Theme T 8

Innovative Techniques in Ground Improvement
Effect of Lime-Coir Fiber on Geotechnical Properties of Black Cotton Soil

Ramesh, H.N.  
Professor and Chairman  
e-mail: rheddur@yahoo.com

Krishna, K.V. Manoj  
Research Scholar  
e-mail: shree_manoj@yahoo.com

Mamatha, H.V.  
Former Post Graduate Student

Department of Civil Engineering, UVCE, Bangalore

ABSTRACT

A series of Compaction and Unconfined Compressive Strength (UCS) tests were conducted to study the effects of Randomly Distributed Coir Fiber (RDCF) inclusions and lime on the geotechnical properties of BC soil (Black Cotton soil) as one combination and effect of bitumen coating on coir fiber reinforced BC soil as another combination. These UCS tests were conducted up to 180 days of curing. Indian brown colour coir fiber was mixed with optimum percentage of lime to BC Soil in different proportions. The strength increases up to 30 days linearly with curing period, with further curing the increase in the strength is marginal. Optimum fiber of 1.0 % (by weight) with 0.5 centimeter length was identified for improving the strength of BC Soil. From UCS test with 180 days of curing it is found that addition of bitumen coated coir fiber in BC soil is less beneficial.

1. INTRODUCTION

Expansive soil occurs all over the world. India has large tracks of expansive soil known as Black cotton soil (BCS), which is about 20% of total area. The major areas of their occurrence are state of Maharashtra, Gujarat, Southern parts of Uttar Pradesh, eastern parts of Madhya Pradesh, parts of Andhra Pradesh and Karnataka. This type of soil is available up to a depth of 3.7 meters on an average in the above parts of India. Expansive soil occurring above the water table undergoes volume changes with change in moisture content. Increase in water table causes swell – shrink behaviour in these type of soil which leads to cracks and differential settlement resulting in several damages to the foundations, buildings etc. Chemical stabilization is one of the oldest method of stabilization of BCS. In recent days it has been investigated that addition of fibers to soil, increases the ductility and reduces the cracks. An attempt is also made in this paper to study the effect of bitumen coating on coir fiber in terms of its strength.

2. LITERATURE REVIEW

Several researchers had carried out to investigations to judge the behavior of treated ground with chemical or fibers alone. Gosavi et al (2004) & Ramesh et al (2010) studied the behaviour of BC soil reinforced with fibers. According to Kaniraj & Vasant (2001) fly ash – soil specimens compacted at the MDD-OMC state exhibits brittle behavior in unconfined compression test. The brittle behavior is more marked in cement stabilized specimens than in unstabilized specimens. The fiber inclusions change the behavior in both instances to ductile behavior. The increase in the unconfined compressive strength of unstabilized fly ash-soil specimens due to fiber inclusions depends on the unconfined compressive strength of the unreinforced specimens. The unconfined compressive strength of a fly ash- soil mixture increases due to addition of cement and fiber. Depending on type of mix and curing period, the increase in unconfined compressive strength caused by the combined action of cement and fibers is either more than or nearly equal to the sum of the increase caused by them individually. However, according to Sheeha et al (2000) coir composites for long term reinforcement effect need treatment. In sand beds which are not very vulnerable to degradation, needle felt gives increased resistance due to large area of exposed surface. Untreated felt is prone to disintegration and cement-PVA coating gives higher modulus and greater resistance to deformation. Bituseal treatment with high concentration of bitumen can lead to loss of friction which lowers the efficiency of the reinforcement. Also Manoj & Prathap (2010) brought out that natural fibers are effectively made use of provided they are given suitable treatment. In this paper, natural fiber like coir is selected and strength effect between uncoated and bitumen coated coir fibers are studied in terms of its compaction effort and strength.

3. MATERIAL AND METHODS

Black Cotton Soil

Black cotton soil is collected from Davanagere, Karnataka.
state, India by an open excavation from a depth of 2 meters below natural ground level. The air dried soil passing 425 micron IS sieve is used for the present investigation. The properties of soil are shown in Table 1.

Table 1: Basic Properties of Black Cotton Soil

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural moisture content</td>
<td>8.70</td>
</tr>
<tr>
<td>Grain Specific Gravity</td>
<td>2.72</td>
</tr>
<tr>
<td>Liquid Limit (%)</td>
<td>83.00</td>
</tr>
<tr>
<td>Plastic Limit (%)</td>
<td>32.47</td>
</tr>
<tr>
<td>Plasticity Index(%)</td>
<td>50.53</td>
</tr>
<tr>
<td>Shrinkage Limit(%)</td>
<td>8.25</td>
</tr>
</tbody>
</table>

Lime

Lime obtained from Sd Fine Chemicals Limited, Mumbai, India is used in present investigation. The composition of lime are shown in Table 2.

Table 2: Chemical Composition of Lime

<table>
<thead>
<tr>
<th>Chemical Configuration</th>
<th>Ca(OH)₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum assay</td>
<td>90.0</td>
</tr>
<tr>
<td>Maximum limits of impurities:</td>
<td></td>
</tr>
<tr>
<td>Chloride(Cl) (%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Sulphate(SO₄) (%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Arsenic(As) (%)</td>
<td>0.0004</td>
</tr>
<tr>
<td>Lead(Pb) (%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Hydrochloric acid insoluble matter (%)</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Coir Fibers

Coir fibers cut into random lengths were used as a natural reinforcing material. Coir fibers were collected from the local small scale factory in Trichy, Tamilnadu, India with the cooperation of Coir Board Pollachi, Tamilnadu.

Bitumen was collected from local shop in Bangalore, Karnataka India.

In the present investigation lime and coir fibers used are in percentage by weight of soil. Optimum lime content was determined by mixing BC soil with 2 to 8% lime (by weight of soil). Fiber – reinforced soil samples were prepared at maximum dry density (MDD) and optimum moisture content (OMC). Samples were prepared by adding coir fibers 0.25%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% (by weight of soil). Fibers were randomly mixed in soil to form homogenous mixture. Moist soil fiber mix was transferred to the mould and compacted. Compaction test was conducted using Mini compaction test apparatus (Sridharan and Sivapullaiah, 2005) and unconfined compressive strength tests were conducted for various combinations of soil sample compacted to their OMC-MDD as per BIS 2720 part X (1973).

4. RESULTS AND DISCUSSIONS

Effect of Lime On Compaction Behavior of Black Cotton Soil

It is observed from Fig.1 that MDD of BC soil increases with addition of lime. The increase is significant up to 4% (by weight of soil) there after it reduces. The reduction is due to disintegration of soil particles. This is in accordance with Ramesh et al (2010).

Effect of Coir Fiber on Compaction Behavior of Black Cotton Soil

In general addition of coir fiber increases the optimum moisture content (OMC) and decreases the maximum dry density (MDD). Similar conclusions were drawn by Gosavi et al (2004). Fig.2 shows the decrease in OMC and increase in MDD with the addition of 1% coir fiber (by weight of soil) of 0.5 cms length. These observations are in accordance with Kaniraj & Gayathri (2003), Ramesh et al (2010).
Effect of Lime and Bitumen on Compaction Behavior of Coir Reinforced BC Soil

It can be observed from Fig. 3 addition of 1.0% uncoated coir fiber to lime treated black cotton soil reduces the MDD by 2.0% as well as OMC by 0.35% where as addition of bitumen coated coir fiber to black cotton soil reduces the MDD 3.5% and OMC reduces by 1.8%. This reduction in OMC indicate that due to bitumen coating water absorption capacity of coir fiber get reduces. This is in accordance with Manoj and Prathap (2010).

Fig. 3: Density-Water Content Relationship of Black Cotton Soil with Lime/Coir Fiber Uncoated and Bitumen Coated

Effect of Fiber on Unconfined Compressive Strength of Fiber Reinforced BC Soil

From the Fig. 4 it is observed that addition of lime to BC soil increases the strength by 5 folds and BC soil reinforced with coir increases the strength by 3.5 folds. The strength of BC soil reinforced with 1% coir fiber (by weight of soil) coated with bitumen is less than uncoated one. However, the strength in both the cases are more than the strength of BC soil alone. These discussions are in accordance with Sheebha et al (2000). According to them bituseal treatment with high concentration of bitumen can lead to loss of friction which lowers the efficiency of the reinforcement.. However uncoated at 180 days of curing shows a white fungus on the surface of UCS sample where as bitumen coated coir fiber reinforced UCC sample are free from that white fungus attack.

5. CONCLUSIONS

1. The BC soil reinforced with 1% coir fiber (by weight of soil) for 0.5 cms length of coir fiber is found to be optimum.
2. Addition of 4% lime (by weight of soil) is found to be optimum percentage.
3. Lime treated BC soil reinforced with 1% coir fiber of 0.5 cms length increases the strength of BC soil.
4. Bitumen coating is less beneficial compared to uncoated coir fiber as far as strength criteria is concerned.

REFERENCES


