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Impact of RHA on Expansive soils in Road Construction

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***Abstract*– Roads have been running through several problematic soils some of them are black cotton soil. Roads constructed on black cotton soils as sub-grade and fill material subjected to lot of cracking and heaving. To reduce its impact Rice husk ash was added to black cotton soils and tested for plasticity, compaction, strength and swelling characteristics.. From the test results 30-40% of RHA is sufficient for the given expansive soils to achieve non plastic conditions. This range of dosage has given good bearing strengths with respect to CBR as 10 and improved high shear strength values and seepage characteristics.**

Key words: **Black cotton soil, compaction, CBR, Rice husk Ash.**

I. INTRODUCTION

Expansive soils one example of Black cotton soils of India, are always problematic, as these are not only shrink due to drying, but also show marked swelling with increase of moisture content which depend upon clay content. Expansive soils are highly problematic because of their alternate swelling and shrinkage. World over, problem of expansive soils have appeared as cracking and break-up of pavements, railway and highway embankments, roadways, building foundations, irrigation systems, water lines, sewer lines, canal and reservoir linings. The losses due to extensive damage to the above structures over expansive soil sub-grades are estimated to be in billions of dollars all over the world. To study their severity and characterization several soils were selected and tested for Atterberg limits, consistency indices and swell characteristics. Katti(1979)[10] 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].Soil stabilization is one of the techniques to control volume characteristics by addition of stabilizers like cement, lime and Industrial wastes like Fly Ash, Rice Husk Ash etc and improvement in volume change characteristics can be studied in terms of Index properties, Swell and Strength properties.

Rice Husk Ash is an agricultural waste which is obtained by burning of Rice Husk which is abundantly available in India by cultivation of paddy crop one of the staple food. Rice Husk Ash is dominated by siliceous materials which is nearly 67%-70% of the total composition Oyepola and Abdullah 2006)[14]. Some of the researchers Brookers (2009)[4] studied effect of Rice Husk Ash on Expansive soils in terms of sub grade and sub bases for highway projects. Yadu et.al (2011)[22] studied Rice Husk Ash on Expansive soils in terms of CBR, Atterberg limits and Unconfined compressive strength. Vamsi mohan et al (2012)[21] studied Performance of Rice Husk Ash Bricks .Satyanarayana.P.V.V et.al (2003)[16] studied effect of Rice husk Ash on Expansive soils as construction materials like sub grade, bricks etc. Krishan rao.C.V (2004)[5] et al studied effect of fly ash and lime on expansive soil as road and embankement material. Muntohar A.S and Hantoro G (2000)[12] studied Influence of Rice Husk Ash and Lime on Engineering Properties of a Clayey Sub grade. Ali M, Sreenivasulu V (2004)[1] studied An Experimental Study on the Influence of Rice Husk Ash and Lime on Properties of Bentonite Koteswara, R. D., Pranav, P. R. T., and Anusha, M., (2011)[15], "Stabilization of Expansive Soil with Rice Husk Ash, Lime and Gypsum An Experimental Study.

In the present investigation various percentages of Rice husk ashes are added to expansive soils and effect of RHA was studied in terms of plasticity, compaction and strength characteristics.

II. MATERIALS

To study the effect of RHA 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 of Andhra Pradesh, India.

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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

Geotechnical properties	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

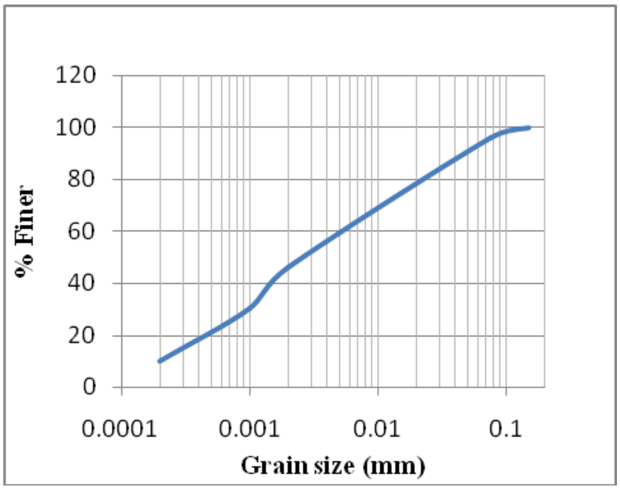

Fig.1 Gradation distribution curve of Expansive soil

From the test results it is identified that it contains fines(less than 75µm) of 95% .shows it is of alluvial origin and contains 55% 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% and classified as CH soil based on IS:1498-1970.It also exhibited high swelling characteristics with FSI as 100 and swell pressure as 90kpa.It exhibited very low strength values under soaking condition in terms of CBR as 1% .

B. Rice Husk Ash

Rice husk Ash(RHA) was collected from Tekkali, Srikakulam, 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

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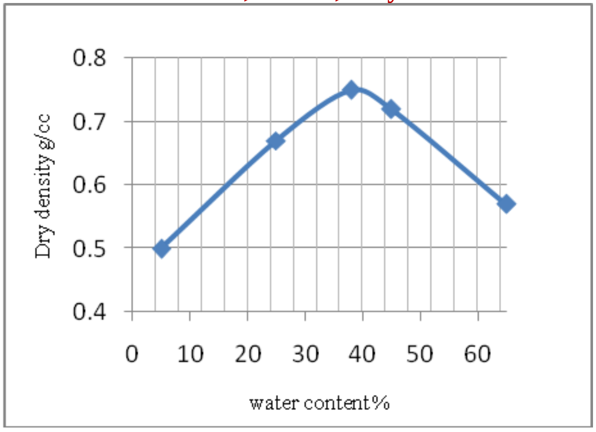
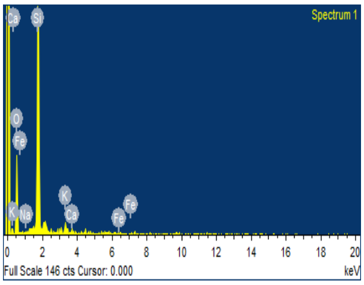


Fig-2 Compaction curve of RHA

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



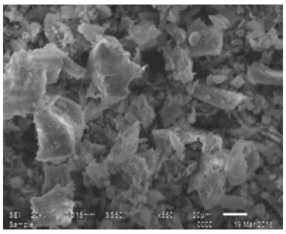


Fig.3. and Fig.4.SEM for RHA particles

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.

III. RESULTS AND DISCUSSION

To study the effect of RHA on expansive soil, various % of RHA i.e. 5,10,15,….100% of dry weight of soil were added and effectively mixed and tested for characteristics like plasticity, compaction, strength and swell as per IS:2720 results are shown in table-4 and fig-3(a),fig-3(b), fig-3(c),fig-3(d), fig-3(e),fig-3(f).

Table -4 Variations of Geotechnical properties with RHA

RHA %	W_L %	W_P %	I_P %	OMC %	MDD (g/cc)	CBR %	C t/m^2	Φ (deg)	K (cm/sec)
0	74	29	45	26	1.52	1	10	15	$4.6x10^{-7}$
5	70	30	40	26.5	1.5	1.5	9	16	$6.5x10^{-7}$

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Volume 5, Issue 3, May 2016

10	63	31	32	27.2	1.47	2.5	7.5	18	$8.9x10^{-7}$
15	56	32	24	28	1.43	3.5	6	20	$1.1x10^{-6}$
20	42	34	8	28.8	1.4	5	4	24	$2.4x10^{-6}$
25	32	NP	NP	29.8	1.36	6.5	1.5	28	$3.6x10^{-6}$
30	NP	NP	NP	30	1.32	8	1	32	$5.5x10^{-6}$
35	NP	NP	NP	31	1.28	9	0.8	33	$6.7x10^{-6}$
40	NP	NP	NP	31.8	1.24	10	0.6	33	$8.2x10^{-6}$
45	NP	NP	NP	32.6	1.2	10.5	0	34	$9.8x10^{-6}$
50	NP	NP	NP	33.2	1.15	9.5	0	34	$1.3x10^{-5}$
55	NP	NP	NP	33.6	1.1	9	0	35	$2.2x10^{-5}$
60	NP	NP	NP	34	1.05	8.5	0	35	$3.5x10^{-5}$
65	NP	NP	NP	34.7	1	8	0	36	$5.2x10^{-5}$
70	NP	NP	NP	35.4	0.94	7.5	0	36	$7.4x10^{-5}$
75	NP	NP	NP	36	0.88	7.5	0	37	$9.1x10^{-5}$
80	NP	NP	NP	36.5	0.84	7	0	37	$1.5x10^{-4}$
85	NP	NP	NP	37	0.8	7	0	37	$3.9x10^{-4}$
90	NP	NP	NP	37.4	0.77	6.5	0	38	$6.8x10^{-4}$
95	NP	NP	NP	37.7	0.74	6	0	38	$9.4x10^{-4}$
100	NP	NP	NP	38	0.7	6	0	38	$3.8x10^{-3}$

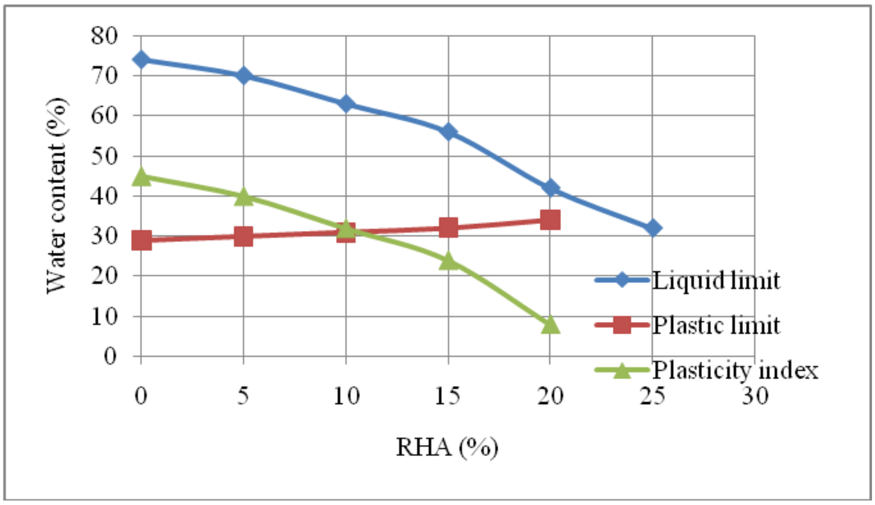

Fig.5 (a) consistency limits

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International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 5, Issue 3, May 2016

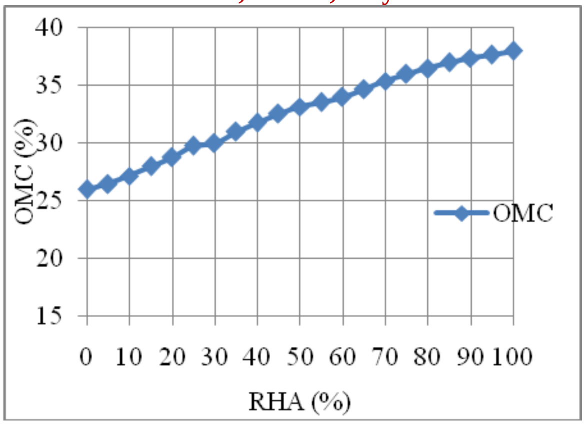

Fig.5 (b) OMC Vs RHA

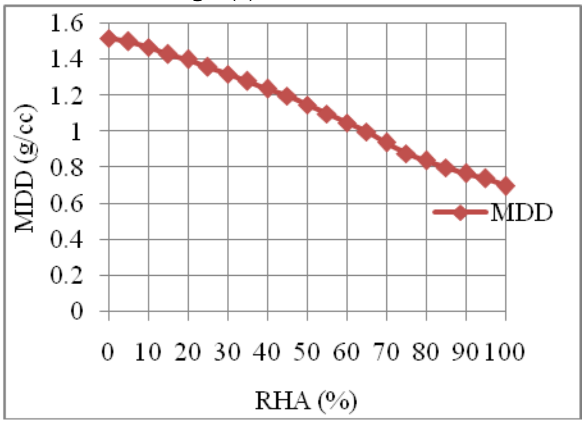

Fig.5(C) MDD Vs RHA

From the consistency test data it is identified that liquid limit values are decreasing, plastic limit values are increasing and plasticity index values are decreasing with increasing the percentage of Rice Husk Ash up to 25% and further increasing it became a non plastic. The decrease in liquid limit is due to the decrease in diffused double layer by replacement of clay particles by RHA particles. Increase in plastic limit is due to development of shear resistance at inter particle level, and the soil-RHA matrix requires high moisture content to roll.

From the compaction test data it is identified that with increasing the percentage of RHA, OMC values are increasing and MDD values are decreasing. At lower percentage of RHA this phenomenon is steady; at higher percentage it is rapid. The increase in OMC is due to the development of flocculated structure which resists the compaction effort requires more water to mobilize and offers low dry densities and nature of RHA particles in soil-RHA matrix.

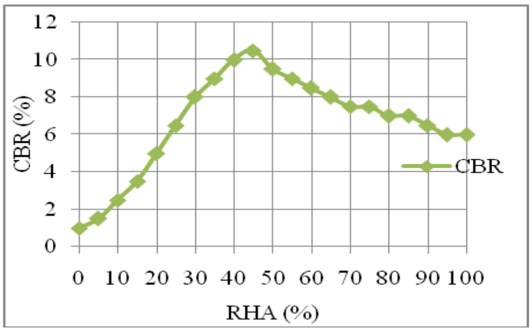

Fig. 5(d) CBR Vs RHA

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International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 5, Issue 3, May 2016

CBR test data shows that the increase in percentage of RHA increases the CBR values up to 40-45% of RHA and then decreases. The increased CBR values are due to the development of shear resistance generated against penetration and decreases are due to development of more voids and dominating of RHA behavior.

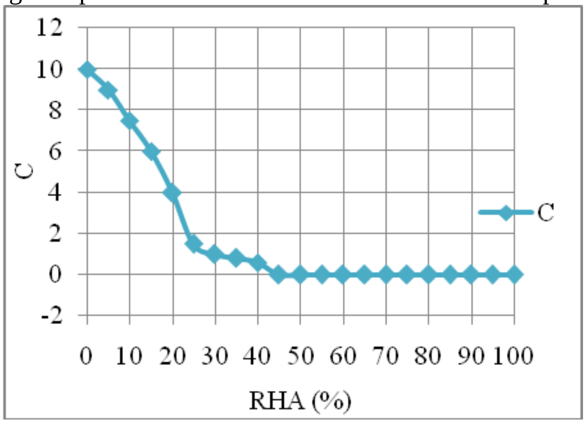

Fig. 5(e) C Vs RHA

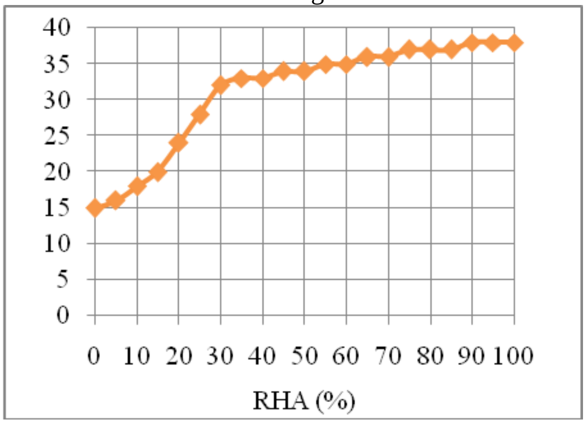

Fig.5(f) Φ Vs RHA

From the shear test data it is identified that with increasing percentage of RHA, cohesion values are decreasing and angle of shearing resistance values are increasing rapidly in between 15-30% of RHA and further increasing slowly. The decreased cohesion and increased angle of shearing Resistance are due to replacement of fines by RHA particles. From the permeability test results shown the increase of percentage of RHA and coefficient of permeability values are increasing. The increased permeability values are due to replacement of clay particles by RHA particles transforms impervious conditions to pervious.

APPLICATIONS:

1. Addition of 30-40% RHA to Black cotton soil attained CBR values are in the range of (8-10%) and non-plastic and non-swelling can be used as a sub-grade material.
2. By achieving high shear strength interms of C& Φ. It can be also be used as fill material.
3. High percentage of RHA helps to attain high Φ values mobilizes more shear strength can be used as construction material.

IV. CONCLUSIONS

The stabilization of Black cotton soil with agricultural industrial waste like Rice husk ash is used as sub-grade, fill material and liner material in Geo-technical applications. The 30-40% RHA to the soil attained good engineering properties due to high volume nature of RHA. It also gives CBR values 8-10% and RHA increases the shearing value and permeability values.

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