Geotechnical Application of Rice Husk Ash and Lime Admixtures of Black Cotton Soil having High Expansive Nature

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Abstract

Black cotton soils are expansive soils which exhibit high swelling and shrinking when exposed to changes in moisture content. This cyclic swelling and shrinking of soils subjected to distress under moisture variations and these cause severe failures. Stabilization of expansive soils with various addictives attained lot of success. Rice Husk Ash is an agricultural industrial waste which found abundantly in delta regions. In this connection different percentages of cementitious material like lime is added to soil and also combination of RHA-lime added to soil and tests like plasticity, compaction, swell and CBR were performed. From the test results it is identified that addition of lime decreases plasticity and improves strength characteristics. Addition of RHA and lime makes the expansive soil to non-plastic, non-swelling and attain higher CBR of greater than 50% for 10%lime +20%RHA and 10%lime +30%RHA.

Keywords- *CBR, Expansive soil, Lime, Rice husk ash.*

I. INTRODUCTION

In India the soil mostly present is expansive soil which is known as black cotton soil and these form about 20% of total area of the country. These soils possess volume change characteristics when they have moisture variations. These are strong in dry seasons and soft in wet seasons. Katti(1979)[6] has given properties of Black cotton soils which have Liquid limit 40%-100%, Plastic limit 20%-60%, Differential Free Swell index 20%-100%.Structures located on these soils subjected to differential settlements due to moisture variations (Bala Subramanyam et.al 1989)[2].However these soils easily available at low cost and frequently used for construction purposes (Bell 1988)[3].In recent times demand of sub grade material has increased due to increased construction activities in road sector. To overcome this stabilization of sub grade soil is one of the best techniques to control volume characteristics by addition of stabilizers like cement, lime and Industrial wastes like Fly Ash, Rice Husk Ash etc.

Now a day's conventional addictives like cement and lime costs increased lot. Keeping in this view investigation carried out with Rice Husk Ash (RHA). RHA is an agricultural industrial waste produced by burning of Rice Husk a residue of milling of paddy. In India 100 million tons of paddy is producing annually out of which 20 million tons as Rice Husk by burning it produces 20% of ash. Bulk production of Rice Husk Ash needs huge quantities of lands for their disposal and threat to environment. Some of the researchers Satyanarayana.P.V.V et.al (2003)[9] studied Use of Rice Husk Ash ,Lime, and Gypsum in strengthening Sub grade and sub base in low cost Roads , DilipShrivastava et.al(2014)[4] studied Effect of lime and rice husk ash on engineering properties of black cotton soil,Satyanarayana.P.V.V et.al(2016)[10]studied Partial and Full Replacement of Crusher Dust with Rice Husk Ash as Fill and Sub-Grade Material, Satyanarayana.P.V.V et.al (2016)[8]studied the engineering properties of expansive soil stabilized with high volume rice husk ash, Vamsi Nagaraju.T et.al(2016)[11] studied Effective Use of Rice Husk Ashes in Geotechnical ApplicationsYadu et.al (2011)[12] studied Rice Husk Ash on Expansive soils in terms of CBR, Atterberg limits and unconfined compressive strength, Ali M, Sreenivasulu V (2004)[1] studied An Experimental Study on the Influence of Rice Husk Ash and Lime on Properties of Bentonite, Sabat A.K et.al(2011)[7] studied effect of marble dust on strength and durability of Rice Husk Ash stabilized Expansive soil, J. O. Akinyele et.al (2015)[5] studied The Use of Rice Husk Ash as a Stabilizing Agent in Lateritic Clay Soil.

In present investigation various percentages of Rice husk ash and lime mixes are added to expansive soils and effect of these mixes was studied in terms of plasticity, compaction, swell and strength characteristics.

II. MATERIALS

To study the performance of RHA and Lime mixes on expansive soil, which is obtained from delta areas of Godavari River in Bhimavaram, Andhra

Pradesh, India and RHA, was collected from Tekkali Srikakulam district, Andhra Pradesh, India, and Lime was collected from locally available market.

A. *Black Cotton Soil*

Expansive soils in India are popularly known as Black cotton soils, the collected soil was dried and pulverized into the required sizes and tested for properties like gradation ,compaction, strength as per IS2720 and the results are shown in table-1 and fig-1

Table.1.Geotechnical properties of Black cotton soil

Property	Values
Gravel (%)	0
Sand (%)	4
Fines (%)	96
a) Silt	50
b) Clay	46
Liquid Limit (%)	74
Plastic Limit (%)	29
Plasticity Index (I_P)	45
IS Classification	CH
Optimum moisture content (OMC) (%)	26
Maximum dry density (MDD) (g/cc)	1.52
California bearing ratio (%) (CBR Soaked)	1.0
Angle of shearing resistance (Ø)	15
Cohesion (t/m^2)	10

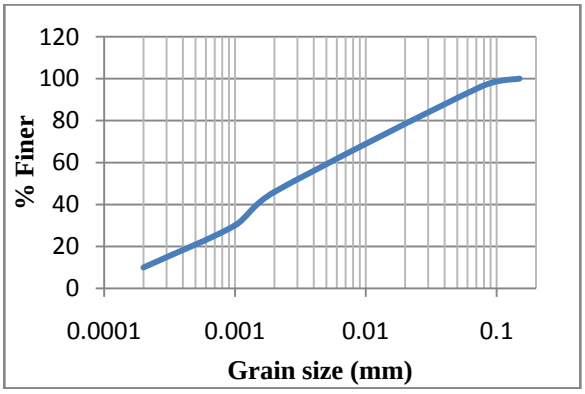


Fig-1: Gradation Curve of Black Cotton soil

From the test results it is identified that it contains fines (less than 75µm) of 96% .shows alluvial origin out of which 50% of silt and 46% as clay particles. The presence of fines contributed for high liquid limit (W_L) of 74% and plasticity index of 45% can be classified as CH soil based on IS1498 1970 It also exhibited high swelling characteristics with FSI (Free swell index) as 100 and swell pressure as 90kpa and very low strength values under soaking in terms of CBR as 1%

B. *Rice Husk Ash*

Rice husk Ash (RHA) was collected from Tekkali, Srikakulam district, Andhra Pradesh. The collected Rice husk ash was dried and subjected to various geo-technical characterizations such as gradation, compaction, strength, permeability etc., and the test results are shown in table -2 and

Table 2-Geotechnical properties of RHA

Property	Values
Gravel sizes (%)	0
Sand sizes (%)	84
Fines (%)	16
a. Silt sizes (%)	16
b. Clay sizes(%)	0
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SM
Specific gravity	1.8
Optimum moisture content (OMC) (%)	38
Maximum dry density (MDD) (g/cc)	0.7
Angle of Shearing Resistance	36
California bearing ratio (CBR) (%)	8
Coefficient of uniformity (Cu)	9.14
Coefficient of curvature (Cc)	1.75
Volume of RHA for a mass of 10g	35cc

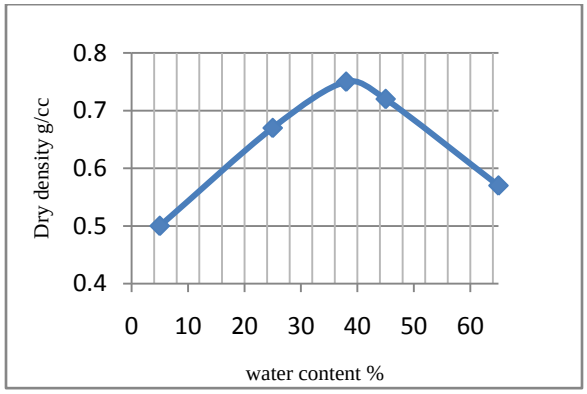
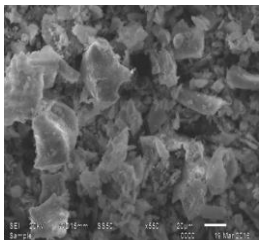


Fig-2 Compaction Curve of RHA

Table -3 Chemical Properties of RHA

Chemical Compound	Percentage
SiO_2	97.69
Al_2O_3	0
Fe_2O_3	0.22
CaO	0.29
MgO	0
Na_2O	0.41
K_2O	1.39



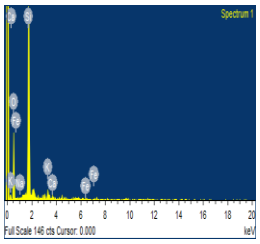


Fig.1. and Fig.2.SEM for RHA particles

From the test results of Rice husk ash the following identifications are made. Majority of Rice husk ash particles are under fine sand range and of angular shape with rough surface texture. The gradation also shows it comes under zone IV. Based on BIS it is classified as poorly graded sandy nature with non-plastic and incompressible fines are named as (SP) with C_u=9.74 and C_c= 1.75

Compaction characteristics of Rice husk ash under standard Proctor test have OMC of 38% and MDD of 0.7 g/cc. From the compaction curve it can be seen that Rice husk ash attained lower densities for wide variation in moisture contents. Regarding strength characteristics it has an angle of shearing resistance (Ø) as 36 degrees under un-drained condition and CBR of 8% and has good drainage characteristics with coefficient of permeability as 3.4 * 10^{-3}cm/sec .RHA attained low densities due to low specific gravity, porous nature and distribution of uniform size of particles.

Chemical analysis of Rice Husk Ash was carried out using Scanning Electron Microscope (SEM) we observed silica(SiO_2) is the major compound of 97% and oxides of calcium, iron, potassium, sodium as minor compounds.

C. Lime:

Lime is chemically known as calcium oxide (CaO) and which is obtained from local market and is of 95%purity

III. RESULTS AND DISCUSSION

A. Effect of Lime on Engineering Properties of Expansive Soils

To study the effect of lime on expansive soil, various percentage of lime i.e. 0,2,4,6,8,10% by dry weight of soil were added and effectively mixed and tested for characteristics like plasticity, compaction and swell as per IS2720,as the results are shown in table-4 and fig-3(a)-3(d)

Table -4: Variation of Geotechnical Properties of Expansive Soil with Lime

LIME	W_L	W_P	I_P	OMC (%)	MDD (g/cc)	FSI (%)	CBR (%)
0	74	29	45	26	1.52	100	1
2	66	31	35	27	1.5	85	5
4	52	32	20	28.3	1.48	60	10
6	34	34	0	29.5	1.45	20	16
8	NP	NP	NP	30.5	1.43	0	22
10	NP	NP	NP	31.6	1.41	0	26

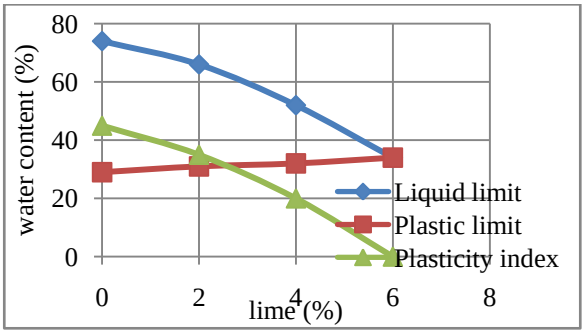


Fig 3(a).Consistency Limits

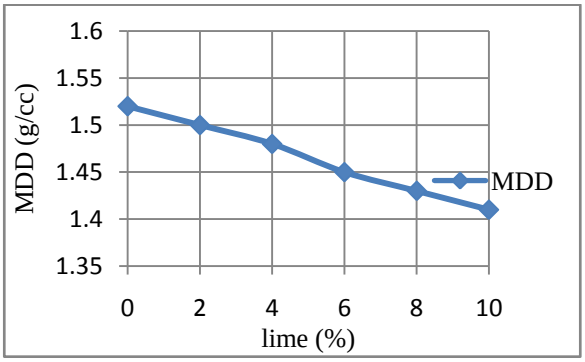


Fig 3(b).OMC (%) Vs Lime (%)

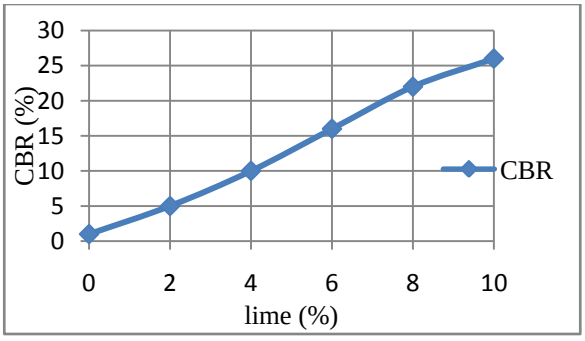


Fig 3(c).MDD (g/cc) Vs Lime

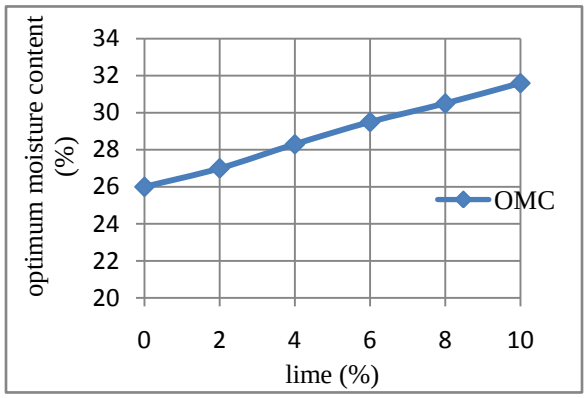


Fig.3(d).CBR(%) Vs Lime

From the consistency test data, it is identified that as the percentage of lime is increasing liquid limit and plasticity index values are decreasing and plastic limit values are increasing. This phenomenon is continued up to 6% of lime after it became non-plastic. The decrease in liquid limit is due to the decrease in diffused double layer by absorption of calcium ions and to surface of clay particles and increase in plastic limit is due to the development of shear resistance at inter particle level and require more water to mobilize for rolling.

From the compaction test data it is identified that with increasing the percentage of lime OMC values are increasing and MDD values are decreasing. This increase in OMC values are due to the development of flocculated structure which resists the compaction effort and decreasing dry density due to less solids occupied in the given volume due to structural arrangement of clay particles.

It is also observed that with increasing percentage of lime free swell values are decreasing. At a dosage of 8% it became non-swelling. The decrease in swelling characteristics is due to the decreasing repulsive forces between clay particles.. From the test results of CBR it is identified that as the percentage of lime is increasing CBR values are also increasing. The increasing CBR values are due to the development of cementicious compounds between clay and lime particle which increases shearing resistance at inter particle level.

LIME(%)	RHA (%)											
	10				20				30			
	OMC (%)	MDD (g/cc)	FSI	CBR	OMC (%)	MDD (g/cc)	FSI	CBR	OMC (%)	MDD (g/cc)	FSI	CBR
0	27.2	1.47	75	2	28.8	1.4	40	5	30	1.32	10	8
2	28	1.46	50	6	29.6	1.39	15	12	30.8	1.31	0	15
4	29	1.45	15	12	30.5	1.38	0	20	31.6	1.3	0	28
6	30	1.44	0	20	31	1.37	0	30	32.5	1.29	0	40
8	31	1.43	0	26	32	1.36	0	42	33.5	1.28	0	55
10	31.5	1.41	0	32	33	1.35	0	50	34	1.27	0	70

Table 5 various Geo Technical Characteristics of soil-RHA-Lime Mixes

B. Effect of Lime on RHA Stabilized Expanssive Soil

To study the combine effect of Lime and RHA on expansive soil, various percentage of lime i.e. 2,4,6,….10% by dry weight of soil were added and effectively mixed and tested for characteristics like compaction, strength as per IS2720,and the results are shown in below table 5

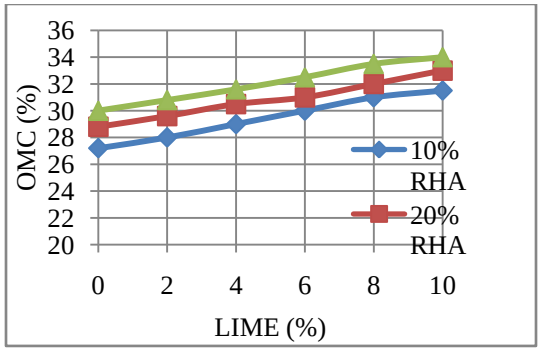


Fig 4(a).MDD (g/cc) Vs Lime (%)

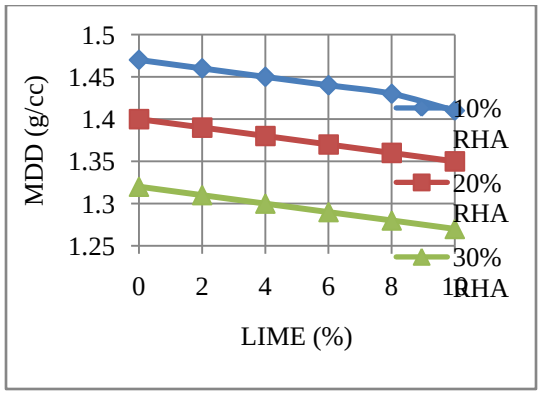


Fig 4(a).OMC (%) Vs Lime (%)

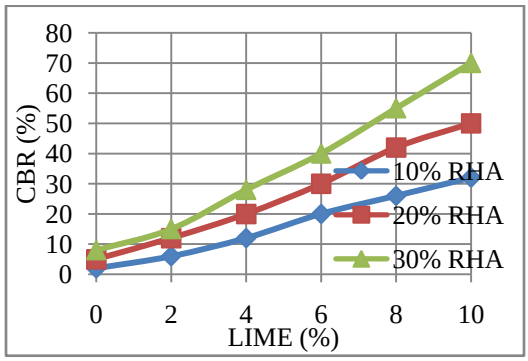


Fig 4(a).OMC (%) Vs Lime (%)

Compaction test data shows in table.5 and identified that with increasing the percentage of RHA & lime OMC values are increasing & MDD values are decreasing. Increase in OMC and decrease in MDD values are due to increase in lime concentration in pore water makes the solid particle which needed more pore water to mobilize the particle against compaction effort. And which helps less solids are to be available in the given volume of soil RHA-soil-Lime matrix.

It is also observed that with increasing percentage of RHA and LIME free swell values are continuously decreasing. At low percentages of RHA (10-20%) and 4% lime required and at 30% RHA and 2% of lime required low swelling. Further increasing lime content the soil RHA –Lime matrix becames non-swelling.

From the test results of CBR it is identified that as the percentage of RHA and Lime is increasing CBR values are also increasing with curing period of 28 days. At low percentages of RHA be effect of lime is marginal improving CBR values. At 30%RHA a considerable increase in CBR values were observed with effect of lime on clay particles. At low percentages of Lime and at a given RHA dosage low values of due to absorption maximum calcium ions on to the clay surfaces which makes less quantities of free calcium ions are available to react with silica and alumina from the RHA and soil particles for formation of C-S-H&C-A-H gel compounds which are responsible for cementetious action or amorophous with curing time. At high percentages of lime and at High dosage of RHA high values of CBR due to high quantities of free calcium ions are available to react with silica and alumina from the RHA and soil particles for formation C-S-H&C-A-H gel compounds which are responsible for cementetious action and are get into the crystalline with curing period.

IV. APPLICATIONS

- Addition of 6% of lime to Black cotton soil with CBR value grater than 10 it can be used as sub-grade material.
- Addition of 20-30% RHA and 6% lime can be used as Sub-base material
- Addition 30% RHA and 8-10% of lime can be used as base-course material for low traffic volume.

V. CONCLUSIONS

High Expansive Black cotton soil can be effectively utilized as a Geo technical material by addition of 20-30% RHA and 8-10% lime. At these dosage of admixtures the Black cotton soil can be behaves non-plastic and non-swelling can reduce the problems of volume change. Bulk utilization of RHA reduces its deposal problem.

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