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A Experimental Study of Black Cotton Soil, Stabilized with Rice Husk Ash, Fly Ash and Lime

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***Abstract*- An experimental investigation is carried out to study the effect of Rice husk ash, Fly ash and Lime on index and engineering properties of Black cotton soils. The properties of stabilized soil such as compaction characteristics, unconfined compressive strength and california bearing ratio were evaluated. Various percentage of Rice husk ash (5,10,15&20), Fly ash(10,15,20&25),Lime(2.4.6 & 8) have been used to improve the engineering properties of expansive black cotton soil. One ingredient at a time has been mixed with soil and index as well as engineering properties have been determined. The optimum content of each ingredient has been mixed together and the same properties have been evaluated.**

It has been concluded that liquid limit & plastic limit of soil is reduced by adding of any ingredient individually. However the improvement in shrinkage limit is not substantial. The standard proctor perimeter are influenced negatively i.e. OMC varies from 15% to 18% using RHA and Fly ash. The maximum dry density (MDD) is reduced from 1.71 to 1.57 gm/cc. The Φ value decreases from 19° to 10°and Cohesion value is increases from 0.5 to 1 kg/cm^2 using RHA The Φ value is decreases from 19° to 14° and Cohesion value increases from 0.5 to 1.1 kg/cm^2 using fly ash. The CBR value increases from 1.52% to 3.64% using Lime, it increases from 1.52% to1.70% using Fly ash and 1.52% to 1.70% using RHA. The CBR value is 12.74% at combination of RHA, fly ash and lime. The UCS value increases with increase in percentage of RHA, Fly ash and Lime. Swelling pressure is decreases at different percentage of Lime and Fly ash. Coefficient of permeability is decreases at different percentage of Lime and fly ash. Plasticity index of soil is decreases with increase the percentage of RHA, Fly ash and Lime. The optimum percentage of RHA , fly ash and lime is 8%,20% and 20%. On treated soil reduction in sub-base layer by 60% and reduction in DBM layer by 40.7% in comparison to pavement design on Untreated Black Cotton soil. Pavement cost also decreases on treated soil. The objective of this work is to estimate the effect of RHA, Fly ash and Lime on some geotechnical properties of black cotton soil, in order to determine the suitability of RHA, Fly ash and Lime for use as a modifier or stabilizer in the treatment of black cotton soil for roadwork. The aim of this work is to find the optimum percentage of RHA, Fly ash and Lime.

1. INTRODUCTION- General

Soil is defined as sediments or other accumulation of mineral particles produced by the physical or chemical disintegration of rocks plus the air, water, organic matter and other substances that may be included. Soil is typically a non homogeneous, porous, earthen material whose engineering behavior is influenced by changes on moisture content and density. Black Cotton soil is clayey soil grayish to blackish in color. Some clayey soil contains montmorillonite clay mineral which has high expansive characteristics. Montmorillonite is the most common of all the clay minerals in expansive clay soils. The mineral made up of sheet like units. The basic structure of each unit is made up of gibbsite sheet I (i.e. octahedral sheet) sandwiched between two silica sheets, and is symbolized as shown in fig. The thickness of each unit is about 10 A and the dimensions in the other two direction are indefinite. The gibbsite layer may include atoms of aluminum, iron, magnesium or a combination of these. In addition, the silicon atoms of tetrahedron may interchange with aluminum atoms. These structural changes are called amorphous changes and result in a net negative charge on the clay mineral. Cat ions which are in soil water (i.e. Na+, Ca++,K+ etc.) are attracted to the negatively charged clay plates, and exist in a continuous state of interchange.

2. MATERIALS -

Natural soil-Soil stabilization is carried out for weak soils having low strength and poor engineering properties, the mostly available black cotton soil has low strength and stability to resist load coming on it and also it has high settlement characteristics. For this study Black cotton soil has been collected from SGSITS campus indore.

Rice husk ash- Rice milling generates a byproduct known as husk. This surrounds the paddy grain. During milling of paddy about78% of weight is received as rice, broken rice and bran. Rest 22% of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. The rice husk ash was collected from N.K. Enterprises, Jharsuguda, Orissa, India. The rice husk ash used in this study was prepared by burning at the temperature within the range of 600 ^{0}C to 800 ^{0}C at approximately 48 hours under uncontrolled combustion process. The ash obtained was grounded in a ball mill for 30 minutes and its appearance in color was grey. The specific gravity of R.H.A. is founded 1.85.

The basic constituents of RHA shown in table no. 1

Constituents (% mass)	Percent Content
Fe_2O_3	0.21
SiO_2	90.23
CaO	1.58
Al_2O_3	2.54
MgO	0.53
carbon	2.23
KaO	0.39

Fly ash- Fly ash is one of the material available in abundance as a result of industrial byproduct. It is generated in vast quantity as a result of burning coal in thermal power plants. The main constituents in Fly ash is silica and alumina up to 85% and other is 15%.
The basic constituents of Fly ash shown in table no. 2

Constituents of fly ash(%mass)	Values
Silica(SiO_2)	60
Alumina(Al_2O_3)	25
Ferric oxide($Fe2O_3$)	8.12
Calcium oxide(CaO)	2.9
Magnesium oxide(MgO)	0.82
Titanium oxide(TiO_2)	0.24
Free lime content	0.75

Lime- Lime has been widely used either as a modifier for clayey soil or as a binder. Major chemical constituent of lime is calcium hydroxide [Ca (oH)2]. Hydrated lime was used in this study. Collected from local market of indore.

The basic constituents of Fly ash shown in table no. 3

Components	Weight %
SiO_2	1
$Al2O_3$	2.54%
carbon	2.23%
CaO	90%
MgO	3
KaO	0.39%
Fe_2O_3	0.21

3. OBJECTIVE-

- ✓ To determine the properties of Black cotton Soil and soil Stabilized with different percentage of Rice husk ash, Fly Ash and Lime individually.
- ✓ To find the optimum value of RHA, Fly ash and Lime
- ✓ To evaluate the effect on the properties of Black Cotton soil stabilized with mixture of Rice husk ash, Fly ash and Lime.
- ✓ To analyze the cost and thickness of pavement at treated and untreated soil

4. SOIL PREPARATION AND EXPERIMENTS-

Lime is mixed in varying percentage of 2,4,6,8 with Natural soil. Fly ash is mixed in varying percentage of 10,15,20,25 with Natural soil. RHA is mixed in varying percentage of 5,10,15,20 with Natural soil.
Natural soil is treated with combination of Lime, Fly ash and RHA in 8%,20%,20%.

Number of laboratory tests were conducted on natural soil and stabilized soil such as show in below

- Particle Size Distribution Test.
- Compaction Test (Stander proctor test).
- California Bearing Ratio Test.
- Atterberg's limits (liquid limit, plastic limit, shrinkage limit).
- Unconfined Compressive Strength Test.
- Direct shear test.
- Swelling pressure.
- Permeability test

5. RESULTS AND DISCUSSION-

Plasticity index-
Plasticity index of black cotton soil is decreases at varying percentage of RHA, Fly ash and Lime.
Compaction parameters –
There is not major change in Maximum dry density (MDD) and Optimum moisture content (OMC) of Black cotton soil with stabilizers.
California bearing ratio (CBR) –
The California bearing ratio (CBR) values of BC soil increases with increase of RHA, fly ash and Lime content. The variation of the soaked CBR values with the increasing percentages of RHA, fly ash and Lime shown in figure

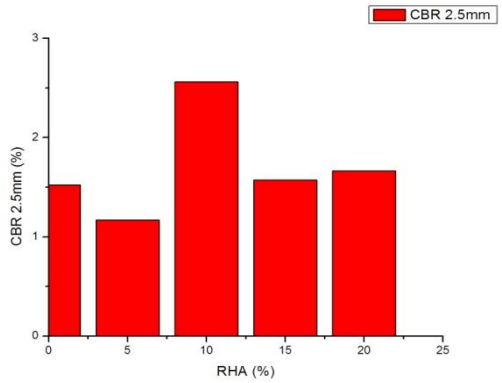


Fig. no.1Soaked CBR of soil stabilized with diff. % of RHA

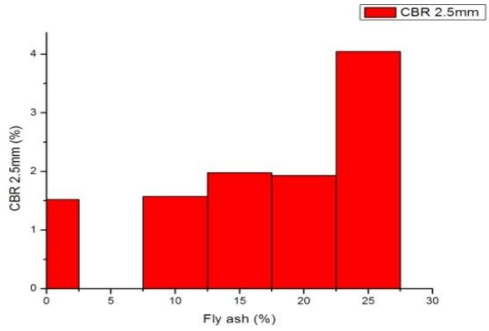


Fig. no.2Soaked CBR of soil stabilized with diff. % of Fly ash

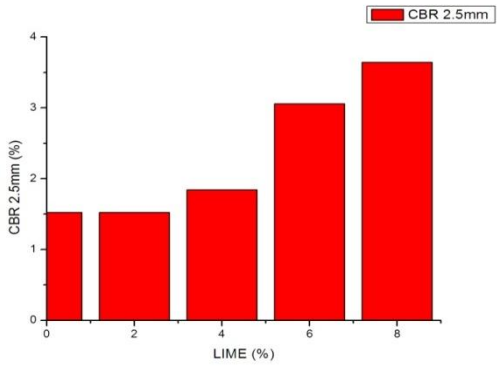


Fig. no.3 Soaked CBR of soil stabilized with diff. % of Lime.

The CBR value of soil at combination of Lime, fly ash and Rha(8%,20%,20%) is 12.5
Comparision of CBR value of treated and untreated soil is shown in fig.

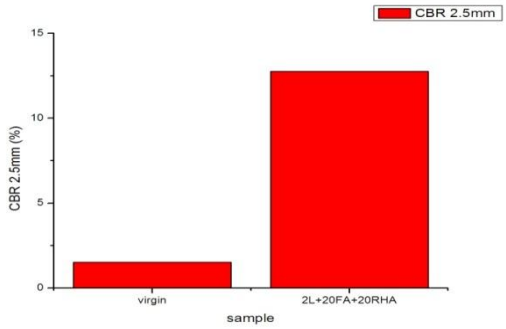


Fig. no.4 Soaked CBR of soil stabilized with combination of lime (8%), Fly ash (20%), and Rice husk ash(20%)

Unconfined compression test-
The UCS values of BC soil increases with increase of RHA, fly ash and Lime content. The variation of the UCS values with the increasing percentages of RHA, fly ash and Lime shown in figure.

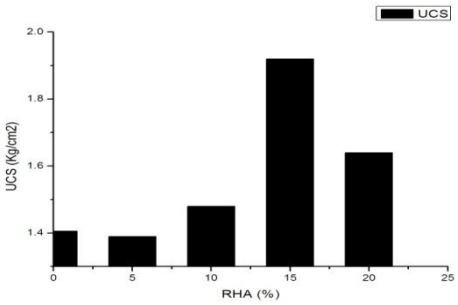


Fig. no.5 UCS value of soil stabilized with diff. % of RHA.

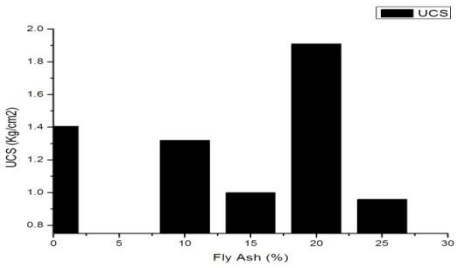


Fig. no.6 UCS value of soil stabilized with diff. % of Fly ash.

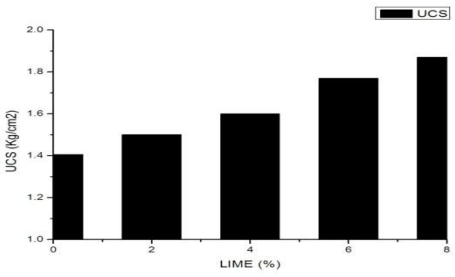
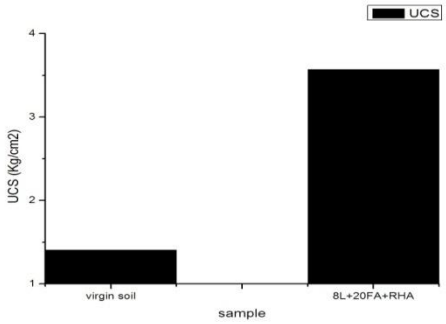
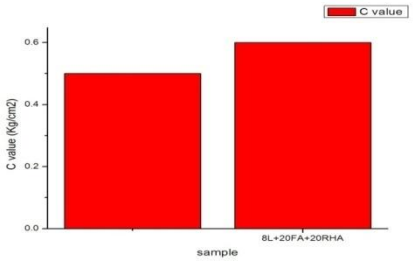


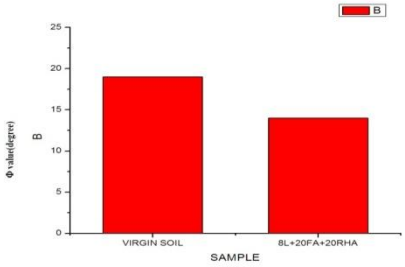
Fig. no.6 UCS value of soil stabilized with diff. % of Lime.

The UCS value of soil at combination of Lime, fly ash and Rha(8%,20%,20%) is 3.57 Kg/cm2 Comparision of UCS value of treated and untreated soil is shown in fig. no. 7



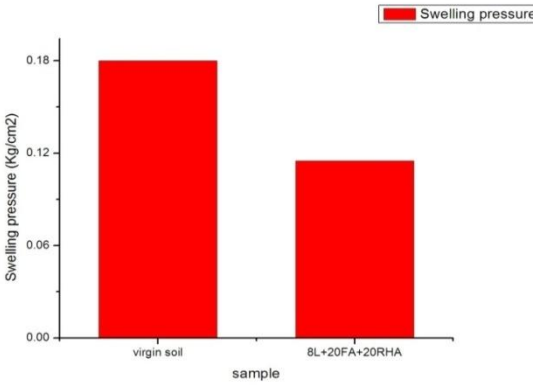
Direct shear test- C value is increaes of treated soil and Φ Value is decreases of Treated soil. Comparision of C & Φ value of treated and untreated soil is shown in fig.no. 8&9





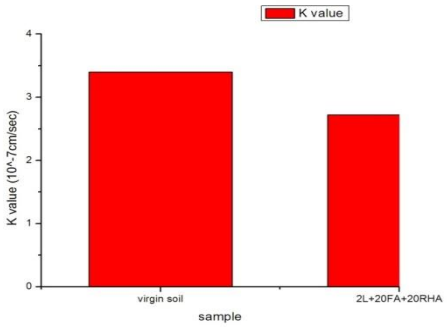
Swelling pressure-

The value of Swelling pressure of treated soil is decreases. Comparision of swelling pressure value of treated and untreated soil is shown in fig. no. 10



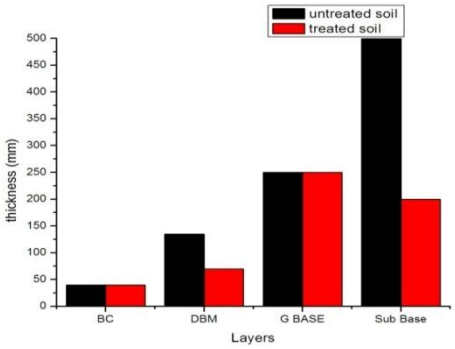
Permeability test-

K value of treated soil is decreases. Comparision of K value of treated and untreated soil is shown in fig. no. 11



6. PAVEMENT THICKNESS ANALYSIS –

Pavement thickness on natural soil is 925mm and thickness on treated soil with combination of RHA (20%), Fly ash (20%) and Lime (8%). Pavement Thickness Comparisons on treated on untreated soil is shown in fig.no.12



The test results of treated and untreated soil is shown in table.no.4

Sr. no.	Sample	Compaction		Atterberg limits(%)			CBR Value	UCS value	Direct shear		Swelling pressure	permeability
		MDD (gm/ cc)	OMC (%)	LL	PL	SL		(Kg/ cm^2)	C value (Kg/ cm^2)	Φ value (degree)	Kg/cm^2	K value (10 ^-7)
1	BC soil	1.71	18	55	32	17	1.52	1.406	.5	19	.18	3.4
2	2% lime	1.72	15	49	29	28	1.52	1.501	.3	25	.096	2.6
3	4% lime	1.72	18	48	29	22	1.84	1.6	.6	23	.263	3.6
4	6% lime	1.71	18	48	27	25	3.06	1.7	.2	20	.134	3.2
5	8% lime	1.71	18	44	28	21	3.64	1.8	.6	26	.16	3.0
6	10% Fly ash	1.64	15	49	27	26	1.57	1.32	1.1	26	.263	1.7
7	15% fly ash	1.7	15	49	28	27	1.98	1	.7	15	.263	1.3
8	20% fly ash	1.65	18	49	32	21	1.93	1.91	.8	14	.134	2.1
9	25% fly ash	1.67	18	NP	NP	39	4.05	.96	.8	15	.16	2.0
10	5% RHA	1.66	15	49	29	26	1.17	1.39	.5	11	.117	4.3
11	10% RHA	1.62	15	50	29	22	2.56	1.48	.7	10	.117	3.5
12	15% RHA	1.64	18	52	31	31	1.60	1.92	1.4	12	.117	3.6
13	20% RHA	1.57	18	NP	NP	43	1.70	1.64	1	12	.07	3.2
14	RHA(20)Fly ash(20) Lime(8)	1.65	18	46	30	20	12.7	3.57	.6	14	.115	2.72

7. CONCLUSION-

- Liquid limit and plastic limit of Black Cotton soil decrease with increasing % Lime. But Liquid limit and plastic limit of Black Cotton soil increase with increasing % Fly ash and % Rice husk ash.
- CBR value of Black Cotton soil also increase with increasing varying % Rice husk ash. The optimum percentage of fly ash at 20% for gave the best result for sub grade soil.
- CBR value of Black Cotton soil also increase with increasing varying % fly ash. The optimum percentage of fly ash at 20% for gave the best result for sub grade soil.
- CBR value of Black Cotton soil also increase with increasing varying % Lime. The optimum percentage of Lime at 8% for gave the best result for sub grade soil.
- UCS value of Black Cotton soil also increase with varying % of RHA, Fly ash and lime.
- CBR value of Black Cotton soil is maximum with combination of Lime (8%), Fly ash (20%) and RHA (20%).
- Swelling pressure is minimum at 20% of RHA.
- Permeability of Black Cotton soil is decrease with varying % of Lime and Fly ash.
- It can be concluded that the waste material such as fly Ash and Rice husk ash can be used effectively in the civil engineering construction but it is become more effective with lime.
- By designing the road treated with combination of Lime (8%), Fly ash (20%) and RHA(20%) having 12.5% CBR found that reduction in sub-base layer by 60% and reduction in DBM layer by 40.7% in comparison to pavement design on Untreated Black Cotton soil.
- By designing the road treated with combination of Lime (8%), Fly ash (20%) and RHA(20%) pavement thickness reduces by 40% and the cost of the pavement reduced by 35% to the original cost of pavement.

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