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Stabilization of Black Cotton Soil Using Rice Husk Ash for Flexible Pavement Construction

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Abstract: In India there are different types of soils, and the most likely present soil is clay. The flexible pavement consists of different layers such as embankment, subgrade, GSB, WMM, DBM and BC. Sub grade is the layer which acts as the foundation for pavement. In order to use the cut and fill principle, available nearby lands are selected as the borrow area for making sub grade. In this situation, the soil may not be suitable for subgrade construction. Keeping this in view stabilization of weak soil in situ may be done with suitable stabilizers to save the construction cost considerably. In the present investigation agricultural waste materials like Rice Husk Ash (RHA) which is mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics.
Key words: Black cotton soil, RHA, Stabilization, CBR Flexible pavement.

I. INTRODUCTION

Stabilization is also called as ground modification is process of altering soil properties or the engineering properties of the native problematic soils to meet the design specifications. Now a days, soils such as, soft clays and organic soils can be improved to the civil engineering requirements.

This focuses on soil stabilization method which is one of the several methods of soil improvement. The reaction of a soil with the stabilizer is important for stabilization or modification and design methodology. Soil characteristics including mineralogy, gradation and physio-chemical properties of fine grained soils influence the soil-additive interaction. Hence stabilizer selection should be based on the effectiveness of a given stabilizer to improve the physio-chemical properties of the selected soil. The preliminary selection of the appropriate additive(s) for soil stabilization should consider:

1) Soil consistency and gradation
2) Soil mineralogy and composition
3) Desired engineering properties
4) Purpose of treatment
5) Mechanisms of stabilization
6) Environmental conditions and engineering economics.

The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increase in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations. These types of soil quality improvement are referred to as soil modification.

II. LITERATURE REVIEW

The C.B.R. values of black cotton soil raised from 1.94 to 9% on addition of lime with RHA. (Puram Nagaraju .et.al 2017). There is also an improvement within the unsoaked CBR (106% at 10% RHA content) compared with the CBR of the natural soil. Unsoaked and soaked CBR values of soil increases at 6% lime with 10%, 15% RHA but starts decreasing at 20% and 25% RHA. When lime varied as 3% and 9% at optimum percentage of RHA, the optimum value of CBR is at 3% lime (Garima Kishore et.al 2015).

CBR value of black cotton soil also increase with increasing in rice husk ash. CBR value of black cotton soil is maximum with combination of lime (8%), ash (20%) and RHA (20%) (Pravin Patel .et.al 2017) the increase in CBR value corresponds to the increase in cement content. Adding RHA into cement-treated soil, the CBR value increase. The maximum amount as 60% is found at combination of 4% cement and 5% RHA (E.A. Basha et.al 2004).

III. MATERIALS USED

1) *Black Cotton Soil:* Black cotton soil used in the study is obtained from Belagavi in the state of Karnataka. It is smooth in texture. For the purpose of tests, the soil is collected at a depth of 1mt below the ground level. It is pulverised, dried, sieved through different sieves for the required tests and stored in polythene bags in the laboratory.
2) *Rice Husk Ash:* The rise husk ash is collected from Vishalakshi Rice Mill at Belagavi. The rise husk ash is ground and sieved through 0.075mm aperture before use.

IV. RESULTS AND DISCUSSIONS

The properties of BC soil is determined in the laboratory as per Indian standards and the results are shown in table: 1

Table: 1 Index properties of BC soil.

Sl No	Laboratory tests	Results
1	Grain size distribution;Gravel and Sand (%) Silt and Clay (%)	8.89 91.11
2	Specific gravity(G)	2.72
3	Liquid limit (ws) (%)	65.80
4	Permeability of soil (k) cm/sec	$2.06X10^{-6}$
5	Plastic limit (wp) (%)	35.50
6	Plasticity Index (PI)	30.30
7	Shrinkage limit (ws) (%)	13.8
8	Unified soil classification	CH

1) *Index Properties:* Wet sieve analysis test is carried out on soil sample and it is found that silt and clay fraction is about 91.11%. Specific gravity test is conducted using density bottle method and is found to be 2.72.The liquid limit test is conducted by Casagrande method and it is found to be 65.80% for BC soil which is very high. Plastic limit is found to be 35.50 % and shrinkage limit is 13.8 %. Hence the soil is inorganic clay of high plasticity .The permeability of soil is obtained from falling head permeability test which gives the co-efficient of permeability k= $2.06X10^{-6}$ cm/sec.
2) *Compaction Properties Of Bc Soil:* Proctor test is conducted to determine the maximum dry density and optimum moisture content of BC soil and the results are shown in table 2

Table 2. Proctor test results

Sl No	Laboratory tests	Results
1	Optimum moisture content (OMC) %	23
2	Max dry density (MDD) gm/cc	1.41

It is observed that the maximum dry density is found to be 1.41gm/cc and corresponding optimum moisture content is found to be 23%.

3) *Strength Properties Of Bc Soil:* Direct shear test is conducted on the remoulded sample using the optimum moisture content obtained from proctor test. The result is shown in table 3.

Table: 3 Strength properties of BC soil

Sl No	Laboratory tests	Results
1	Cohesion (C),kg/cm^2	0.3
2	Angle of internal friction (Φ) ^{o}	13^o
3	UCS, kg/cm2	1.30
4	CBR Value	
a	Unsoaked 2.5mm	5.60 %
b	5.0mm	2.18%
c	Soaked 2.5mm	3.65%
d	5.0mm	2.06%

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V. RESULTS AND DISCUSSIONS OF BC SOIL STABILIZED WITH RICE HUSK ASH WITH DIFFERENT PERCENTAGES

Table: 4 compaction properties of BC soil stabilized with RHA

Percentage replacement of BC soil by rice husk ash	Maximum dry density gm/cc	Percentage increase or decrease of maximum dry density w.r.t reference mix	OMC %
0% Ref mix	1.41	-	23.00
5%	1.43	1.42	22.20
10%	1.44	2.13	21.60
15%	1.43	1.42	22.80
20%	1.42	0.71	23.50
25%	1.41	0.00	24.40
30%	1.39	-1.42	25.80
35%	1.36	-3.55	27.80
40%	1.33	-5.67	28.70

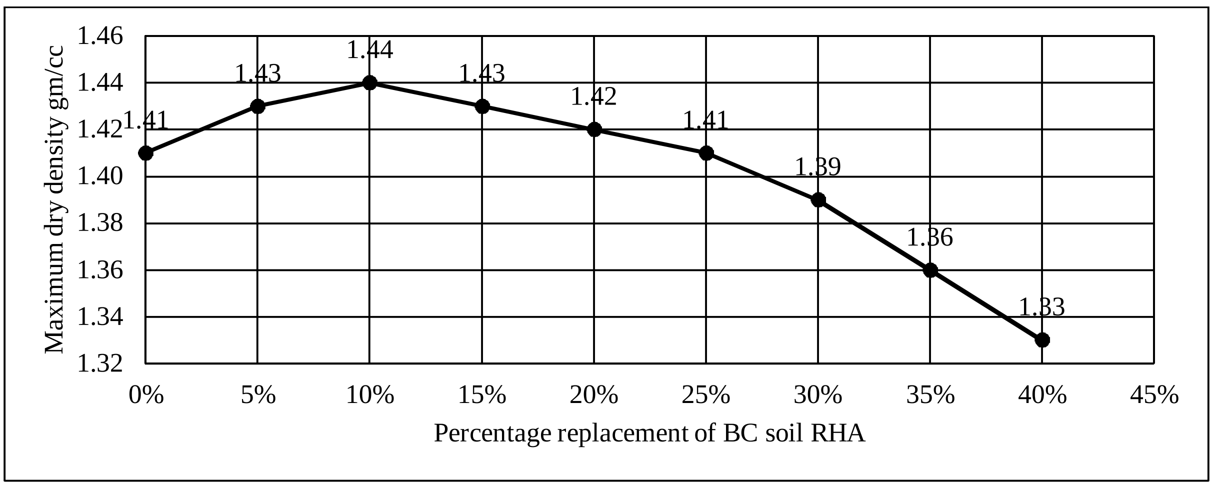

Fig: 1 Variation of maximum dry density for different percentage replacement of BC soil by RHA

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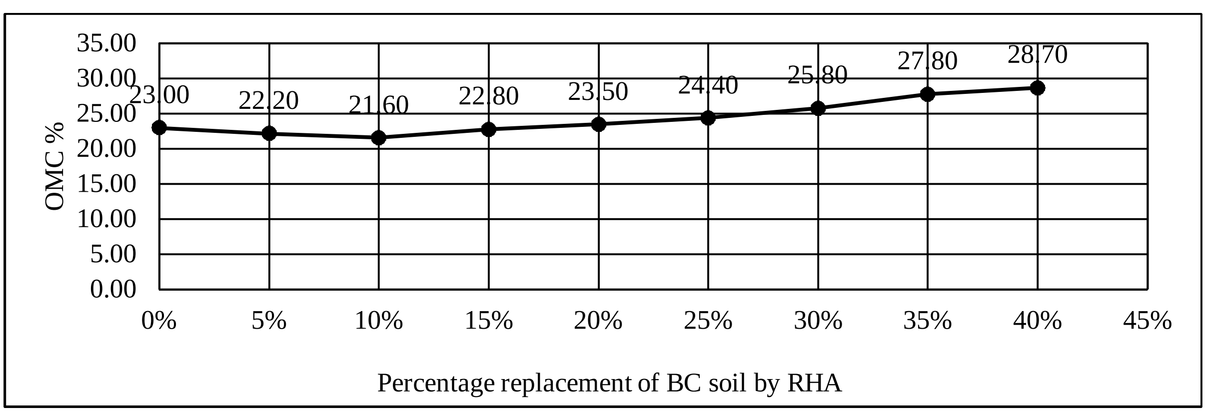

Fig: 2 Variation of optimum moisture content for different percentage replacement of BC soil by RHA.

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Table 5 CBR value of BC soil stabilized with RHA.

CBR %			
Unsoaked	Percentage increase or decrease of unsoaked CBR w.r.t reference mix	Soaked	Percentage increase or decrease of soaked CBRw.r.t reference mix
5.60		3.65	
7.80	39.29	4.32	18.36
10.94	95.36	5.23	43.29
10.54	88.21	4.65	27.40
10.32	84.29	4.46	22.19
10.17	81.61	4.38	20.00
10.08	80.00	4.32	18.36
9.85	75.89	4.27	16.99
9.78	74.64	4.21	15.34

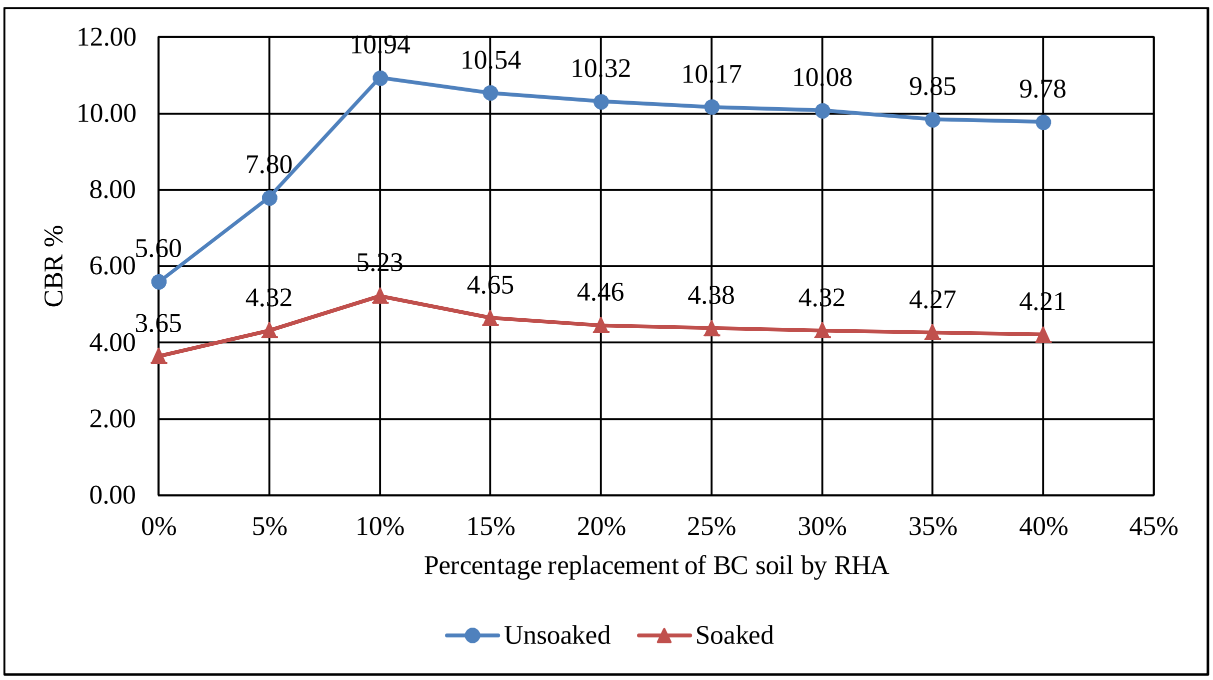

Fig: 3 Variation of unsoaked and soaked CBR values for different percentage replacement of BC soil by RHA.

Table 4 and fig 1 and fig 2, and it is observed that the maximum dry density is obtained at 10% replacement of BC soil with RHA. At 10% replacement level the maximum dry density is found to be 1.44gm/cc and corresponding optimum moisture content is found to be 21.60%.

The reduction in dry density after 10% replacement level is due to result of flocculation and agglomeration of fine grained BC soil particles which occupies larger space leading to a corresponding drop in maximum dry density. It is also the result of initial coating of BC soil particles by RHA to form larger aggregate, which consequently occupy larger spaces.

Thus it may be concluded that the maximum dry density of BC soil stabilized with RHA may be obtained at 10% replacement level.

Table 5 and fig 3 illustrates the variation of CBR values. It is observed that soaked and unsoaked CBR values reach their higher values when 10% BC soil is replaced by RHA. There after the CBR values show decreasing trend.

This may be due to the fact that the increase in the contact area and adhesion between RHA and soil which will create a dense network of interconnected particles. The increase in CBR value may be due to the shear transfer mechanism between the soil and RHA and the improvement in the strength is due to the puzzolonic action of BC soil-RHA mix.
Thus, it may be concluded that the CBR values reach their higher value when 10% BC soil is replaced by RHA.

VI. CONCLUSIONS

Based on the above results and discussions the BC soil when stabilized with RHA shows improvement in the strength properties. The maximum dry density of BC soil stabilized with RHA may be obtained at 10% replacement level and also the CBR values reach their higher value when 10% BC soil is replaced by RHA.Hence 10% of RHA can be effectively used to stabilize the BC soil in flexible pavement construction.

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