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Application of RHA and Lime in Improving Strength Swelling Characteristics of Black Cotton Soil

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Abstract: **Black cotton soils have posed challenges and difficulties in the construction activities because of their shrink and swell behaviour. These soils are not suit for construction activities due to low strength on wetting to overcome this improvement of soil can be done by stabilization. Therefore, it is necessary to properly choose the stabilizer for the economics of the process and considering environmental aspects. Rice Husk Ash is an Agricultural Industrial Waste produced by burning of Rice Husk a residue of milling of paddy. In India it is found abundantly and is a pozzolanic material that could be potentially used in various geotechnical aspects. In this paper different percentage of RHA and lime mixes were added to the soil and tests like plasticity, swell potential, permeability and UCS were performed. From the test results it is identified that addition of lime decreases plasticity and improves strength characteristics. Addition of RHA+ lime makes the expansive soil non-plastic, non-swelling and leading attain high strengths.**

Keywords: **UCS, Black cotton soil, Lime, Rice husk ash.**

1. INTRODUCTION

The delta regions are more popular with Black cotton soils. These exhibit high swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations.

This behaviour is due to the presence of a mineral montmorillonite. 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].These soils can be improved either by modification or stabilization, or both. The stabilization of soil is done by the adding different type of addictives like cement, lime, lime and rice husk ash etc. to improve its geotechnical properties to make it suitable for various civil engineering constructions like pavements, buildings and embankments etc.

Rice Husk Ash 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 , B.Suneel Kumar et.al (2014)[4] studied the behavior of Clayey Soil Stabilized with Rice Husk Ash & Lime, 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, D.Koteswar rao et.al (2012)[7] studied a laboratory study on the affect of Rice Husk Ash and Lime on the properties of Marine clay,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 Applications, Ali M et.al (2004)[1] studied An

Experimental Study on the Influence of Rice Husk Ash and Lime on Properties of Bentonite, 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, swell potential, permeability and UCS of 7days and 28days curing period.

2. 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.

2.1. 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

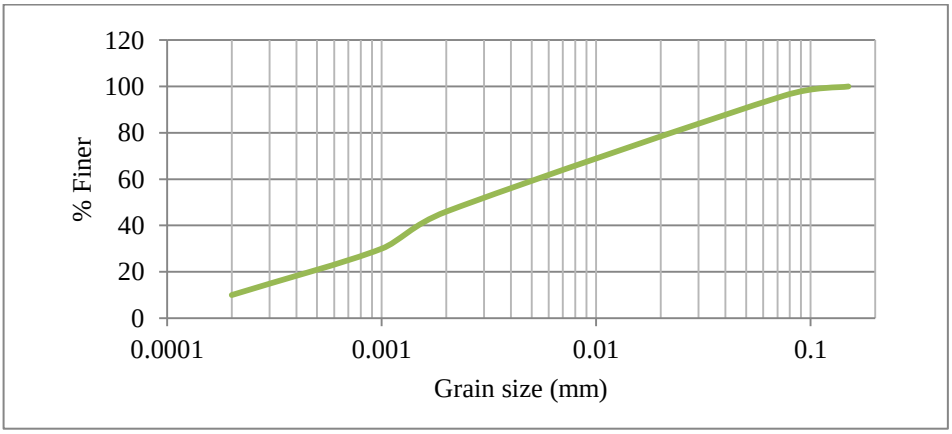


Fig-1: Gradation curve of Black Cotton soil

From the test results it is identified that it contains fines (less than 75µm) of 95% .shows alluvial origin out of which 40% of silt and 55% 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 FIS as 100 and swell pressure as 90kpa and very low strength values under soaking in terms of CBR as 1%.

2.2 Rice Husk Ash:

Rice husk Ash (RHA) was collected from Tekkali, Srikakulam, and 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 Fig 2.

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

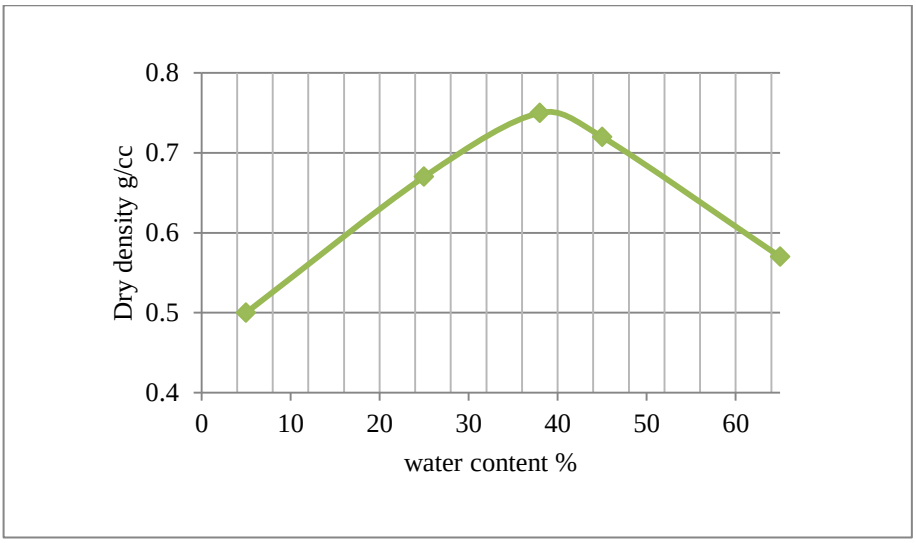
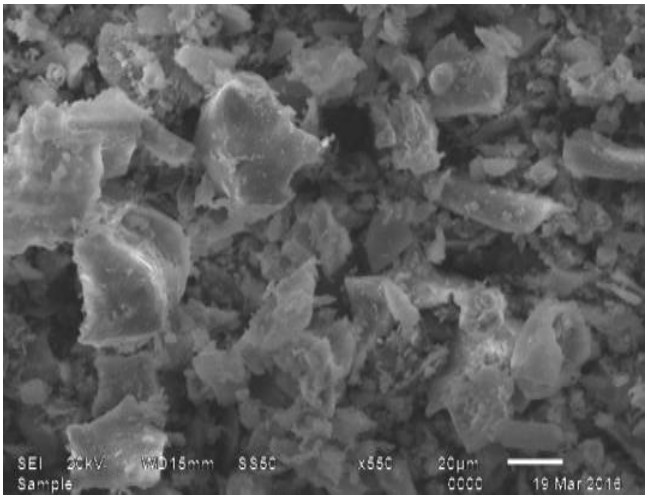


Fig-2 Compaction curve of RHA

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



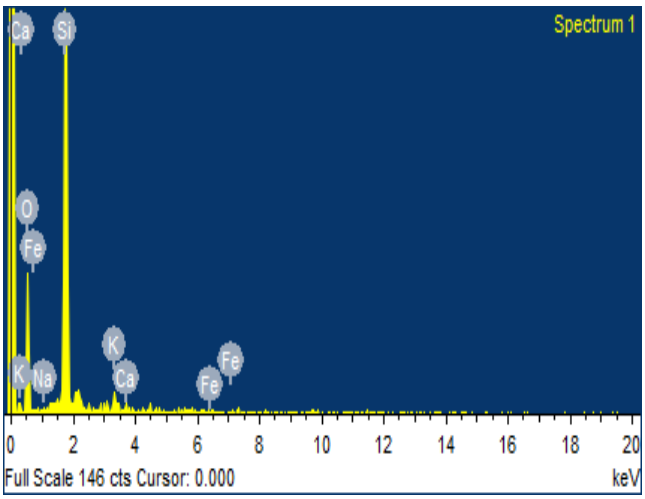


Fig.1. and Fig.2.SEM for RHA particle

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.

2.3 Lime:

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

3. RESULTS AND DISCUSSIONS

3.1 Effect of lime on Engineering Properties of Expansive Soils:

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

Table 4. Various Characteristics of Soil-RHA Mixes

LIME (%)	W_L	W_P	I_P	UCS (Mpa)		SWELL PRESSURE(Ps) (kPa)	K (cm/sec)
				7	28		
0	74	29	45	0.2	0.23	95	$4.6x10^{-7}$
2	66	31	35	0.35	0.52	68	$5.2x10^{-7}$
4	52	32	20	0.45	0.7	30	$7.0x10^{-7}$
6	34	34	0	0.68	0.95	5	$8.5x10^{-7}$
8	NP	NP	NP	0.85	1.12	0	$9.8x10^{-7}$
10	NP	NP	NP	1.04	1.28	0	$1.1x10^{-6}$

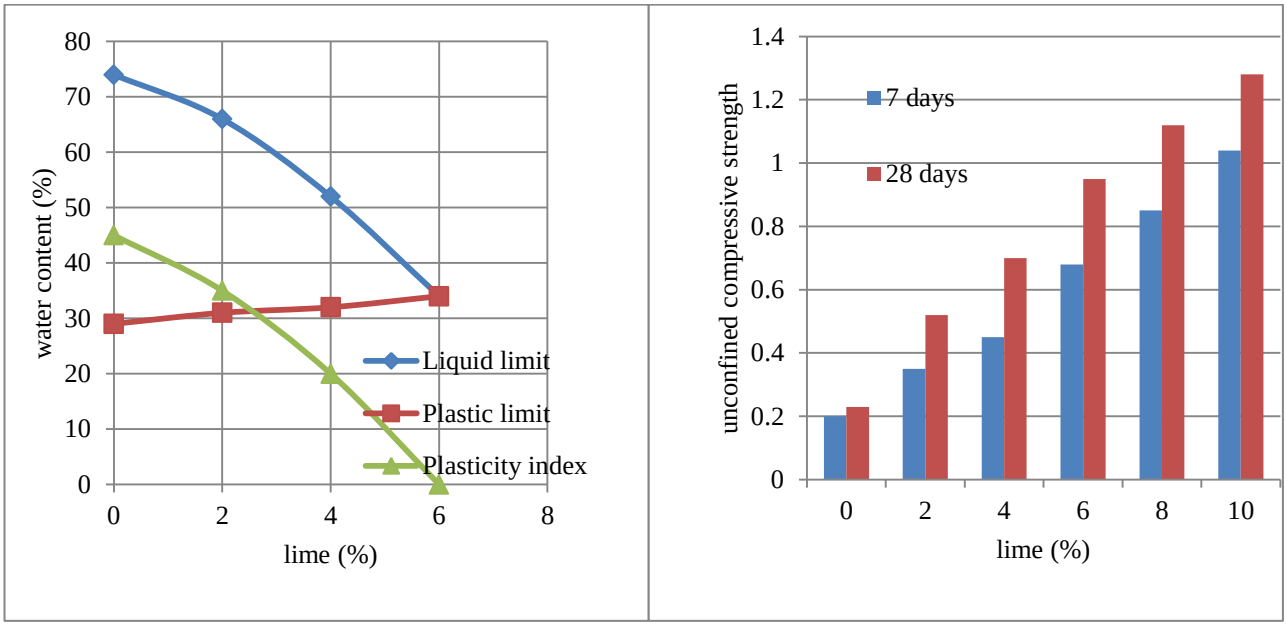


Fig-3(A)-3(B)

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% and at 8% it became non-plastic. The decrease in liquid limit is due to the decrease in diffused double layer by absorption of calcium ions on to the clay surface and increase in plastic limit is due to the development of shear resistance at inter particle level and the particles in soil-lime matrix require more water to mobilize for rolling.

From the unconfined compression test data it is identified that with increasing percentage of lime increases UCS values with curing time. The increase in compression strength values are due to development of cementtiious compounds.

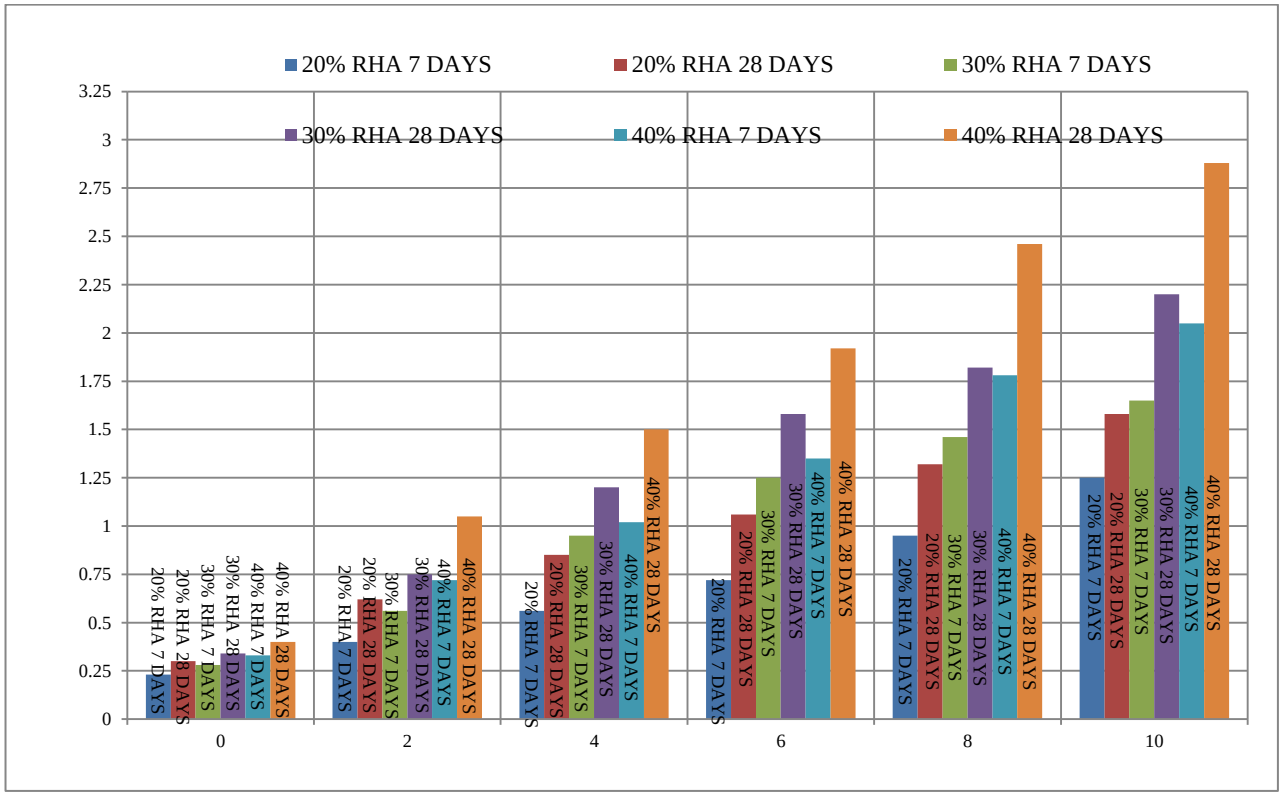
From the swelling characteristics, it is identified that as the percentage of Lime is increasing Swelling pressure values are decreasing. At 6% of Lime the swelling pressure became 5 Kpa which soil-Lime mix Shows very swelling level. At 8% of lime it shows non-swelling. This is due to decrease of repulsive forces and increase shearing resistance at particle level reduces. This thrust transfer to the surrounding of environment in the form of reduction of swelling pressure values.

3.2 Effect of Lime and RHA on Expanssive Soil:

To study the 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.various Characteristics of Lime Stabilized Expansive soil-RHA mixes

LIME (%)	RICE HUSK ASH (%)					
	20		30		40	
	UCS(Mpa)		UCS(Mpa)		UCS(Mpa)	
	7	28	7	28	7	28
0	0.23	0.3	0.28	0.34	0.33	0.4
2	0.4	0.62	0.56	0.75	0.72	1.05
4	0.56	0.85	0.95	1.2	1.02	1.5
6	0.72	1.06	1.25	1.58	1.35	1.92
8	0.95	1.32	1.46	1.82	1.78	2.46
10	1.25	1.58	1.65	2.2	2.05	2.88



At low % of RHA clay particles absorbs calcium ions on to the surfaces which makes less quantites of free calcium ions are available to react with silica and alumina from the RHA and soil particles for forming C-S-H&C-A-H gel compounds which are responsible for Cementitious action. This exhibited low UCS values at low perentage of RHA. At high percentage of RHA more free calcium ions are available to react with silica and alumina particles from RHA and soil particles to form CSH& CAH gels make soil RHA compounds high cementitious and becoming crystalline with curing periods. This phenomenon is more pronounced at 28 days curing period. From the test results it is identified that as the percentage of lime is increasing UCS values are increasing with curing period. Hence at low percentage of lime i.e is at (2-4%) and earlier curing periods(7days) a steady increase was observed. whereas at higher (6-10%) and high curing period 28days a rapid increase in strengths were observed. It is also identified that high dosage of RHA required. High percentage of lime which has given high strengths.

4. APPLICATIONS & CONCLUSIONS

Effect of lime has positive influence improving the engineering properties of Expansive soils. Addition of 6% of lime makes the Expansive soil low to non-swelling with low unconfined compressive strength values whereas addition of 30-40% RHA and 4-6% of lime help to achieve high UCS values can be used as construction material such as Sub-base, Base and liner materials.

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