Stabilization of lime treated Black Cotton Soil using Plastic Waste

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ABSTRACT: Plastic, typically organic polymers of high molecular mass are used in an enormous and expanding range of products due to its low cost, ease of manufacturing etc. Rapid urbanization and increase in population has led to a huge demand in use of plastic nowadaysk. The disposal of used plastic is causing environmental pollution adversely affecting wildlife and humans. Hence the disposal of plastic has become a great challenge. Here we made an attempt to use this plastic waste in the stabilization of expansive soils. Expansive soils are considered to be one of the most problematic soils for the construction practices due to its large volume changes and undesired settlements. Hence there arises the need to stabilize the expansive soils for making it useful for construction activities. In the present study, expansive soil collected locally is stabilized with plastic waste. The expansive soil is mixed with plastic waste from 0 to 4% at an increment. The samples are tested for Unconfined Compressive Strength value based on the Maximum dry density and Optimum moisture content values obtained from Proctor test. The percentage of plastic waste added to the expansive soil which yields the maximum UCS strength is reported as the Optimum percentage of plastic based on the laboratory tests.

KEYWORDS: Soil Stabilization, Compaction, Unconfined Compressive Strength, Black Cotton Soil.

I. INTRODUCTION

Soil Stabilization is the process of alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. The stabilization process is mostly adopted for soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. The fine grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter.

Expansive soils contain montmorillonite minerals such as smectite clays that are capable of absorbing water. When they absorb water they increase in volume. Expansions of 10% or more, are not uncommon. This change in volume can exert enough force on their building or structure to cause damage. Cracked foundations, floors and basement walls are typical types of damages done by swelling soils. Expansive soils will also shrink when they dry out. In India these expansive soils are known by local names such as black cotton soils in central India, bentonite in Rajasthan and Kashmir, mar in Uttar Pradesh. These soils occupy about 20-30% of the land area of India.
Use of plastic bags bottles and other plastic products is exponentially increasing year by year. Due to which we are facing various environmental problems and disposal problems. So, here we stabilize soil using this plastic waste so that the cost of stabilization decreases and the pollution also decreases which will be useful in economical consideration.

Increased use of plastics in day to day consumer applications resulted in the municipal solid waste, an ever-growing fraction of plastic material which were used for a short time and then discarded. There is, therefore a growing need to find alternative uses of reclaimed plastic bag waste to lengthen the usage time of the plastic material and there by save the degrading environment. The concept of pre-forcing soil masses with strips of plastic covers maybe relatively, a new development. In contrast, the use of random-materials as reinforcement for soil is probably not older than written history, but only sparsely represented.

The main scope of this project is to analyse the effects of inclusion of plastics fibres in soil on the stability of soil in a cost-effective manner. The four different replacement percentages of plastic fibres (0%, 1%, 2%, 4%) will be tested.
II. LITERATURES REVIEW

V. Mallikarjuna, T. Bindu Mani [1] studied about black cotton soils and stated that the expansive nature of BC soil is due to the presence of montmorillonite, which is an expansive lattice. This paper presents the result of an attempt that was made to find the unconfined compressive strength and CBR of black cotton soil by adding plastic waste in the proportions 2%, 4%, 6% & 8%. The unconfined compressive strength of the black cotton soil increases by adding the soil with plastic waste. The CBR value has been increasing up to 4% plastic content and thereon it started to decrease. From this, it can be inferred that, 4% plastic content is the optimum utilization of waste plastic in the soil. Shiva Kumar K, Vidyaranya V et.al, [2] worked on stabilization of black cotton soil using plastic strips (0.05%, 0.1%, 0.15% and 0.2%). Plastic was made in to strips mixed with black cotton soils were studied by carrying unconfined compression tests and California bearing ratio tests. The results showed that there is appreciable increase in strength and CBR value for the black cotton soils by the addition of plastic strips. The proposed method can be used for small projects like implementing for construction of pavements for village roads. The thickness of pavement layer can be reduced by using waste plastic strips. It was found that the UCS value increased with the increase in curing days. Large change in UCS value was not observed with 0% and 0.05% and when 0.10% and 0.15% was compared. Arpitha GC, Dayanandha BV et.al, [3] attempted to find the unconfined compressive strength of black cotton soil by adding plastic waste pieces as admixture. The admixture plastic waste pieces are added with an increment. Plastic strips are mixed at different percentage i.e., 0.05%, 0.1%, 0.15%, 0.2% to the dry weight of soil. Modified proctor test, unconfined compression strength test and California bearing ratio tests are conducted to determine the strength and CBR values of the soils. In this study, the maximum CBR value can be achieved when 2% amount of plastic bottle strips are added to the soil but it decreases when further amount of plastic bottle strips is added. So from this study, 0.75% is optimum amount of the strips that can added to soil the soil for efficient use.

III. METHODOLOGY

Materials

Black Cotton soil: The Black cotton soil used in the present study was collected from VEMAGIRI rural area of RAJAMAHENDRAVARAM. The samples are oven dried at a temperature of around 100-110°C for a period of 24 hr to make it moisture free. It is sieved through 2mm sieve to make it free from debris and foreign matter. The Black cotton soil is stored in moisture tight bags and containers for further experimental use.

Lime: The lime, which is used as an agent of stabilization, is bought from Visakhapatnam market. The samples are sieved through 15 microns sieve and stored in air tight container for subsequent use.

Plastic strips: The admixture used in this study is Plastic strips. It is obtained from waste plastic products like bottles, bags etc. The waste plastic is cut into small strips of dimensions 1-2mm wide and 10-15mm long, manually using scissor.
Table 1: Physical properties of the Soil samples which are oven dried are determined

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Specific gravity</td>
<td>2.72</td>
</tr>
<tr>
<td>Liquid limit (%)</td>
<td>87</td>
</tr>
<tr>
<td>Plastic limit (%)</td>
<td>43.55</td>
</tr>
</tbody>
</table>

1. COMPACITION

The specimens are prepared with plastic strips (PS) percentages 0, 1, 2 & 4% in the mould of volume 113.45cc in 3 layers with 36 blows each with the standard hammer. The specimens are kept in oven for 24 hours to determine moisture content. Thus, the maximum dry densities and the corresponding water contents for the different proportions of plastic waste and Soil with 10% lime are determined from the graphs between dry density and the corresponding water content and are tabulated.

Table 2: Maximum dry density and Optimum Moisture Content of samples at various percentages of plastic waste with Soil and 10% lime

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OMC (%)</th>
<th>Max. Dry Density(g/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansive soil</td>
<td>17</td>
<td>1.712</td>
</tr>
<tr>
<td>Expansive soil + 1% PS</td>
<td>16</td>
<td>1.834</td>
</tr>
<tr>
<td>Expansive soil + 2% PS</td>
<td>15</td>
<td>1.971</td>
</tr>
<tr>
<td>Expansive soil + 4% PS</td>
<td>14</td>
<td>2.07</td>
</tr>
</tbody>
</table>

2. UNCONFINED COMPRESSIVE STRENGTH TEST

The Unconfined Compressive strength of black cotton soil with different percentages of plastic strips as stabilizer (0, 1, 2 and 4%) is studied as per IS 2720 Part 16 1987. The samples are cured at constant temperature of 27° C for 0, 7 and 14 days.
IV. RESULTS AND DISCUSSIONS

Compaction test:

It is observed that with an increase in plastic content in black cotton soil, optimum moisture content decreases where as dry density of soil increases. The MDD of black cotton soil varies from 1.625 g/cc to 2.07 g/cc and the water content decreased from 17% to 14% for increase in plastic content from 0% to 4%.

Unconfined Compressive test:

The strength of the black cotton soil with 10% lime samples increased from 2.332 kPa to 5.67 kPa with no plastic to 2% plastic strips and decreases to 3.43 kPa with 4% plastic respectively. The plastic waste in the form of strips added as stabilizer acts as a fibrous material by holding the soil particles together and lime undergoes pozzolanic reaction with soil. The soil sieved through 2mm sieve is used, which is in fine form resulting in speed reaction. This ultimately results in increase in strength of the soil when lime and plastic are added to it.
Optimum percentage of plastic for different curing periods are tabulated below from the graph showing the variation of Unconfined Compressive strength (kPa) with different percentages of plastic strips.

Table 3: Optimum percentage of plastic strips

<table>
<thead>
<tr>
<th>Curing period</th>
<th>Optimum percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 days</td>
<td>1.60</td>
</tr>
<tr>
<td>7 days</td>
<td>1.90</td>
</tr>
<tr>
<td>14 days</td>
<td>1.75</td>
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</table>

From the values obtained from the compaction and unconfined compressive strength tests it is determined that the average optimum percentage of plastic that can be used for stabilization of black cotton soil along with 10% lime is 1.75%.

Fig 6: Variation of UCS (kPa) different percentages of plastic strips in soil over different curing periods

V. CONCLUSIONS

Experiments are conducted to determine the strength properties of black cotton soil stabilized with 10% of lime and plastic waste in form of strips.

1. The Maximum Dry Density of black cotton soil varies from 1.712g/cc to 2.07g/cc and the Optimum Moisture Content decreased from 18% to 13% for increase of plastic content from 0 to 4%.
2. With an increase in plastic content, the unconfined compressive strength of soil samples increases from 2.332kPa to 5.67kPa with no plastic to 2% plastic and decreases to 3.4kpa with 4% plastic respectively.

3. The immediate strength of black cotton soil samples increased with an increase of plastic content up to 2%. The strength decreased from 3.42kPa to 2.9kPa for 2% plastic content to 4% plastic content in soil samples.

4. For the curing period of 7 days, the unconfined compressive strength of soil increases from 2.92kpa to 4.89kpa with no plastic to 2%plastic respectively and decreases to 3.1kpa for 4% plastic.

5. For the curing period of 14 days, the unconfined compressive strength of soil increases from 3.5kpa to 5.67kpa with no plastic to 2%plastic respectively and decreases to 3.4kpa for 4% plastic.

Thus we can conclude that the optimum percentage of plastic content that can be used for stabilization of soil is 1.75%.

REFERENCES


