Experimental Study on Stabilization of Black Cotton Soil by Fly Ash, Coconut Coir Fiber & Crushed Glass

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Abstract— As the Black Cotton Soil possess undesirable engineering properties like Excessive Variation in volume with change in water content, There is considerable shrinkage on drying result in formation of extensive cracks, Black Cotton soil experiences high swelling on being soaked, Low compressive strength at higher water content etc.

The objectives of the present studies focus on to analyze property of soil such as Atterberg’s Limits, Compaction Curve (O.M.C. and M.D.D.), Shrinkage Limit, California Bearing Ratio, Swelling Pressure, Permeability, direct shear test, effect of Fly Ash, Coconut fiber& crushed Glass with various percentages along with Black cotton Soil, combination on the above proportion of ingredients, use of waste products instead of conventional materials like cement, lime, etc. & how to increase cost benefit ratio.

To achieve this goal experimental study on 48 trial samples test were carried in two phase such as in first phase, the physical properties of soil such as hygroscopic moisture content grain size distribution, specific gravity, Atterberg’s limits, Direct shear test, Swelling pressure, MDD-OMC, CBR, Permeability test values are determined. In second phase, various test investigation performed on black cotton soil using different percentages of Fly Ash (FA) at 10%, 15%, 20%, 25%, Coconut Coir Fiber (CCF) at 0.25%, 0.5%, 0.75%, 1% & Crushed Glass (CG) at 3%, 5%, 7% (glass crushed to have gradation of sand size).

Keywords— Black cotton soil, California Bearing Ratio Coconut Coir Fibre, Crushed Glass, Fly ash, Soil Stabilization, Swelling Pressure.

I. INTRODUCTION

Marginal and weak soils, including soft clays, black cotton soil, organic deposits, and loose sand, are often unsuitable for construction due to their poor engineering properties. Expansive soil experiences volume change due to alteration in moisture content. Black Cotton soil covers about 30% of the land area in India. The name “Black Cotton” as an agricultural origin. Most of these soils are black in colour and are good for growing Cotton.

In monsoon seasons, soils imbibe water, swell become soft and capacity to bear water is reduced. In drier seasons, these soils shrink or reduce in volume due to evaporation of water and they become harder. Due to its peculiar characteristic of high plasticity, excessive swelling, shrinkage and low strength when wet, the soil is regarded unsuitable for construction material. Heavy financial investments are required to be made for construction of roads, canals and embankments due to non availability of suitable soil.

During the last two decades environmental hazards, regulations and heightening of public awareness has made it difficult as well as costly to dispose of the waste materials. Therefore fly ash may be stabilized through traditional soil stabilization agents such as lime, cement, and chemicals. These materials are costly, harmful for environment and inconvenient in handling with fly ash. Soil is used as sub grade or sub base material. Waste materials, such as waste glass, coconut coir fibers, etc. can be use with fly ash in soil stabilization of expansive soil.

II. LITERATURE REVIEW

Bairwa Ramlakhan et al.[1] represents a study of the lime and fly ash as the admixtures or stabilizers in improving some engineering Properties of Black cotton (BC) soils. This experimental program evaluates the effect of the lime and fly ash on the some basic engineering properties of BC soil such as Liquid limit, plastic limit and compaction of BC soil and California bearing ratio (CBR) of BC Soil. The percentage of lime used in black cotton soil varied from 3% to 12%. Besides the percentage of fly ash used in BC soil varies from 10% to 40%.

Barua et.al [2] has studied on the roads of Assam facing problems like formation of potholes, ruts, cracks and localized depression and settlement especially during rainy season.
Laboratory and field studies have shown that this fly ash was suitable for stabilizing gravel roads. This conclusion is based on: An initial leaching of K, Na, Cl and SO4 was found from the test sections but the leaching decreased with time and after two years the concentrations were similar between reference and test sections and The sections had high infiltration capacity but despite that a discrepancy was found between leaching from the road and leaching of fly ash in laboratory experiments.

Singh et al. [7] has carried out experimental studies on the stabilizing effect of Natural fiber (coconut coir) on soil properties. Soil samples for unconfined compression strength (UCS) and California bearing ratio (CBR) tests are prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould without and with coir fiber. Tests result indicates that both unsoaked and soaked CBR value of soil increases with the increase in fiber content.

### III. Experimental Setup

(a) Material Used

- Expansive soil was excavated from Double Choukey near NH-59 A Indore (M.P.) at depth of 0.5 m by random sampling.
- Fly Ash was purchased from Fly ash brick plant situated at Manavta Nagar, Indore (M.P.). The fly ash is a byproduct obtains from thermal power plant having low densities useful for structural fills, highway embankments.
- Coconut coir fiber was brought from Siyaganj Market and Various temples in Indore (M.P.).

(b) Experimental Investigation Performed

In first phase, the physical properties of soil such as hygroscopic moisture content grain size distribution, specific gravity, Atterberg’s limits, Direct shear test, Swelling pressure, MDD-OMC, CBR, Permeability test values are determined.

In second phase, various test investigation performed on black cotton soil using different percentages of Fly Ash (FA) at 10%, 15%, 20%, 25%, Coconut Coir Fiber (CCF) at 0.25%, 0.5%, 0.75%, 1% & Crushed Glass (CG) at 3%, 5%, 7% (glass crushed to have gradation of sand size).
TABLE 1
Properties of Soil

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<th>PROPERTIES</th>
<th>TEST RESULTS</th>
<th>IS CODE REFERRED</th>
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<td>IS Classification</td>
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<td>IS: 2720 (part IV)-1965</td>
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<tr>
<td>MDD (gm/cc)</td>
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<td>IS: 2720 (part VIII) 1980</td>
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<tr>
<td>OMC %</td>
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<td></td>
</tr>
<tr>
<td>CBR %</td>
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<td>IS 2720 (part XVI)</td>
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<tr>
<td>Liquid Limit %</td>
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<td>IS: 2720 (Part V)-1985</td>
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<td>Plastic limit %</td>
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<td>IS: 2720 (Part V) 1965</td>
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<tr>
<td>Direct Shear Test</td>
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<td>Swelling Pressure Test</td>
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TABLE 2
Properties of Fly Ash Soil

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<tr>
<td>CBR %</td>
<td>3.48</td>
<td>IS 2720 (part XVI)</td>
</tr>
</tbody>
</table>

Figure 1 Soil Grain size distribution of Soil & Fly Ash

Figure 2 CBR comparison

IV. ANALYSIS & DISCUSSION

- Within present experimental study following discussions are drawn. On carried out experimental study on 48 trial samples we observe following things which are enlightened in the following paragraphs.

- On studying Fig.5.1, this curve shows great variation and required certain control condition to carry out test. We obtain all the values greater than the plain soil. It means that due to adulteration of this foreign material (F.A, CG & CCF) soil quality improves to great extent.

- In these test individual behaviour of FA.CG & CCF with soil has also carried out which shows that for adding 10%, 15%, 20%, 25% & 30% FA with soil produces highest CBR of value 4 at max 25%, after that curve height decreases gradually.

- Similarly on adding 3%, 5% & 7% we obtained highest CBR of value 3.1 at 7% CG after curves falls down enormously. Also for adding 0.25%, 0.5%, 0.75%, 1% & 1.25% of CCR we obtained max curve height at CBR value of 3.6 after that curve should successive depletion.

- Hence we determined from experimental results for combinations made for 25%FA, 7% & 1%CCF to set range for combination for this 48 trial samples are made. During this trial C.B.R, curve attains highest value at 5.2 and falls down 2.2 and again it goes to 3.8, for different set of combination.

V. CONCLUSION

On the basis of present experimental study following conclusions are drawn.

- Addition of Fly Ash, Coconut Coir Fibre (CCF), and Crushed Glass (CG) in Black Cotton Soil improves the Engineering properties of soil.

- Present study shows that optimum combination is 20% FA + 5% CG +1 % CCF With soil.

- Reduces swelling pressure up to 1/10th.
Increases enormously raise California Bearing Ratio up to 3.5 times for optimum combination.

- Direct Shear Test value Of C (Cohesion) decreases and Value of \( \phi \) (Angle of internal friction) increases.
- Increases soil Permeability which is good for drainage purpose.
- After Analysing the \textit{cost benefit Ratio} cost has reduced up to Rs 7, 45,000/- per kilometer.
- This set of combinations shows that individual they are weak to produce good result but use in proportion increases the soil properties more than there individual performance.

VI. \textbf{FUTURE SCOPE}

In future study tests can be carried on black cotton soil or on different types of soil. The fly ash can be replaced by lime, stone dust, sand, cement. Also Nylon fibers can be replaced by coconut coir, jute (natural fibers) or polypropylene, shredded rubber tire (artificial fibers), geo-textile or geo-synthetic. From the above materials, mixes of different proportions or combinations can be made for improving the properties of soil which may be used for construction of embankment or soil sub grade in highways.

\textbf{REFERENCES}


[6] IRC SP 58 “Guidelines for use of Fly ash in Road Embankment”.


[8] IS: 2720 (part IV)-1965 Methods of Test for soil “Determination of Grain size analysis by sieving (Dry analysis)”.


