ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 9, March 2016

Partial and Full Replacement of Crusher Dust with Rice Husk Ash as Fill and Sub-Grade Material

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ABSTRACT-Conventional materials like natural soils, sands and broken rock pieces are popular for the construction of sub-grade embankment and fill material. Soils dominated by fines subjected for distress at wet condition under repeated wheel loads to reduce the thrust on natural soils and bulk utilization of industrial waste. In attempt is made to use crusher dust and Rice husk Ash(RHA) as construction material. In this connection partial replacement of crusher dust by Rice husk ash particles has been studied and this behaviour can be explained in terms of density shear strength and CBR. From the test results it is identified that 20% replacement of Crusher dust(CD) by High volume Rice Husk ash gives angle of shearing resistance 42^o and CBR as 15.Hence crusher dust and Rice husk ash combinations can be effectively used as road construction materials.

***Index terms*—CBR, Compaction, Crusher dust, Rice Husk Ash.**

I. INTRODUCTION

Human activities generates huge quantities of industrial wastes. These require thousands of hectares of land for disposal. To reduce thrust on the environment and use of bulk quantities several engineering applications have been under progress. Crusher Dust and RHA are two industrial waste, which have gaining importance in construction activities. Crusher dust (CD) is a residue obtained by crushing of stone into required sizes from crushing stone industry which has sizes ranging from 4.75mm to 75µm. Rice husk ash is also an Agricultural Industrial waste obtained by burning of Rice husk which also has large potential in constructional activities. Inherent qualities like non plastic and porous, can have several applications in soil structures. Increasing the traffic intensity this transfer heavy wheel load stresses to the ground from the crest of the pavement. Researchers have been searching alternate materials in place of natural grounds to avoid excess deformation and increases the durability of the pavement. Sridharan.A et.al (2005[11], 200612) conducted studies on quarry dust and reported that high CBR and shearing resistance values can enhance their potential use as sub-base material in flexible pavements and also as an embankment material. Praveen Kumar et.al (2006)[7] conducted CBR tests on stone dust as a sub-base material.Arun Kumar.U et al (2016)[1,2] studied A Study on Impact of Industrial Wastes Utilization as Granular Sub Base (GSB) and Base course Material in Flexible Pavement Construction.Wood et.al (1993)[13] identified that the physical properties, Chemical composition and mineralogy of quarry dust vary with aggregate type and source.

In the present investigation industrial wastes such as crusher dust and Rice Husk Ash has been identified has sub grade material has their interaction can be studied in terms of properties like compaction, strength etc for identification of effective dosage of RHA to CD to be used as construction material.

II. MATERIALS

To study the performance of crusher dust in partial replacement with Rice husk ash as a geotechnical material in the construction of roads, the following test program was identified.

A. CRUSHER DUST

Crusher Dust was obtained from local stone crushing plants near Visakhapatnam, Andhra Pradesh and subjected to various geotechnical characteristics and results are shown in table-1 and figure-1(a) &1(b).

Table -1: Geotechnical properties of Crusher dust

Property	Values
Gravel (%)	4
Sand (%)	92
Fines (%)	4
a. Silt(%)	4
b. Clay(%)	0
Liquid Limit (%)	NP
Plastic Limit (%)	NP
Specific gravity	2.66
Optimum moisture content (OMC) (%)	11
Maximum dry density (MDD) (g/cc)	2.02
Angle of shearing resistance(º)	38
California bearing ratio CBR (%) (Soaked)	12
Coefficient of uniformity (Cu)	10.83
Coefficient of curvature (Cc)	1.02
Coefficient of Permeability(k) (cm/s)	$3.4*10^{-3}$

ISSN: 2277-3754
ISO 9001:2008 Certified
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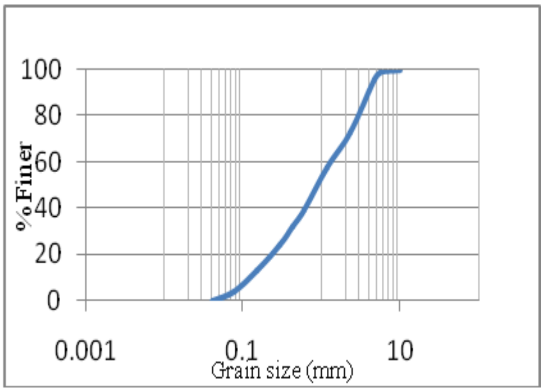

Fig-1(a): Grain size distribution curve

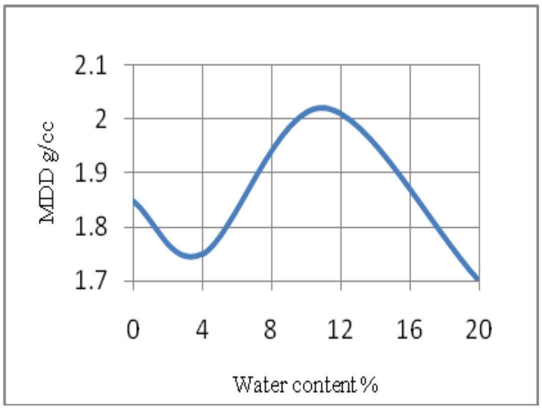

Fig-1(b): Compaction curve for CD

From the test results of crusher dust, the following identifications are made. The grain size distribution of crusher dust (Fig.1 (a)) shows that it consists of 92% of sand size and 4% of silt size particles. It is equally dominated by particles of coarse, medium and fine sand sizes with rough surface texture. Based on BIS, it is classified as well graded particles with non-plastic fines (SW) with C_u as 10.83 and C_c as 1.02. Compaction characteristics (Fig.1 (b)) of crusher dust under modified compaction test has an Optimum Moisture Content of 11% and Maximum Dry Density of 2.02 g/cc. From the compaction curve it can also seen that crusher dust attains higher densities with wider range of moisture contents and increases the workability at high moisture contents. Regarding strength characteristics, it has an angle of shearing resistance (Ø) of 38 degrees under undrained condition and CBR of 12% .It has a coefficient of permeability of 3.4 x10^{-3}cm/sec. Hence it is identified that it has good strength and drainage characteristics.

B. RICE HUSK ASH (RHA)

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

Table-2: Geotechnical properties of RHA

Property	Values
Gravel (%)	0
Sand (%)	84
Fines (%)	16
a. Silt(%)	16
b. Clay(%)	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 (deg)	36
California bearing ratio (CBR) (%)	8
Coefficient of uniformity (Cu)	9.14
Coefficient of curvature (Cc)	1.75
Coefficient of Permeability(k) (cm/s)	$1.74*10^{-3}$
Volume of RHA for a mass of 10g(ml)	35

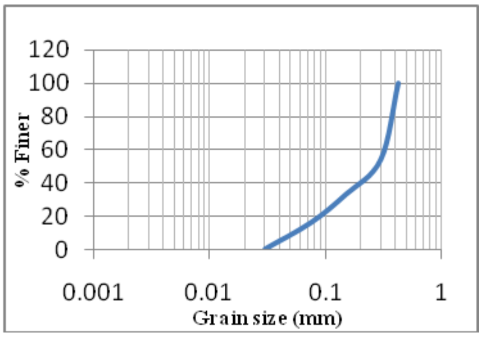

Fig-2(a): Gradation curve for RHA

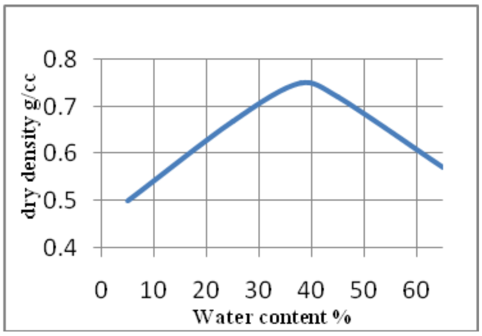

Fig-2(b): Compaction curve for RHA

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 & elongated shape with rough surface texture. The gradation shows it comes under zone IV. Based on BIS it is classified as silty sand with non-plastic and incompressible fines (SM).

Compaction characteristics (Fig.2 (b)) of Rice husk ash under modified Proctor test has OMC of 38% and MDD

ISSN: 2277-3754
ISO 9001:2008 Certified
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of 0.7 g/cc. From the compaction curve it can be seen that Rice husk ash attains lower densities for wider variation in moisture contents. Regarding strength characteristics it has an angle of shearing resistance (Ø) of 36 degrees under un-drained condition and CBR of 8% and has good drainage characteristics with coefficient of permeability as 1.74 * 10^{-3} cm/sec. Comparing the above characteristics of crusher dust with Rice husk ash, crusher dust attained high dry densities with less wider variation of moisture contents where as RHA attained less dry density with wider variation of moisture contents due to nature of particles with low specific gravity, porous and poor distribution of particles.

III. RESULTS AND DISCUSSION

Various percentages of Rice Husk Ash such as 5%, 10%, 15%........50% were added to Crusher Dust and these mixes are listed below in table - 3 and subjected for geotechnical characteristics like compaction, angle of shearing resistance and CBR tests as per IS 2720.

Table-3: Crusher dust-RHA mixes

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

A. PERFORMANCE OF CRUSHER DUST AND RHA MIXES

Mixes of crusher dust and 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) these 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 obtained by compacting CD-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-3(a),3(b),3(c),3(d)

Table-4: Geotechnical properties of crusher dust and RHA mixes:

Mixes	CD(%) +RHA (%)	OMC (%)	MDD (g/cc)	Ø(deg)	CBR (%)
M_1	100+0	11	2.02	38	12
M_2	95+5	12	2	39	12.5
M_3	90+10	13.4	1.96	40	13
M_4	85+15	14.6	1.92	41	14
M_5	80+20	15	1.88	42	15
M_6	75+25	17.3	1.82	41	14.5
M_7	70+30	18.8	1.78	40	14
M_8	65+35	20.2	1.73	39	13.5
M_9	60+40	21.9	1.66	38.5	13.5
M_{10}	50+50	25	1.54	38	13

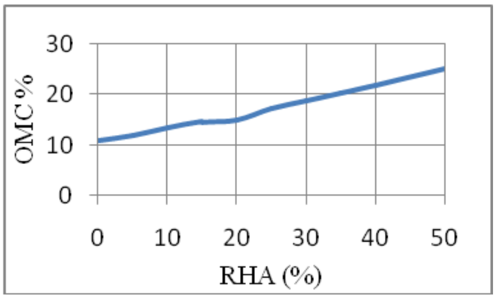

Fig-3(a):RHA(%) Vs OMC

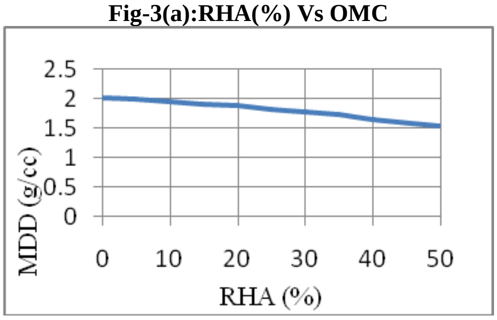

Fig-3(b): RHA (%) Vs MDD

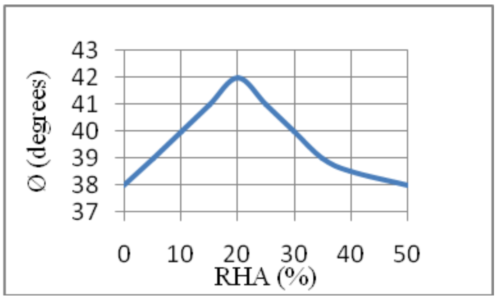

Fig-3(c):RHA(%)Vs φ

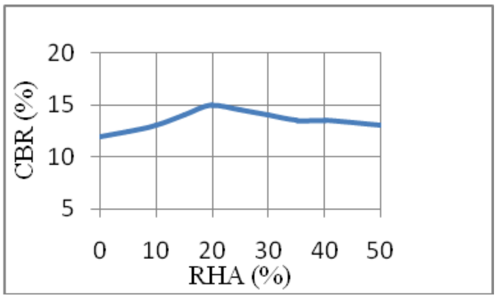

Fig-3(d): RHA (%)Vs CBR

From the compaction test data(Fig.3(b)) it is observed that as the percentage of Rice husk ash is increasing, optimum moisture content values as increasing and maximum dry density values are decreasing. A rapid increase in OMC and decrease in MDD values were observed. At low percentages of Rice husk ash, the

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behaviour of crusher dust is dominating, at high percentages of rice husk ash the behaviour of Rice husk ash particles is dominating in the mixes. The Rapid increase in OMC is due to the shape and nature of Rice husk ash particles, where as rapid decreasing dry densities is due to low specific gravity and replacement of crusher dust with Rice husk ash particles.

From the shear test data(Fig.3(c)) it is observed that as the percentage of Rice husk ash is increasing, the angle of shearing resistance values are increasing up to 20% and then decreasing. Maximum values were attained at a dosage of 20%.The increase in angle of shearing resistance values is due to the development of high frictional resistance and attainment of dense condition against shear. Hence a combination of crusher dust and 20% Rice husk ash particles mobilizes more frictional resistance than individual crusher dust and Rice husk ash particle and achieved maximum angle of shearing resistance value as 42^0.

The percentage of Rice husk ash is increasing, CBR values are increasing from 12-15 up to 20% of RHA and then decreasing (Fig.3 (d)). Maximum value of 15% was attained at a dosage of 20% of Rice husk ash. Increase in CBR values are due to development of frictional resistance by filling up of formed voids in crusher dust and Rice husk ash mixes by the lower sizes of Rice husk ash and crusher dust particles. Hence a combination of crusher dust and Rice husk ash particles mobilizes more frictional resistance than individual crusher dust and Rice husk ash particles against compression and shear.

IV. APPLICATIONS

1.Crusher dust is a coarse grained, non-plastic material with high dry densities (2.02 g/cc) and shear strength values ($\varphi=38^0$) can be used as fill & Embankment material. It is also had the CBR value 12 can be used as Sub-grade material for high traffic intensity roads such as highways and Express ways.

2.RHA is also a coarse grained, non- plastic material with low dry densities (0.7 g/cc) and high angle of shear resistance 36^o , can also be used as embankment and fill material especially on poor grounds and also be used as Sub-grade material (CBR =8).

3. Crusher dust and Rice Husk Ash combination gives high strength values in terms of $\varphi>40^o$ and CBR 12-15 can be used as Fill and Sub-grade material

4. RHA is a high volume ash, to maintain denseness and effective gradation 20-30% of RHA can be recommended as partial replacement to Crusher dust.

V. CONCLUSION

Industrial wastes like Crusher Dust and RHA can be effectively used as fill and Sub- grade material individually and 20-30% replacement of CD by RHA can also be effectively used as Geotechnical construction material by maintaining dry densities in the range of 1.78-2.02 g/cc, angle of shearing resistance in the range of 38-42^o and CBR of 12-15%.

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