Stabilization of black cotton soil by Fly Ash

Ashish Mehta¹, Kanak Parate² and B. S. Ruprai³

ABSTRACT

In India about 51.8 million hectares of the land area are covered with Expansive soils (black cotton soil). The Black cotton soils are very hard when dry, but lose its strength completely when in wet condition. Expansive soils are a worldwide problem that poses several challenges for civil Engineers.

Various methods are adapted to improve the engineering characteristics of expansive soils. The problematic soils are either removed and replaced by good and better quality material or treated using additive. The present paper deals with the properties of expansive soils of Maharashtra, India at various locations. In this study, black cotton was stabilized using fly ash (obtained from koradi thermal power plant). Expansive soils were stabilized with various proportion of fly ash i.e. at 0,10,20 30, 40 & 50%. Fly ash posses no plasticity. Plasticity index of clay fly ash mixes decreases with increase in fly ash content. Thus addition of fly ash makes expansive soil less plastic and increases its workability by colloidal reaction and changing its grain size. The CBR values of clay with fly ash mixes, tested under unsoaked & soaked conditions & there results were observed, with analysis of results it is found that the fly ash has a good potential to be used as an additive for improving the engineering properties of expansive soils.

Keywords: Expansive soil, fly ash, compaction characteristics, CBR value.

1. INTRODUCTION

In India about 51.8 million hectares of the land area are covered with Expansive soils (black cotton soil). The Black cotton soils are very hard when dry, but lose its strength completely when in wet condition. Expansive soils are a worldwide problem that poses several challenges for civil Engineers. Various methods are adapted to improve the engineering characteristics of expansive soils. The problematic soils are either removed and replaced by good and better quality material or treated using additive. The stabilization of the problematic soils is very important for many of the geotechnical engineering applications such as pavement structures, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, and sewer lines to avoid damage due to settle of soft soil or to the swelling action of expansive soil.

Generally, the stabilization concept can be dated 5000 years ago. Treated earth roads were used in ancient Mesopotamia and Egypt, and that the Greek and Roman used soil-lime mixtures [1]. The first experiments on soil stabilization were achieved in the USA with sand/clay mixtures around 1906. In the 20th century, especially in the thirties, the soil stabilization relevant to road construction was applied in Europe [2] The pavement soil qualities will be improved by thoroughly mixing...
and compacting with additives include Portland cement, fly ash, bitumen, and combinations of any of the additives [4]. The type of the additive and the amount required are dependent upon the soil classification and the degree of improvement desired [5].

Numerous investigators, ([6], [7], [8], [9] & [10], have studied the influence of lime, cement, lime-cement, lime-flyash, lime–ricehusk- ash and cement – fly ash mixes on soil properties, mostly focusing on the strength aspects to study their suitability for road bases and subbases. As lime and cement are binding materials, the strength of soil-additive mixtures increases provided the soil is reactive with them. However, for large-scale field use, the problems of soil pulverization and mixing of additives with soil have been reported by several investigators ([6],[7],[8],[9],[10]).

2. MATERIALS AND METHODS

Black cotton soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. This Black cotton soils occurs mostly in the central and western parts and covers approximately 20% of the total area of India. Because of its high swelling and shrinkage characteristics, the Black cotton soil (BC soils) has been a challenge to the highway engineers.

2.1 BLACK COTTON SOIL

Geotechnical properties of black cotton soil are given in Table 1

<table>
<thead>
<tr>
<th>Colour</th>
<th>Specific Gravity</th>
<th>Liquid limit (%)</th>
<th>Plastic limit (%)</th>
<th>Shrinkage limit (%)</th>
<th>OMC (%)</th>
<th>MDD (g/cc)</th>
<th>Free swell index (%)</th>
<th>Swelling pressure (kg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>2.65</td>
<td>40- 60</td>
<td>15 - 25</td>
<td>8 - 15</td>
<td>20-30</td>
<td>1.4-1.6</td>
<td>50 to 60</td>
<td>4-6</td>
</tr>
</tbody>
</table>

2.2 FLY ASH

Fly ash additive in soil, fly ash is use due to
- Fly ash is costless and abundantly available all over the country.
- As fly ash is a by-product of thermal power plants, land area required for its disposition is a great problem in a densely populated country like India.
- Utilization of fly ash solves the problem of air and water pollution.

Table 2: Properties of fly ash

<table>
<thead>
<tr>
<th>Colour</th>
<th>Specific Gravity</th>
<th>Plasticity</th>
<th>OMC (%) at MDD (g/cc)</th>
<th>Cohesion (kN/m²)</th>
<th>Angle of internal friction</th>
<th>Compression index C_c</th>
<th>Permeability (cm/sec)</th>
<th>Coefficient of uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey</td>
<td>1.90 – 2.55</td>
<td>Non plastic</td>
<td>38.0 – 18.0</td>
<td>0.9 – 1.6</td>
<td>Negligible</td>
<td>30° – 40°</td>
<td>0.05 – 0.4</td>
<td>8 x 10^{-6} – 7 x 10^{-4}</td>
</tr>
</tbody>
</table>
3. TEST PROGRAMME

Several tests have been conducted to observe geotechnical properties of black soil like

   i) Specific Gravity
   ii) Atterberg limit tests

In case of flexible pavement construction, the bottom most layer is soil subgrade. It is desired that soil subgrade should carry loads without large deformations which finally results in failure of pavements. For economic design, locally available soil should be used as soil subgrade. It is tedious for civil engineers to provide flexible pavement on black soil due to swelling shrinkage nature of soil. As for soil subgrade, normally locally available soil is used, and soil improvement will be required. Nowadays, various techniques are available to stabilize the soil. So, as part of soil stabilization, fly ash is used in varying percent as 10, 20, 30, 40 & 50%, and the effect of fly ash on water content density relationship & CBR value will be observed.

4. OBSERVATION & RESULTS

4.1 EFFECT OF COMPACTION

   Effect of fly ash on geotechnical properties of soil are

   

<table>
<thead>
<tr>
<th>Particular</th>
<th>OMC (%)</th>
<th>MDD(N/m³)</th>
<th>CBR (soaked)(%)</th>
<th>CBR (unsoaked)(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. c soil</td>
<td>20.4</td>
<td>14.7</td>
<td>3.1</td>
<td>6.89</td>
</tr>
<tr>
<td>B. c soil+10% fly ash</td>
<td>29.17</td>
<td>14.20</td>
<td>2.52</td>
<td>12.78</td>
</tr>
<tr>
<td>B. c soil+20% fly ash</td>
<td>22.19</td>
<td>14.97</td>
<td>2.0</td>
<td>22.90</td>
</tr>
<tr>
<td>B. c soil+30% fly ash</td>
<td>26.19</td>
<td>14.4</td>
<td>1.89</td>
<td>6.98</td>
</tr>
<tr>
<td>B. c soil+40% fly ash</td>
<td>27.1</td>
<td>13.9</td>
<td>2.49</td>
<td>7.68</td>
</tr>
<tr>
<td>B. c soil+50% fly ash</td>
<td>24.16</td>
<td>13.6</td>
<td>2.35</td>
<td>7.61</td>
</tr>
</tbody>
</table>

Figure 1: Water content density relationship for soil fly ash mix
With following results it is observed that, the unsoaked CBR value is higher with 20% Fly ash compared to other mixes. Comparatively the dry density with 20% fly ash is higher than the other percentages of fly ash. So it may be reported that fly ash has good potential for use in geotechnical applications. The relatively low unit weight of fly ash makes it well suited for placement over soft or low bearing strength soils. Its low specific gravity, freely draining nature, ease of compaction, insensitivity to changes in moisture content, good frictional properties, etc. can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures, etc.

REFERENCE


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