shown in figure with different percentages of addition of polypropylene fiber and constant lime (4%). The compression strength increases up to 0.75% after that compression strength decreases with further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

[4]. The increment in the shear strength or cohesion as shown in figure 7 with different percentages of addition of polypropylene fiber and constant lime (4%). The shear strength increases up to 0.75% after that shear strength slightly decreases with further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

[5]. The results obtained for different percentages of polypropylene fiber and constant lime (4%) as shown in figure 8. The increment in the CBR value as shown in figure with different percentages of addition of polypropylene fiber and constant lime (4%). The CBR value increases up to 0.75% after that CBR value greatly decreases with further addition of...
polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

[6]. Hence we obtained the optimum percentage of lime and polypropylene fiber as 4% and 0.75% for soil stabilization.

V. REFERENCES:


