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Partial and Full Replacement of Sand with Rice Husk Ash As Fill And Sub-Grade Material

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Abstract: *Sand is an universal constructional material in civil engineering applications, to reduce impact on this and to generate characteristics like strength, RHA has been identified an alternative to sand. In this connection, various percentages of Rice Husk Ash were added to the sand and tested for compaction; shear strength and CBR characteristics. From the test results it is identified that addition of RHA to the sand increases angle of shearing resistance values and CBR values, which attained maximum value at 20% dosage with "φ" as 40^0 and CBR as 14%. Hence 20% partial replacement of sand by Rice Husk Ash gives an effective results and can be used as geotechnical constructional material.*

Keywords: *CBR, Compaction, Rice Husk Ash, Sand.*

I. Introduction

Naturally, sand has universal characteristics like rough texture, well drained characteristics and effective strength parameters may be given opportunities to engineers to be used as constructional material. In recent times, due to scarcity of sand and its cost engineers have been searching for alternative materials. One such material is Rice Husk Ash which is obtained by burning of Rice Husk and its production is 100 million tonnes annually.

Researchers like like Muntohar (2002)[5] studied RHA and Lime in stabilizing Expansive soils, Ali et.al (2004)[1] carried out investigations on Rice Husk Ash on Bentonite soils. Rajan B.H et.al (1982)[8] studied Rice Husk Ash on Black Cotton Soils. Ramanamurthy and Hari Krishna (2003)[9] studied Morrum soils in Pavement construction. Nunan T.A (1990) studied Gravel stabilization methods in road construction. Mohan N.V et.al (2012)[12] studied partial and full replacement of Rice Husk Ash in preparation of clay bricks. Rama Rao.R et.al (2003)[11] studied Lime, Rice Husk Ash and Gypsum in stabilization of expansive soil to suit as Sub-base material

In the present investigation various percentages of Rice Husk Ashes were added to sand, and studied for Compaction, Shear strength and CBR characteristics to suit as road construction material.

II. Materials

To study the performance of Sand in partial replacement with Rice husk ash as geotechnical material in the construction of roads, the following test program has done.

2.1. SAND

Sand was obtained from River Nagavali, Srikakulam, Andhra Pradesh and the collected sand was subjected to Geotechnical characterizations. The results are shown in table-1 and fig-1

TABLE-1: Geotechnical Properties of SAND

Property	Values
Gravel (%)	0
Sand (%)	98
Fines (%)	2
a. Silt(%)	2
b. Clay(%)	0
Liquid Limit (%)	NP
Plastic Limit (%)	NP
I.S Classification	SW
Specific gravity G	2.67
Optimum moisture content (OMC) (%)	5.6
Maximum dry density (MDD) (g/cc)	1.84
Angle of shearing resistance(φ)	36
California bearing ratio CBR (%) (Soaked)	10
Coefficient of uniformity Cu	9
Coefficient of curvature Cc	1.03
Coefficient of permeability(k) (cm/s)	$2.6*10^{-2}$

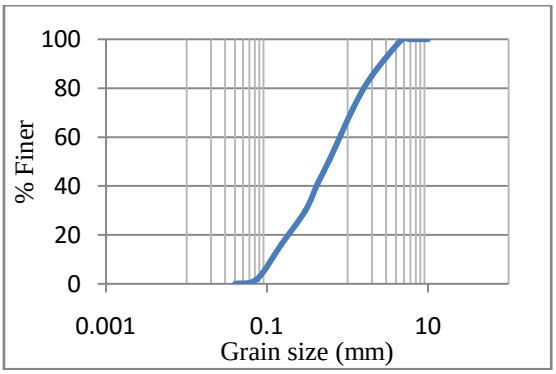

Fig-1: Grain size distribution curve

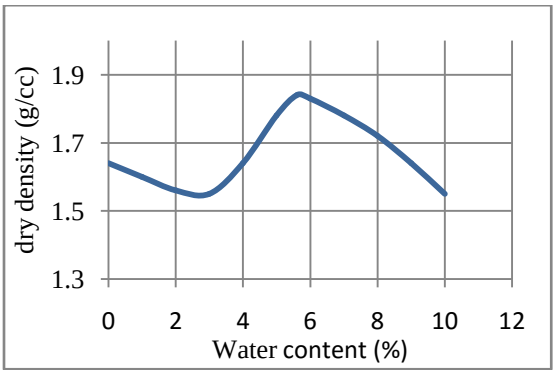

Fig-2: Compaction curve

From the test results of sand, the following identifications are made. The grain size distribution(Fig-1) of sand shows that it consists of 98% of sand sizes and 2% of silt size particles. Majority of sand particles are medium sand to fine sand ranges with rough surface texture. Based on BIS, it is classified as well graded particles with non-plastic fines (SW) with C_u as 9 and C_c as 1.03. Compaction characteristics(Fig-2) of sand under modified compaction test have an Optimum Moisture Content of 5.6% and Maximum Dry Density 1.84g/cc, it has an angle of shearing resistance (Ø) of 36 degrees under undrained condition and CBR of 10% and coefficient of permeability as 2.6x 10^{-2}cm/sec..

2.2rice 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
Coefficient of permeability(k) (cm/s)	$1.74*10^{-3}$

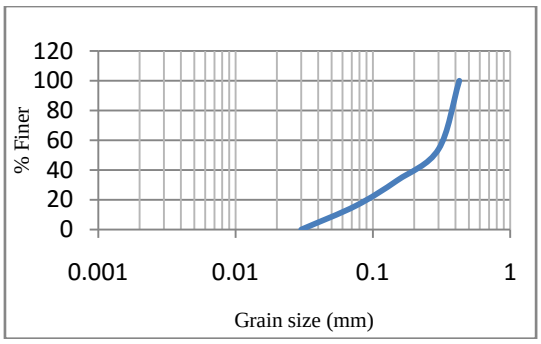

Fig-2(a): RHA Gradation distribution curve

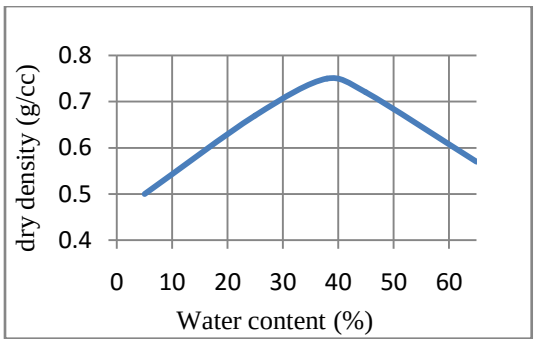

Fig-2(a): RHA Compaction curve

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

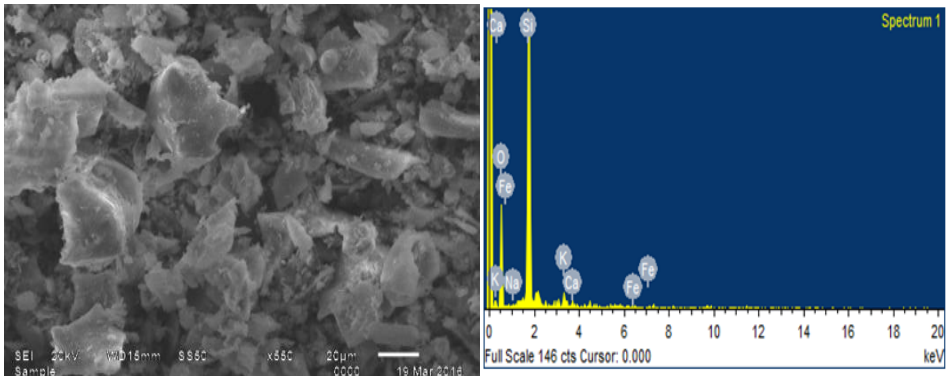

Fig-3(a) & 3(b): SEM analysis pictures of RHA particles

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 to elongated 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 in nature (SP) with C_u=9.14 and C_c=1.75**.**

Compaction characteristics of Rice husk ash under modified Proctor test have OMC of 38% and MDD 0.7 g/cc. From the compaction curve it can be seen that Rice husk ash has attains 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. From the compaction curve it can be seen that Rice husk ash attained a maximum dry density of 0.7 g/cc at optimum moisture content of 38%.Comparing the characteristics of sand with Rice husk ash attained lower densities with wide variation of moisture contents due to nature of particles, low specific gravity ,porous and poor gradation of particles.

III. Results And Discussions:

Performance of RHA in partial replacement of sand:

Various percentages of Rice Husk Ash such as 5%, 10%, 15%.....50% were added to Sand and the mixes are listed below in table - 4 and subjected for geotechnical characteristics like compaction, angle of shearing resistance and CBR tests as per IS 2720

Table 4: Sand and RHA mixes:

SAND	100	95	90	85	80	75	70	65	60	50
RHA	0	5	10	15	20	25	30	35	40	50
Mixes	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}

Mixes of Sand - Rice husk ash such as M1,M2.....M10 were subjected to heavy compaction by compacting the samples with a rammer of 4.89 kgs, five layers and each layer was subjected to 25 blows and their optimum moisture contents and maximum dry densities were determined as per IS 2720 part 8(1983). To know the shear parameter (φ) this samples were compacted at their maximum dry densities in the shear box apparatus and tested at a strain rate of 1.25 mm/min as per IS 2720-part 13(1986). CBR characteristics were compacted SAND-RHA particles in the CBR mould at their maximum dry densities and soaked for four days and tested at a strain rate of 1.25mm/min as per IS 2720: part 16 (1987) and the results are shown in table-4 and fig-4(a),4(b),4(c),4s(d)

Table -5: Geotechnical properties of Sand and RHA mixes:

RHA	Compaction characteristics		Shear parameter	Strength parameter
	OMC (%)	MDD(g/cc)	Ø(deg)	CBR
0	5.6	1.84	36	10
5	7	1.82	37	11
10	8.4	1.8	38	12
15	10	1.76	39	13
20	11.8	1.72	40	14
30	14.6	1.62	40	13
40	17.9	1.48	39	12
50	21.6	1.34	38.5	11

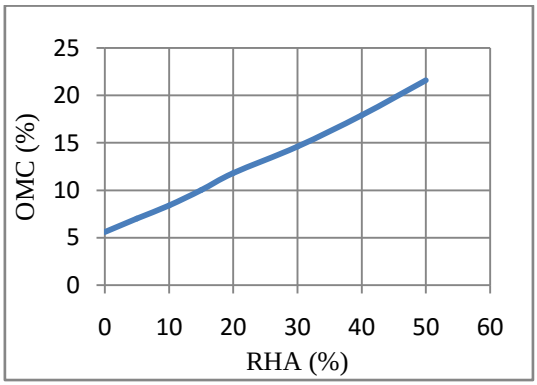

Fig-4(a): RHA (%) Vs OMC

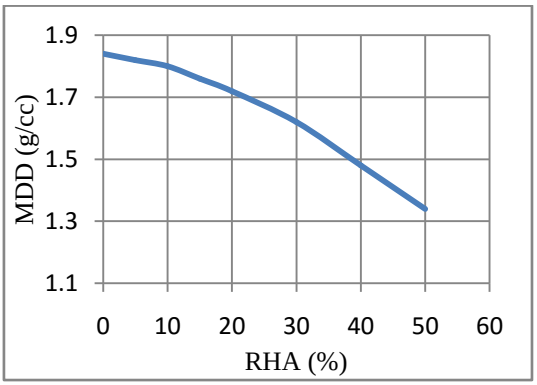

Fig-4(b): RHA (%) Vs MDD

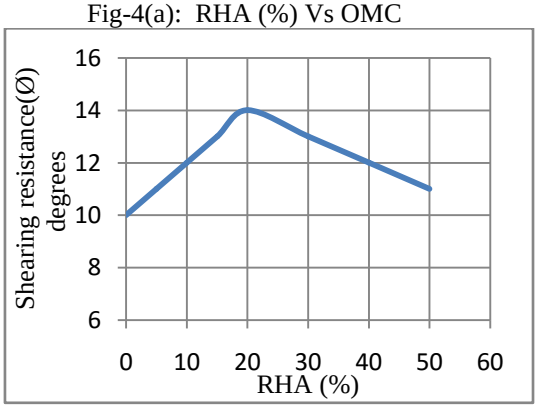

Fig-4(c): RHA (%) Vs φ

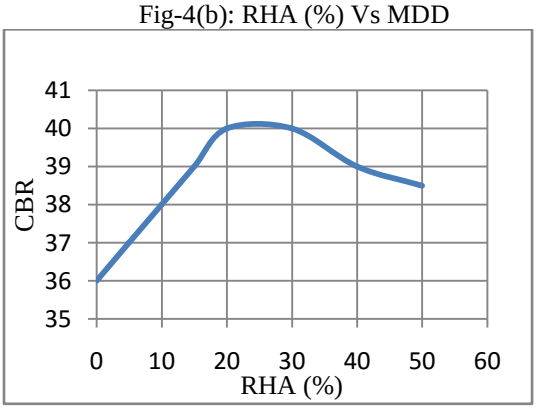

Fig-4(d): RHA (%) Vs CBR

From the compaction test(IS 2720-Part 8:1983) data it is observed that as the percentage of Rice husk ash is increasing, optimum moisture content values are increasing and dry density values are decreasing. A rapid increase in OMC and decrease in MDD values are observed. At low percentages of Rice husk ash, the behavior, of sand is dominating, at high percentages of Rice husk ash the behavior of Rice husk ash particles is dominating in the mixes. The increase in OMC is due to the shape and nature of Rice husk ash particles, where as decrease in dry densities is due to low specific gravity and porous nature of Rice husk particles.

From the Direct shear test (IS 2720-Part 17:1986) data it is observed that as the percentage of Rice husk ash is increasing, the angle of shearing resistance values are increasing up to 30% and then decreasing. Maximum values were attained at a dosage of 20%. The increase in angle of shearing resistance values is due to development of high shearing resistance due to attainment of dense condition. Hence combination of sand and Rice husk ash particles mobilizes more frictional resistance than sand and Rice husk ash particles.

From the CBR test IS 2720-Part 16:1987 data it is observed that as the percentage of RHA is increasing CBR values are increasing(10-14) up to 20% and then decreasing to 8.Maximum values attained (14) at a dosage of 20%.Increase in CBR values are due to development of frictional resistance by filling up of formed voids of sand and RHA mixes by the lower sizes of sand and RHA particles. Hence a combination of sand and RHA particles mobilizes more frictional resistance than individual sand and RHA particles against compression.

IV. Applications

1. RHA is a coarse grained , non-plastic , light weight material with maximum dry density as 0.7 g/cc, and angle of shearing resistance of 36^0 and CBR of 8% can be used as embankment and fill material as also Sub grade material for road construction.

2. Sand is a coarse grained, non plastic material with high dry densities (1.84 g/cc) and shear strength values ($\varphi=36^0$) can be used as fill & Embankment material. It is also had the CBR value 10 can be used as Sub grade material for high traffic intensity roads such as highways and Express ways.
3. Sand and Rice Husk Ash combination gives high strength values $\varphi>40^o$. CBR 14 can be used as Fill and Sub grade material
4. .Partial replacement of Sand by RHA up to 20% attained good bearing resistance value with φ as 36^0-40^0, as CBR as 11-14% ,density as 1.72-1.84 g/cc by maintaining dense condition can be used as fill, embankment and Sub grade material.
5. RHA is a high volume ash, to maintain denseness and effective gradation 20-30% can be recommended as partial replacement of Sand.

V. Conclusions

Industrial wastes like RHA and natural sand can be effectively used as fill and Sub- grade material individually and 20-30% replacement of Sand by RHA can also be effectively used as Geotechnical construction material by maintaining Dry densities in the range of 1.34-1.78 g/cc, angle of shearing resistance in the range of $36\text{-}40^o$ and CBR of 11-14%.

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