Studies On The Use Of Fish Net Fibers For Stabilization Of Black Cotton Soil

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ABSTRACT:
Developing roads for heavy traffic is one of the main components of the infrastructure of country. Therefore there is a need for constant search of stabilizing materials to strengthen weak sub-grade soils giving due consideration to financial aspects. There is Black cotton soil in most parts of central and western parts of India and covering approximately 20% of the total area of India and it has been a challenge to highway engineers since this soil is highly susceptible to moisture changes. The main objectives of the proposed project is to determine the index and engineering properties of Black cotton soil, determination of engineering properties of fish net fibre modified soil, reducing swelling tendency of moist- compacted Black cotton soils, to check the efficacy of fish net fiber (Grid type) reinforced soil as a fill material through laboratory model studies. Laboratory tests are conducted to check the improved properties of the stabilized material with respect to unstabilized soils and the laboratory experiments conducted on soil are conducted as per IS:2720. The main test methodology of the proposed project is to determination of engineering properties of modified soil, such as Wet Sieve Analysis, Determination of Liquid Limit and Plastic Limit, Standard Compaction Characteristics, Soaked CBR Test, Unconfined Compressive Strength Test, Tri axial Test. This study demonstrates the influence of fish net fiber on swelling, compressibility and hydraulic conductivity and these have been shown to decrease considerably when Black cotton soils is treated with fish net fibers. The results indicate that primary swell and secondary swell percentage decreases with increase in fish net fiber layers.

Key Words: Black cotton soil, Fish net fibers (Grid type).

1. INTRODUCTION
Black cotton soil deposits occur in the arid and semi-arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season. Black cotton soils are a worldwide problem that poses several challenges for civil engineers. They are considered as a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Black cotton soils will cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earthquakes and floods. Black cotton soils are semitropical soils found in areas where the annual rainfall is 500 to 750 mm. They range from black to dark gray. They tend to become hard with very large cracks when dry and very soft and spongy when wet. These soils are found in large areas of Australia, India, and Southeast Asia [1].

1.1 Background of the present study
During the last few decades damage due to swelling action has been observed clearly in the semi-arid regions in the form of cracking and breakup of pavements, roadsways, building foundations, slab-on-grade members, and channel and reservoir linings, irrigation systems, water lines, and sewer lines. Black cotton soils usually contain the clay mineral montmorillonitic and include sedimentary and residual soils, clay stones and shale.

In arid and semi-arid climates, they exist in a moisture-deficient, unsaturated condition. The expansive nature of soil is most obvious near ground surface where the profile is subject to seasonal, environmental changes. Expansive soil are called as Black cotton soil in India. The name “Black cotton soil” has an agricultural origin. Most of these soils are black in colour and are good for growing cotton. These soils possess high strength in summer and strength decreases rapidly in winter. The soil has a swelling property due to the presence of montmorillonitic mineral. It is very necessary to discuss about the engineering behavior of these soils.

1.2 Main Objective of the Present Study
For the present study the objectives considered are mentioned below:

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1. To determine the Dry density and optimum moisture content of Black cotton soil Mix prepared using Fish Net Fiber (Grid type) and by rammer.
2. To assess the CBR of Black cotton soil Mix prepared using Fish Net Fiber (Grid type) at optimum moisture content.
3. To compare the shear strength Characteristics of the specimen cast using rammer
4. To study the unconfined compressive strength behavior of Fish Net Fiber (Grid type) soil mixes

1.3 Brief Methodology
In the present study the Black cotton soil Properties for Soil Stabilization as per IS 2720 specifications has been adopted. Basic Engineering tests on Black cotton soil and Fish Net Fiber were conducted in the laboratory to assess their properties.

Standard Compaction Method of mix preparation was adapted to carryout mix design for Soil Stabilization Mix prepared using Fish Net Fiber (Grid Type). The Compaction specimens were prepared using rammer. The rammer is a type of compactor which simulates the field condition in laboratory. Standard Compaction Test, Unconfined Compressive Strength Test and California Bearing Ratio, Tri Axial Test and Permeability Test were conducted on Black cotton soil with Fish Net Fiber.

1.4 Literature Review
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 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 (1).

To determine the reinforcing effect of randomly distributed short polypropylene fibers on the compaction characteristics, penetration resistance and unconfined compressive strength of lime stabilized Black cotton soil. The study focuses on effect of change of percentage fiber content and curing period on the engineering properties of soil (2).

25mm and 50mm, 25mm referred as short fiber and 50mm as long fiber) and reported that short fibers encouraged more in effective stabilization and reduced swell pressure to a considerable extent (3).

2. EXPERIMENTAL STUDY
2.1 Laboratory Testing For Basic Properties of Materials
The Soil is subjected to laboratory investigations in accordance with Indian Standard specified test methods for determining the physical properties. The results of tests which were conducted are as shown in Table 1

2.2 Fish Net Fiber (Grid type)
Soil Stabilization is generally recommended for the roads with heavy traffic and locations of extreme climatic conditions. The selection of soil stabilization will be based on climatic, traffic factors, performance reports and life cycle cost analysis. Some test results are shown in Table 2

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Specific gravity</td>
<td>2.65</td>
</tr>
<tr>
<td>2 Particle Size distribution</td>
<td></td>
</tr>
<tr>
<td>a) Gravel</td>
<td>4.1</td>
</tr>
<tr>
<td>b) Sand, Silt + clay</td>
<td>52.48, 43.42</td>
</tr>
<tr>
<td>3 Liquid Limits (%)</td>
<td>66</td>
</tr>
<tr>
<td>4 Plastic Limits (%)</td>
<td>35</td>
</tr>
</tbody>
</table>

Table 1 Properties of Black cotton soil
3. RESULTS AND DISCUSSION

3.1 Determination of Maximum Dry Density and Optimum Moisture Content of Black cotton soil treated with Fish Net Fibers

Maximum dry density and optimum moisture content of Black cotton soil alone are 17.17 KN/m$^3$ and 18% respectively. The results of compaction test on Black cotton soil treated with different layers of Fish Net Fibers are given in Figure 3.

<table>
<thead>
<tr>
<th>Material Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Grey</td>
</tr>
<tr>
<td>Mesh Aperture Size (mm)</td>
<td>5×5</td>
</tr>
<tr>
<td>Thickness of the Fiber (mm)</td>
<td>0.8</td>
</tr>
<tr>
<td>Density of the Fiber</td>
<td>1.5-2 g/cm$^3$</td>
</tr>
<tr>
<td>Tensile Strength (psi)</td>
<td>12,400</td>
</tr>
<tr>
<td>Flexural Strength (psi)</td>
<td>17,000</td>
</tr>
<tr>
<td>Elongation</td>
<td>90%</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Table 2 Mechanical Properties of Fish Net Fibers

![Fig 1 Black cotton soil](image1)

![Fig 2 Fish Net Fibers](image2)

![Fig 3 Compaction Curves for Black cotton soil and Black cotton soil mixed with different Layers of Fish Net Fibers](image3)
3.2 Determination of Unconfined Compressive Strength of Black cotton soil treated with Different Layers of Fish Net Fibers

It is seen from Fig.4 that the unconfined compressive strength of Black cotton soil increases with the addition of Fish Net Fibers. With increase in different layers of fish net fibers (2, 3 and 4 layers), the strength increases, hence 2, 3 and 4 layers of fish net fibers are found to be optimum to strengthen the Black cotton soil.

![Stress-strain Curves for Black cotton soil and Black cotton soil treated with different layers of Fish Net Fibers without curing](image1)

3.3 Determination of California Bearing Ratio value of Black cotton soil treated with Different Layers of Fish Net Fibers

The purpose of the California bearing ratio test is to determine the Capacity of the Black cotton soil (CBR %) for a particular Black cotton soil and Fish Net Fiber. The CBR is determined by the ability of a mix (Grid type) to satisfy stability and flow properties. The Unit per load plotted versus Penetration. The maximum CBR value of 4 layers is 8.1%.

![CBR Curves for Black cotton soil and Black cotton soil mixed with different Layers of Fish Net Fibers](image2)

3.4 Determination of Tri Axial Compression Strength of Black cotton soil treated with Different layers of Fish Net Fibers

Tri axial compressive test calculation at different Layers (2, 3 and 4) of Fish Net Fibers for Soil Stabilization is
shown in the Fig 6 for various compaction efforts. The Shear stress Vs Normal stress. Cohesion of the soil and angle of internal frictions are plotted.

**Fig 6:** Major Principal Stress-Strain curve for Black cotton soil and Black cotton soil with difference Layers of Fish Net Fibers

**Fig 7:** Shear Stress-Normal Stress graph for Black cotton soil only
Fig 8: Shear Stress-Normal Stress curve for Black cotton soil and Black cotton soil with 2 Layers of Fish Net Fibers

Fig 9: Shear Stress-Normal Stress curve for Black cotton soil and Black cotton soil with 3 Layers of Fish Net Fibers
Fig 10: Shear Stress-Normal Stress curve for Black cotton soil and Black cotton soil with 4 Layers of Fish Net Fibers

4. CONCLUSIONS AND SCOPE FOR FURTHER STUDIES

The experiments were conducted on soil stabilization mixes for varying compaction energy using Heavy rammer. The Standard compaction, unconfined compressive strength property of the mixtures was conducted and the key notes are concluded in this chapter from the results obtained. The California bearing ratio, Tri axial test and Coefficient permeability test was also conducted and the conclusions were drawn from the results.

4.1 Conclusions

Based on the laboratory experimentation and the results obtained and analyzing the results the following may be concluded.

1. In this work, the effect of Fish Net Fiber on the engineering properties of Black cotton soil has been studied. In the case of Black cotton soil with 4 layers of Fish Net Fibers there is increase in maximum dry density and decrease in optimum moisture content. Hence Black cotton soil mixed with 4 layers of Fish Net Fibers content is considered to be optimum which shows maximum value of dry density 18.71 KN /M$^3$ at 14.97% optimum moisture content.

2. Unconfined compressive strength of Black cotton soil treated with 4 layers (maximum) of Fish Net Fibers content have shown an increase in the strength by 356.6 KN /M$^2$ compared with Black cotton soil alone.

3. CBR values of Black cotton soil treated with 4 layers of Fish Net Fibers have increased the value by 8.1% compared with Black cotton soil alone.

4. Tri Axial Test values of Black cotton soil treated with 4 layers of Fish Net Fiber have increase the value by 27 and 13° (Cohesion and Degree of friction) compared with Black cotton soil alone.

5. Coefficient of Permeability Test values of Black cotton soil treated with 4 layers of Fish Net Fiber has decrease the value by 1.197×10$^{-4}$ cms/sec compared with Black cotton soil alone.

REFERENCES

5. K. Suresh, V. Padmavati and Apsar Sultan, “Experimental study on stabilization of black cotton soil with stone dust and fibers”, *IGC 2009, Guntur, INDIA.*