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Influence of Water Contents on Strength Characteristics of Rice Husk Ash as a Construction Material

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Abstract: *Rice husk ash (RHA) is a pozzolanic material that could be potentially used in various geotechnical aspects .RHA is an agricultural industrial waste which is nearly 100 million tons, requires huge quantities of land for its disposal. To utilize these huge quantities in several civil engineering applications, physical and engineering properties has been identified to study the quantities of RHA. In this connection Gradation, Seepage, compaction, strength, chemical composition tests and also influence of water contents on shear strength at various drinage conditions were performed .Test results show these are non-plastic, porous, elongated light weight materials. These have low dry densities at high moisture contents and achieved high values of shearing resistance. From drinage conditions it is also identified that rice husk ashes exhibited high shear strength values can be utilized in construction activities.*

Keywords: *Rice Husk Ash, Shear strength, Seepage conditions, Embankment fill.*

I. Introduction

Disposal of solid waste on the land can be minimized if the waste is having desirable properties such that they can be utilized for geotechnical applications. 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. Construction activities have been giving opportunities for the bulk utilization of various industrial wastes. In this concern Rice Husk Ash has been studied for its bulk utilization in Geotechnical construction activities.

Researches contributed its utilization in various fields can be summarized below. Sharma R.S et.al (2008)[8] studied the effect of lime, calcium chloride and Rice Husk Ash on engineering properties of expansive soils, Satyanarayana.P.V.V et.al(2016)[7] studied Partial and Full Replacement of Crusher Dust with Rice Husk Ash as Fill and Sub-Grade Material, Ali M et.al (2004)[1] studied Rice Husk Ash and lime on properties of Bentonite, Sabat A.K et.al (2011) [5] studied effect of Marble dust on strength and durability of Rice Husk Ash stabilized expansive soils, Bhasin et.al (1988) [2] studied utilization waste materials for the construction of roads. Satyanarayana PVV et.al (2003), studied Use of Rice Husk Ash ,Lime,and Gypsum in strengthening Subgrade and subbase in low cost Roads,Vamsi mohan N et.al (2012) [9] studied application of Rice Husk Ash in bricks, Noor et.al (1990)[4] studied Rice Husk Ash and cement combinations with respect to Compaction, Compressive strength, Tensile strength and Durability aspects. Vamsi Nagaraju. T et.al (2016)[10] Studied Effective Use of Rice Husk Ashes in Geotechnical Applications, Yadu et.al (2011)[11] studied Rice Husk Ash on Expansive soils in terms of CBR, Atterberg limits and Unconfined compressive strength. In the present investigation engineering properties of Rice Husk Ash in terms of compaction, strength, seepage and also the influence of water contents on shear strength at various drinage conditions have been studied. These properties help in utilization of rice husk ash in construction activities.

II. Materials

To study the strength characteristics at various moulding water contents Rice husk ashes (RHA) from eight sources were identified from coastal districts of Andhra Pradesh are named as Tekkali and Narasannapeta in Srikakulam district, Padalpeta, and Jammu in Vizianagaram district, Maddi in Vishakapatnam district,and Sesali,Kalla,kallakuru in Westgodavari districts in Andhra Pradesh. These samples were dried and tested for various physical and engineering and chemical properties.

III. Results And Discussions

3.1 PHYSICAL PROPERTIES:

Table-1physical properties of Rice husk ash

S.NO	LOCATIONS PROPERTY	TEKKALI	PADAL PETA	N PETA	MADDI	SESALI	KALLA	K.KURU	JAMMU
1	**Colour**	light black	grey	grey	grey	grey	grey	grey	grey
2	**Texture**	coarse	coarse	coarse	coarse	coarse	coarse	coarse	coarse
3	**Specific Gravity(g)**	1.83	1.8	1.86	1.9	1.85	1.82	1.83	1.82
4	**Volume(cc) For 10g**	35	30	32	30	30	34	32	30

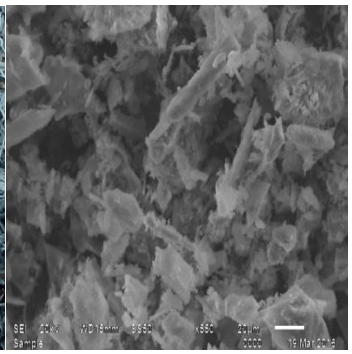
From the physical identification, majority of the Rice husk ashes appear in grey colour where as Tekkali Rice husk ash in light black colour.The colour of Rice husk ash is mainly depends on the type of Rice husk, burning temperature and type and time of burning etc., These rice husk ashes have coarse texture and occupied volume in the range of 30-35cc for a mass of 10g in free pouring conditions can be identified as high volume ashes. It is also identified that the Rice husk ashes have specific gravities in the range of 1.8-1.9, and Low specific gravities are due to presence of silica and absence of heavy metal minerals.
Hence from the observations of physical properties, Rice husk ashes can be identified as light weight, high volume, siliceous, porous with coarse texture and honeycombing arrangement of particles.

3.2 CHEMICAL COMPOSITION:

Collected dried samples of RHA's were subjected to Scanning electron microscopy analysis and identified chemical compositions are listed below table-2 and figures 1(a),1(b)and1(c)

Table.2.chemical compounds

Chemical Compound	TEKKALI	P PETA	N PETA	MADDI	SESALI	KALLA	K.KURU	JAMMU
SiO_2 (%)	97.69	96.93	96.55	96.83	97.21	97.55	97.25	96.87
Al_2O_3 (%)	0	0.67	0.26	0.31	0.46	0.53	0.51	0.58
Fe_2O_3 (%)	0.22	0.43	0.22	0.28	0.12	0.15	0.18	0.35
CaO (%)	0.29	0.08	0.59	0.52	0.39	0.30	0.33	0.10
MgO (%)	0	0.30	0.48	0.40	0	0.29	0.15	0.35
Na_2O (%)	0.41	0.40	0	0.38	0	0	0	0.45
K_2O(%)	1.39	1.19	1.89	1.28	2.82	1.18	1.58	1.30



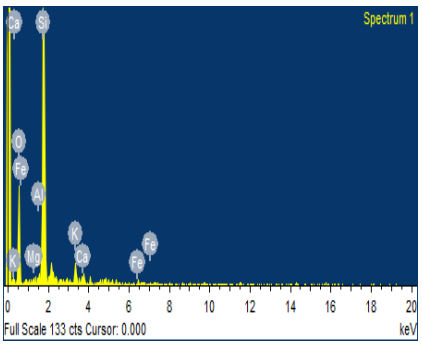


Fig 1(a): collected RHA Sample **Fig1 (b) &1(c):** Typical Images from SEM analysis

From the chemical composition of Rice Husk Ashes it is identified that SiO_2 is dominating as its range is 97-98%.These Rice Husk Ashes have very low percentages of CaO which is in the range of 0.08-0.59% (< 1%). Hence these non-self pozzolanic and can be pozzolanic with addictives like Lime, Cement and Sodium silicates etc.

3.3 ENGINEERING PROPERTIES:

To know the behavior of Rice husk ashes and to predict their engineering behavior tests like gradation, consistency, compaction, permeability, strength and compression were performed as per IS 2720 and results are shown below tables 3.

Table.3.Engineering Properties of Rice Husk Ashes

PROPERTY	TEKKALI	P.PETA	N.PETA	MADDI	SESALI	KALLA	K.KURU	JAMMU
Gravel size (%)	0	0	0	0	0	0	0	0
Sand size (%)	84	82	85	84	81	85	82	83
Fines (%)	16	18	15	16	19	15	18	17
Silt size (%)	16	18	15	16	19	15	18	17
b) Clay size (%)	0	0	0	0	0	0	0	0
Optimum moisture content (%)	38	37	35	34	34.5	35.5	34	34
Max dry density (g/cc)	0.7	0.72	0.73	0.78	0.74	0.73	0.75	0.76
Angle of shearing resistance (Ø) At OMC 1)UU	36	37	35	37	36	35	36	37
2)CD	38	38	37	39	37	37	39	40
Coefficient of permeability(k) cm/sec	$5.29x10^{-3}$	$6.8x10^{-3}$	$7.3x10^{-3}$	$7.0x10^{-3}$	$6.3x10^{-3}$	$5.6x10^{-3}$	$4.8x10^{-3}$	$7.2x10^{-3}$

From the test results it is identified that all the RHAs are dominated by fine sand size particles (<425µm) and percentages of fines (<75µm) in the range of 15-19%. Based on IS 1498-1970, these are classified as silty sand with non-plastic nature (SM).

Compaction test data exhibited low dry densities in the range of 0.72-0.76g/cc and high OMC in the range of 34-38. Low dry densities are due low specific gravity nature and poor gradation of particles. High optimum moisture contents are due to elongated, porous nature of particles.

Shear characteristics of Rice husk ashes show that the angle of shear resistance in undrained condition (Φ_{uu}) is in the range of 35-37^o and in drained conditions it is 37-40^o.

3.4 EFFECT OF WATER CONTENT ON SHEAR STRENGTH OF VARIOUS DRINAGE CONDITIONS

To study the effect of water contents on shear strength at various drinage conditions of Rice husk ashes (RHA) from four sources such as Tekkali ,Jammu ,Kallakuru and Maddi were identified in coastal districts of Andhra Pradesh viz: Srikakulam, Vizianagaram , Westgodavari and Vishakapatnam districts respectively. Collected samples were dried and conducted tests like Unconsolidated Undrained (UU) and Consolidated Drained (CD) as per IS: 2720 (Part XIII)-1985. By compacting the samples at their corresponding water contents and the results are shown in below table 3 and figure 2(a), 2(b),2(c)and2(d).

Table.3.Effect of water contents on shear strength of various drainage conditions

ANGLE OF INTERNAL FRICTION (Φ^O)								
LOCATION →	**TEKKALI**		**JAMMU**		**KALLAKURU**		**MADDI**	
Water content (%)	UU	CD	UU	CD	UU	CD	UU	CD
25	35	36	36	38	35	37	35	37
30	35	36	36	39	36	38	36	38
34	36	37	37	40	36	39	37	39
35	36	38	37	40	36	39	37	39
38	36	38	36	39	36	38	36	38
40	36	37	36	38	35	37	36	37
45	35	36	35	37	35	37	35	36
50	35	36	35	36	34	36	35	36

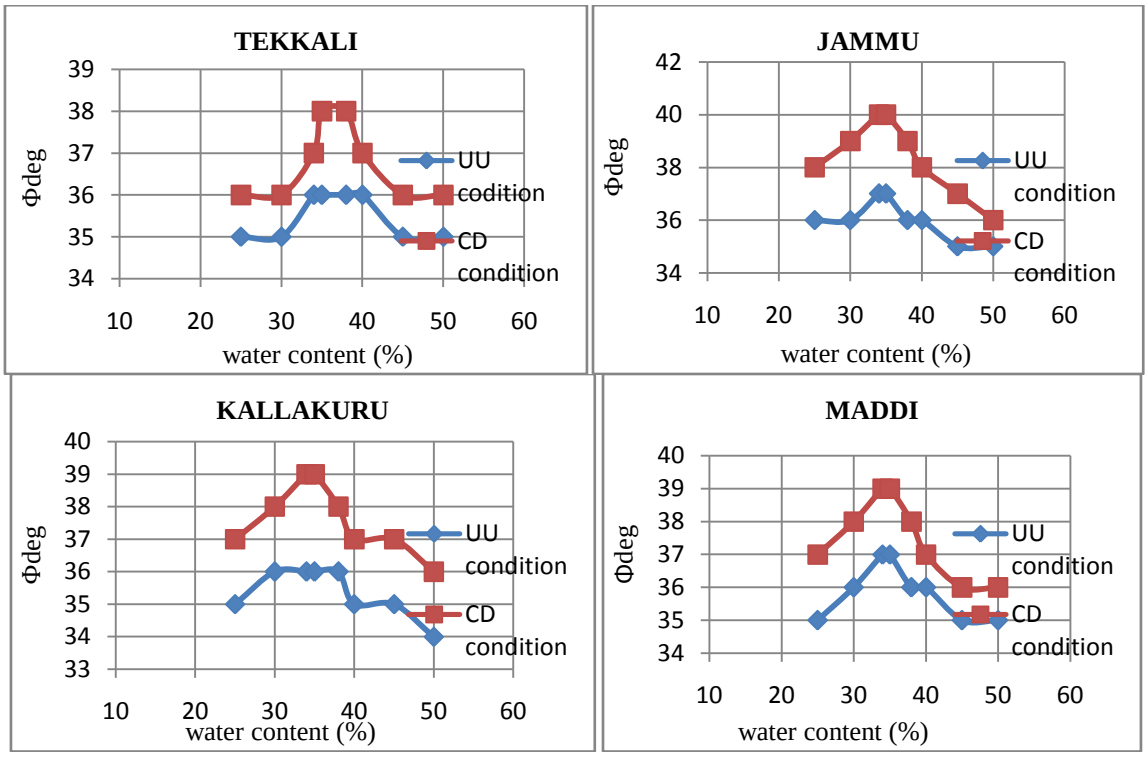


Fig 2(a) to 2(d): variation of shearing resistance with respect to molding water contents

From the test results the following identifications are observed. Angle of shearing resistance values are increasing with increasing water contents up to optimum moisture content and then decreasing for their drained and undrained conditions. Maximum values were obtained at their optimum moisture contents .Higher values are obtained for drained condition than undrained condition. Water contents nearing to their OMC the variation in angle of shearing resistance values are less both in undrained and drained conditions.

Hence rice husk ashes exhibited higher values of angle of shearing resistance by maintaining wide range of moisture contents in dry and wet conditions.

IV. Applications And Conclusions

1. Inherent qualities such as coarse grained, non-plastic, porous nature of rice husk ashes attract their utilization in civil engineering applications.
2. High angle of shearing resistance values (Φ) in the range of 36-40^{o} can be used as embankment and fill material etc
3. High shear strength can be mobilize at high angle of shearing resistance at drained condition can help in reducing seepage pressures.
4. Due to pozzolanic nature of RHA when it interacted with chemical addictives these gives high strengths with curing time.

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