

The Effect of Rice Husk Ash and Sawdust on the Engineering Properties of Soil

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ABSTRACT: Soil in its natural state bears several engineering properties. However these properties can be altered to desired standards by mixing the soil with various materials. In this paper, soil is studied using rice husk ash (RHA) and sawdust(SD). Rice husk is an agricultural waste obtained from milling of rice. Processing of rice generally yields 20-25% husks relative to the weight of paddy. The sawdust is the by-product of wood obtained by cutting, grinding. The investigation includes the laboratory test and analysis of the tested sample which has been classified as coarse grain soil. The properties that were evaluated includes the water content, plastic limit, liquid limit, plasticity index (PI), optimum moisture content(OMC),maximum dry density(MDD) and shearing resistance. Rice Husk Ash content of 5%, 10%, 15% is added by weight of the dry soil. The percentage of adding the sawdust is 2% ,4% and 6% to the soil. From analyzing the laboratory results, it was found that addition of RHA and sawdust to the natural coarse grain soil reduced the liquid limit, increased the plastic limit, decreased the MDD and the moisture content, decreased the shear stress, decreased the angle of internal friction and reduced the bearing capacity.

KEYWORDS: Moisture content, Maximum dry density, Optimum moisture content, Shear strength, Liquid limit and plastic limit, Rice husk ash, Saw dust.

I. INTRODUCTION

Soil is one of the most abundant naturally occurring construction ad foundation material. Generally, the suitability of a soil for a particular use should be determined based on its engineering characteristics. In most cases, soils need to be 'improved' in order to meet the geotechnical characteristics/properties required for a specific project. Soil improvement could be either by modification or stabilization, or even both. Generally, soil modification is the addition of a modifier (rice husk ash and sawdust) to a soil in order to change its index properties, while soil stabilization involves the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification. Considerable amount of research concerning stabilization of soil with additives such as cement, lime, bitumen and polymers has already been extensively carried out and is available in literature. However, in recent years, the use of various waste products in civil engineering construction has gained considerable attention in view of shortage and high cost of convectional construction materials, increasing cost of waste disposal, and environmental constraints. Rice husk is one of the waste products that have been mentioned with potential to be used for stabilization of soil for road construction. When burnt, the resulting Rice Husk Ash contains high percentage of siliceous compounds, making it an excellent material for road construction.

II. RELATED WORKS

Satyanarayan *et al.*, 2004 studied the effect of FA and lime on the expansive soil used for construction of road base, sub base (Satyanarayan *et al.*, 2004). Stabilization of expansive soil using rice husk ash (RHA) as a pozzolanic

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material along with a binder has been studied by researchers a number of times (N K Bhasin *et al.*, 1988), (A S Muntohar and G Hantoro, 2000), Effect of RHA with cement (E A Basha *et al.*, 2003), (A N Ramakrishna and A V Pradeep Kumar, 2006), effect of RHA with calcium chloride (R S Sharma, 2008), effect of RHA with with marble dust (A K Sabat and R P Nanda, 2011), effect of RHA and lime with gypsum (D K Rao *et al.*, 2011) etc. Similarly the mixing of lime sludge along with a pozzolanic material has also been studied. Chandra *et al.* had stabilized a non-expansive clayey soil with RHA and lime sludge (S Chandra *et al.*, 2005). RHA added to soil was from 5 to 20% in steps of 5% and lime sludge from 4 to 16% in steps of 4%. Properties of the stabilized soil studied were, Atterberg's limits, maximum dry density (MDD), optimum moisture content (OMC), unconfined compressive strength(UCS) and soaked California bearing ratio (CBR) of soil.

Brooks (2009) studied the potential of Rice Husk Ash (RHA) and fly ash (FA) blended soil as a swell reduction layer between the footing of a foundation and subgrade. He recommended 12% and 25%, RHA and FA, respectively, for modifying the expansive subgrade soil. Ali *et al.* (2004) studied the effect of RHA and lime on characteristics of bentonite (Ali M and Sreenivasulu V, 2004). S.Kanaka (2012) has effectively shown the positive impact of sawdust on Marine Clays who has proved that liquid limit of soil decreases at 20% Saw Dust, the Free Swell Index of soil is reduces moderately at 20% Saw Dust, addition of small percentage of Gypsum reduces the hardening process, and saw dust can potentially stabilize the expansive soil solely. Basha *et al.* found that the addition of RHA responsible in reducing the plastic limit and maximum dry density of soils.

III. OBJECTIVE OF THE STUDY

The primary objective of this study is to compare the effect of addition of rice husk ash (RHA) to soil in different percentage; and RHA + Sawdust to soil in different percentage. A comparative analysis of the results have been made. Sawdust ash is a pozzolanic material as confirmed by A.A. Raheem *et al.* The chemical composition proves that sawdust ash has sufficient amount of silica and alumina. Silica content gives the ash its pozzolanic properties which makes it a useful cementitious material. Particle gradation analysis showed that sawdust ash had 97.4% Sand, 2% Clay and 0.6% Silt. RHA has a good pozzolanic property. It is non-plastic in nature and was collected from local rice mill. RHA and sawdust is a great environmental threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA.

IV. EXPERIMENTAL RESULTS

A few particular laboratory tests to determine the properties of the collected soil sample was undertaken for experimental evaluation. The grain size distribution curve for the soil sample was obtained for the purpose of appropriate classification of the soil. Thereafter the following experimental determination was made:

Grain size distribution determination: This test was conducted on Soil only. It was found according to the procedure of the IS: 2720 (part 4)-1985. The graph between the particle size and Cumulative percentage finer as shown in Fig-1. It was found that the soil retained on IS: 4.75mm more than 50% and the finer soil is lesser, it can be considered that the soil is coarse grained soil. The soil sample is collected from a depth of 2m and is disturbed sample.

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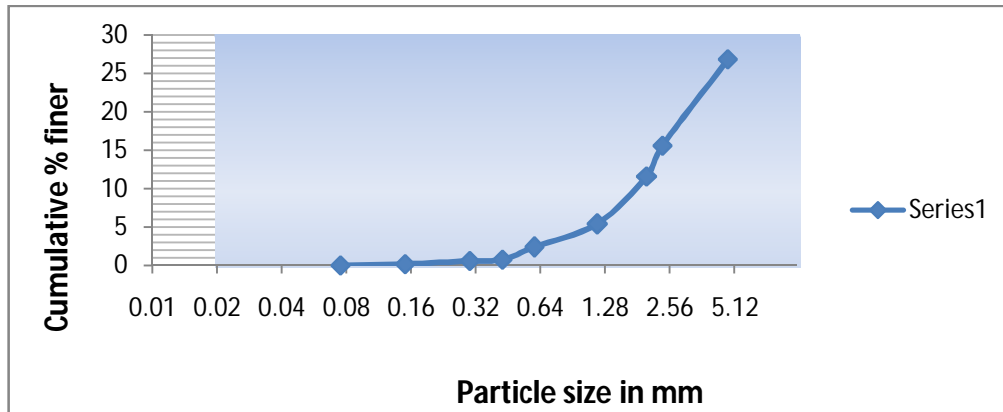


Fig-1: The graph between the Cumulative percentage finer (%) and particle size (mm)

Moisture content determination: This test was conducted on soil only; soil +5% RHA, soil +10% RHA & soil +15% RHA; soil + 5%RHA +2%SD, soil +10%RHA +4% SD and soil +15% RHA +6% SD. It was as per the procedure of the IS: 2720 (part 2)-1973.

Plastic limit and liquid limit determination: This test was conducted on the same sample proportional as mentioned above according to the procedure of the IS: 2720 (part 5)-1985.

Standard proctor determination was found according to the procedure of the IS: 2720 (part 7)-1965.

Direct shear stress determination was found to the procedure of the IS: 2720 (part 13)-1986.
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V. RESULT AND DISCUSSION

The tests results are summarized in tables below. The variation in the moisture contents, dry density, plastic limit, liquid limit, shear stress and plasticity of soil are shown in Figures 1 to 7. Table 1 shows the variation of various consistency limits when soil is mixed with different ratio of RHA and SD

Mix proportion	Moisture content (%)	Plastic limit (%)	Liquid limit (%)	Plastic index (%)
Soil only	15	17.05	50	48.62
	10	18.42	66.67	
	20	16.67	58.33	
Soil + 5%RHA	8.69	13.33	25	20.547
Soil + 10%RHA	3.52	14.94	36.98	
Soil + 15% RHA	12.149	12.09	19.33	
Soil + 5%RHA +2%SD	10.721	19.04	31.75	7.654
Soil + 10%RHA + 4%SD	5.982	26.05	43.67	
Soil + 15%RHA + 6%SD	13.924	21.95	27.22	

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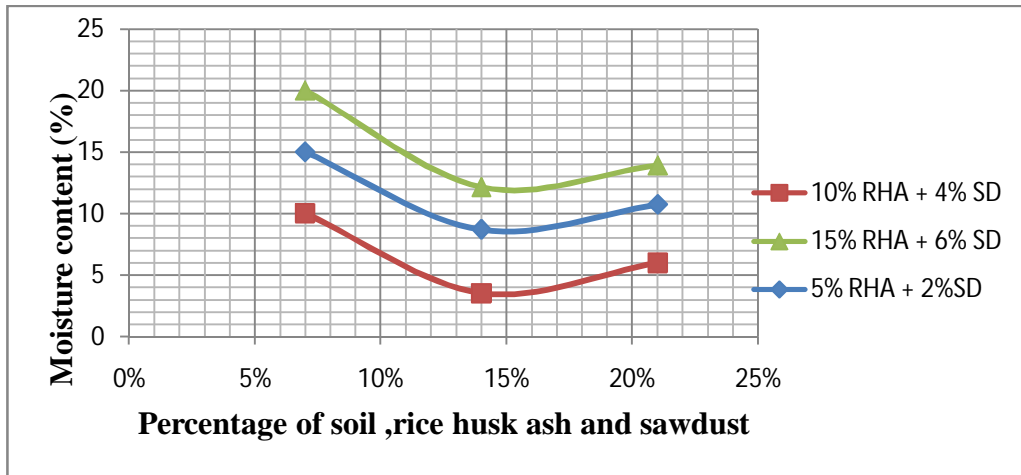


Fig 1 :The moisture content (%) is plotted with the different percentage of soil, soil + rice husk ash and soil + rice husk ash + sawdust

From figure 1 it may be found that the addition of 5% of RHA to the soil decreases the moisture content. Also if the percentage of the rice husk is further increased from 10 to 15%, the moisture content starts increasing.

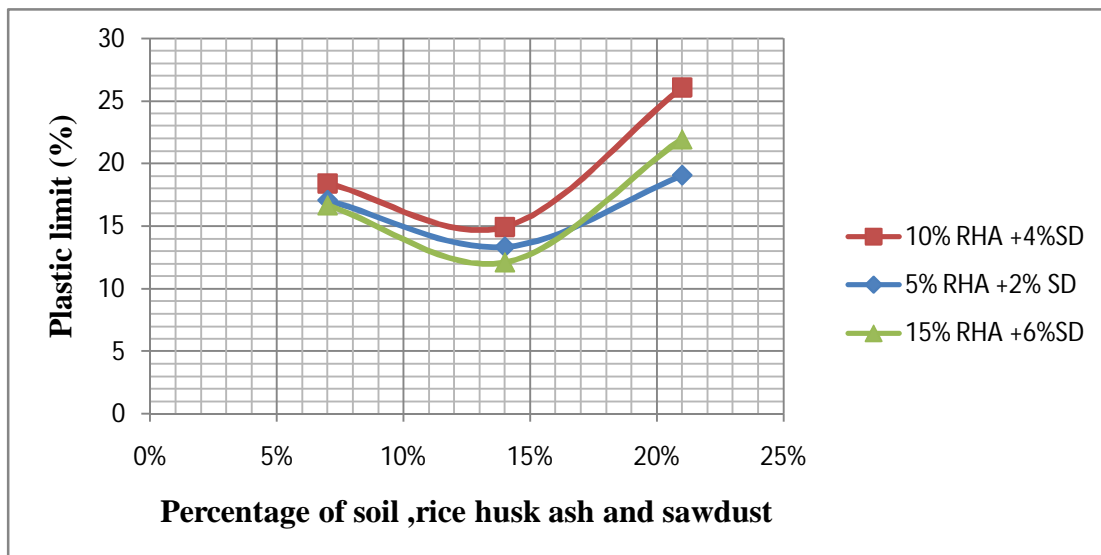


Fig 2: The plastic limit (%) of soil is plotted with the different percentage of rice husk ash and sawdust

From the test result it is seen in figure 2, that the addition of RHA to the soil decreases the plastic limit. However if the saw dust is added to the soil mix, then the plastic limit increases almost by 10% compared to the natural soil sample.

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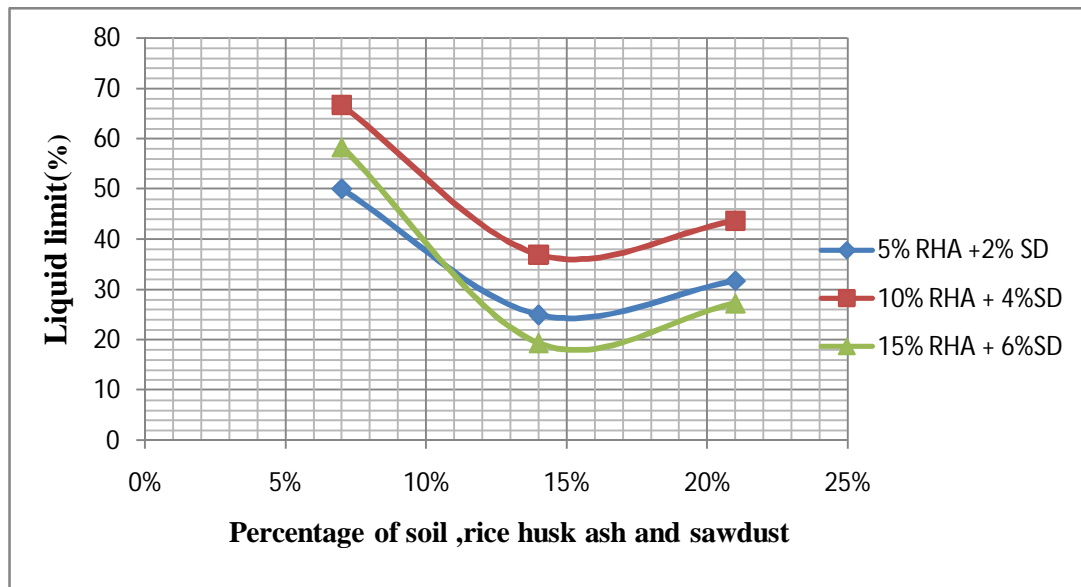


Fig 3: The Liquid limit (%) of soil is plotted with the different percentage of rice husk ash and sawdust

It may be found from figure 3, that the liquid limit decreases after the addition of rice husk ash. After as the % of rice husk ash increases, then the % decreases in liquid limit containing rice husk ash, the liquid limit starts decreasing compared to natural soil, but increases as compared to soil + RHA.

Table 2 illustrates the variation in OMC and MDD when soil is mixed with different ratio of RHA and SD.

Table-2: Proctor Test Results				
Test sample	Moisture content (%)	Dry density (g/cm ³)	OMC (%)	MDD(g/c m ³)
Soil only	0.461	1.855	0.671	2.115
	0.671	2.115		
	1.11	2.089		
Soil + 5%RHA	1.655	1.861	1.655	1.861
Soil + 20%RHA	1.736	0.929		
Soil + 25% RHA	1.352	0.818		
Soil + 5%RHA +2%SD	5.07	1.740	1.926	3.43
Soil + 10%RHA + 4%SD	3.43	1.926		
Soil + 20%RHA + 8%SD	6	0.857		
Soil + 25%RHA + 10 %SD	2.89	0.756		

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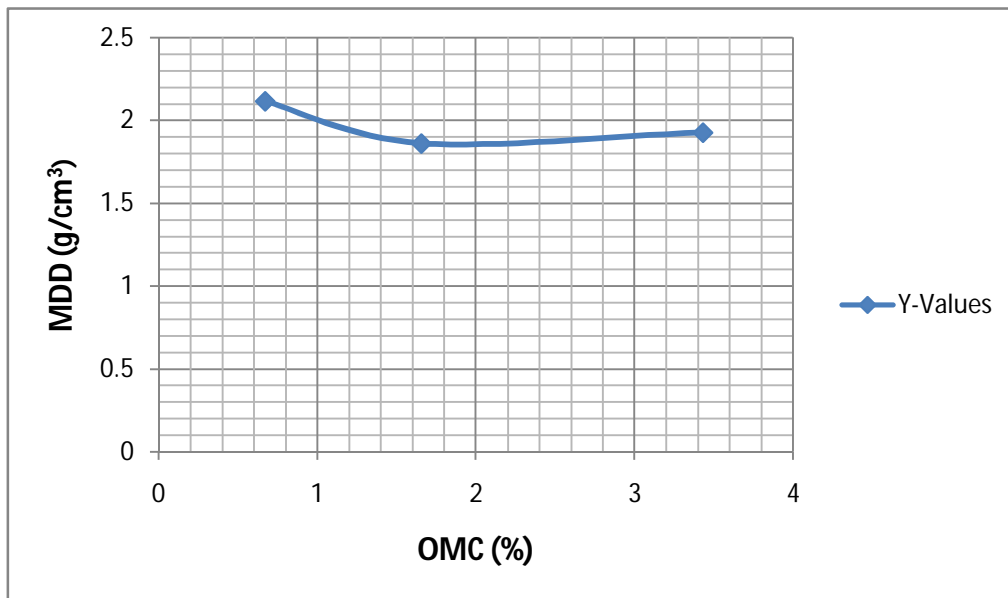


Fig 4. The Maximum dry density (g/cm³) is plotted with the optimum moisture content (%) of only soil, soil +RHA and soil +RHA +SD.

From the figure 4, it is seen that the optimum moisture content increases from 0.671 to 1.655 % after the addition of rice husk ash and the maximum dry density decreases from 2.115 to 1.861 g/cm² after the addition of RHA. Later the addition of sawdust to the soil containing rice husk ash the optimum moisture content start increases from 1.655 to 3.430% and the maximum dry density also increases from 1.861 to 1.926 g/cm³.

Table 3 shows the test results of direct shear test which finally gives the variation in angle of shearing resistance and undrained shear strength of the soil in its natural state and mixed state.

Test sample	Normal stress (Kg/cm ²)	Shear stress at failure (Kg/cm ²)	Maximum shear stress (Kg/cm ²)	Angle of shear resistance (degree)	Apparent cohesion Kg/cm ²
Soil only	0.5	0.0594	0.409	35	0.0594
	1	0.162	0.759		
	1.5	0.254	1.109		
Soil + 5%RHA	0.5	0.0738	0.152	9	0.0738
Soil + 10%RHA	1	0.0799	0.231		
Soil + 15% RHA	1.5	0.0861	0.310		
Soil + 5%RHA +2%SD	0.5	0.0748	0.171	13	0.0748
Soil + 10%RHA + 4%SD	1	0.0799	0.268		
Soil + 15%RHA + 6%SD	1.5	0.0861	0.365		

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Figure 5 illustrates the failure envelop of natural soil sample from direct shear test data which gives the value of cohesion and angle of internal friction of the soil.

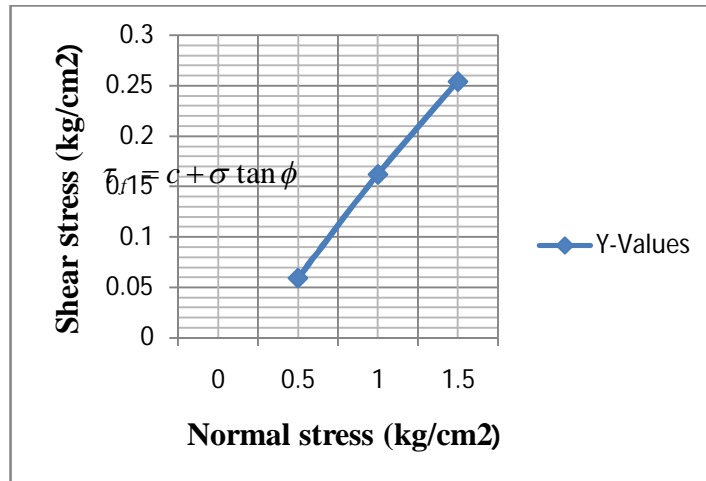


Fig 5: The graph is plotted between the shear stress and normal stress for soil only

Figure 6 illustrates the failure envelop of soil+RHA from direct shear test data which gives the value of cohesion and angle of internal friction of the soil.

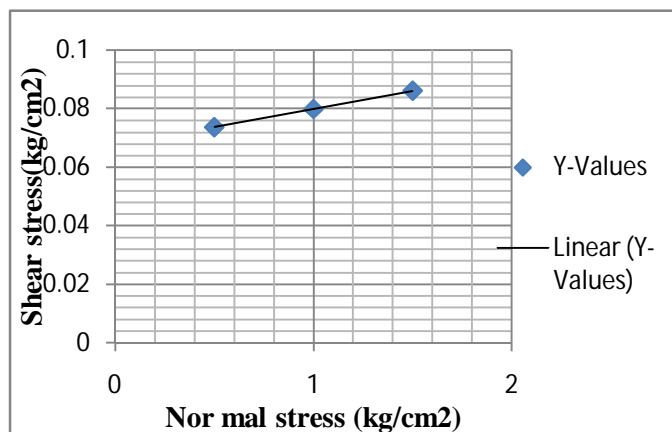


Fig 6: The graph is plotted between the shear stress and normal stress for soil + rice husk ash.

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Figure 7 illustrates the failure envelop of soil+RHA+SD from direct shear test data which gives the value of cohesion and angle of internal friction of the soil.

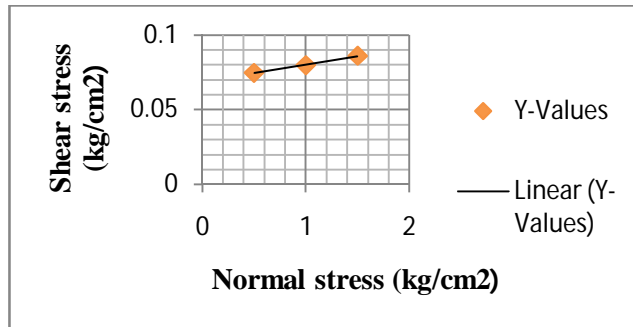


Fig 7: The graph is plotted between the shear stress and normal stress for soil + rice husk ash (RHA) + sawdust (SD).

As shown above the shear stress at failure increases from 0.0594 to 0.0738 kg/cm² under the normal stress of 0.5 kg/cm². Later, the addition of sawdust to the soil and rice husk ash, the shear stress at failure increases from 0.0738 to 0.0748 kg/cm² under the normal stress of 0.5 kg/cm². The angle of friction is decreased after the addition of rice husk ash from 35° to 9° and later on the addition of sawdust to the soil containing RHA, the angle of friction tend to increases from 9° to 11°.

VI. COMPARATIVE ANALYSIS

The effect of rice husk ash and sawdust on properties of soil with the help of laboratory test which include water content, grain size distribution, Atterberg limit, Standard proctor test and direct shear test. With the use of these tested samples we can analysis the effect of rice husk ash and sawdust clearly. The percentage for rice husk ash is taken as 5%, 10%, 15%, etc. and sawdust is also taken as 2%, 4%, 6% etc.

Moisture content analysis:

The comparative analysis of moisture content test for soil, and different percentage of RHA and SD is shown in the form of bar diagram plots in figure 8

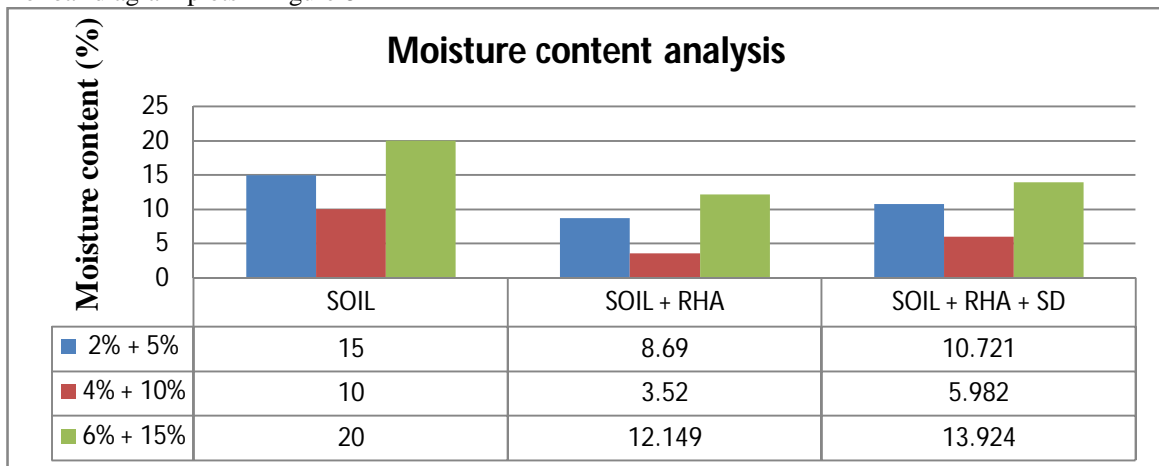


Fig 8. Variation of Moisture content with different percentage of soil, rice husk ash and sawdust (SD)

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Plastic limit analysis:

The comparative analysis of plastic limit and liquid limit for soil, and different percentage of RHA and SD is shown in the form of bar diagram plots in figure 9 and 10 respectively.

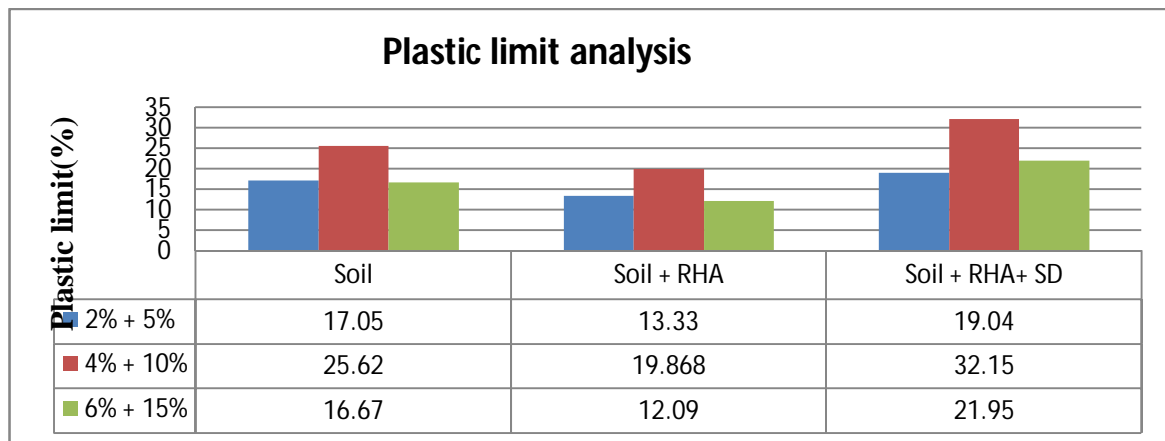


Fig 9: Variation of plastic limit with the different percentage of soil, rice husk ash (RHA) and sawdust
Liquid limit analysis:

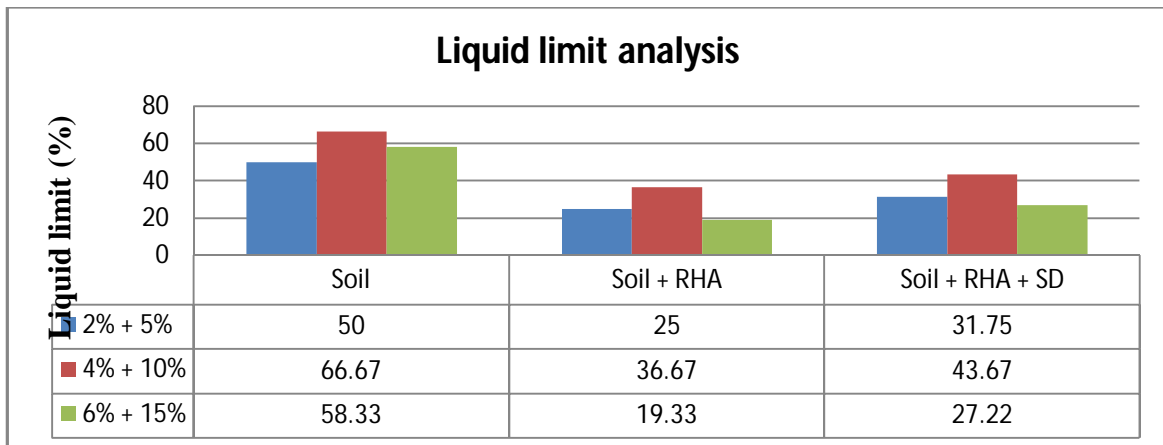


Fig 10: Variation of Liquid limits with the different percentage of soil, rice husk ash (RHA) and sawdust (SD).

Standard proctor analysis:

It includes optimum moisture content and maximum dry density analysis. Figure 11 illustrates the optimum moisture content variation on addition of 5% RHA, and 10% RHA + 4% SD to the soil.

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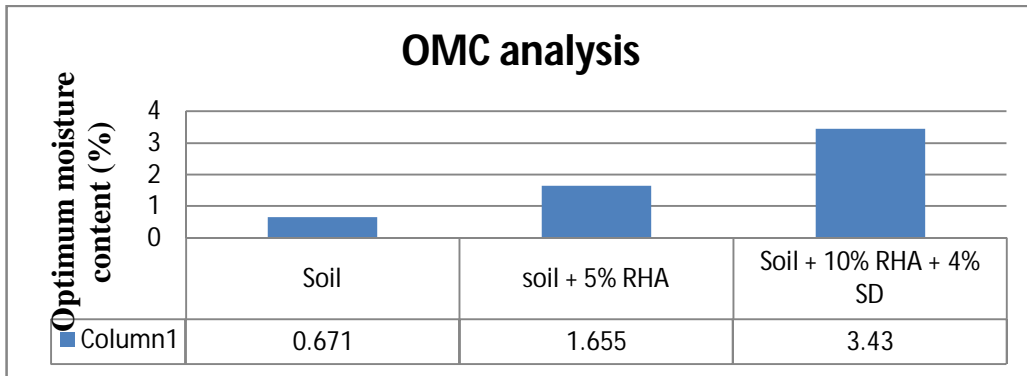


Fig 11: Variation of OMC with the different percentage of rice husk ash (RHA) and sawdust (SD)

Figure 12 illustrates the maximum dry density variation on addition of 5% RHA, and 10% RHA + 4% SD to the soil.

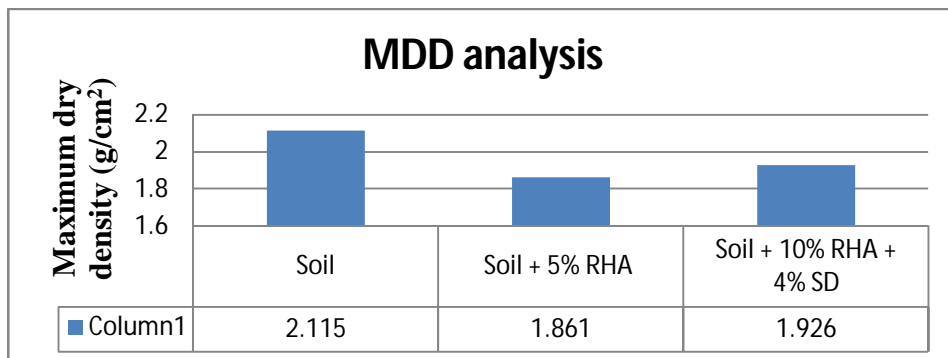


Fig 12: Variation of MDD with the different percentage of soil, rice husk ash (RHA) and sawdust (SD)
Shear stress analysis:

Figure 12 illustrates the optimum moisture content variation on addition RHA and SD to the soil in different proportions.

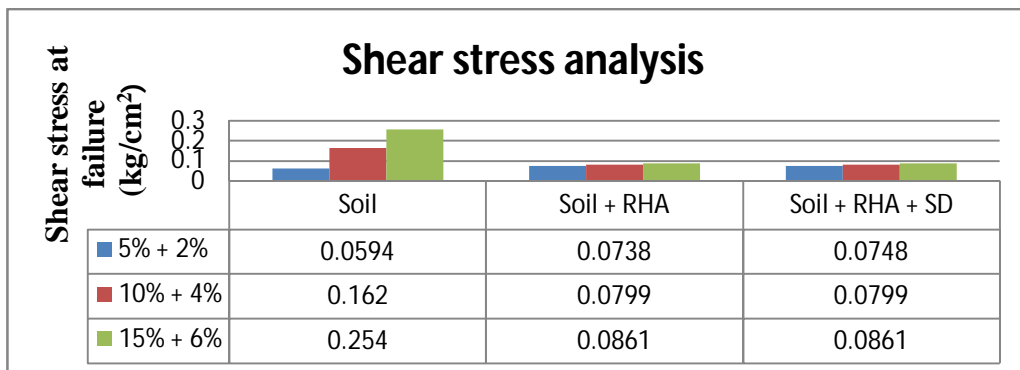


Fig 13: Variation of shear stress with the different percentage of soil, rice husk ash and sawdust

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VII. CONCLUSION

It may be concluded that the effect of rice husk ash and sawdust showed a significant variations in its engineering properties. The moisture content of soil decreases with the addition of rice husk ash and if we increase the percentage of rice hush ash , at certain point the moisture content starts increasing. The addition of saw dust to rice husk increases the plastic limit of soil until it reaches a point after which it starts reducing. The addition of sawdust and rice husk ash to the soil increases the plastic limit in case of coarse grain soil as the plasticity index is seen to increase. The change in behavior depends upon the mix proportion and drying. The MDD and OMC of RHA with soil mix has been decreased and increased respectively as the RHA content has been increased.

If 5% of rice husk ash is added to the soil, the moisture content decreases from 10.7% to 8.69%. Later, the addition of 2% of sawdust to soil containing 10% of rice husk ash the moisture content start increases from 8.69% to 10.72%. The plastic limit of soil is increased from 17.05% to 13.33% after the addition of 5% of rice husk ash. Later, the addition of 2% of sawdust to the soil containing rice husk ash, the plastic limit start increases from 13.33% to 19.04%. The liquid limit of soil is increased from 66% to 34% with 25 numbers of blows after the addition of rice husk ash. Later the addition of sawdust to the soil containing rice husk ash, the liquid limit starts increases from 34% to 28.226%. The plastic index of soil is much more than the rice husk ash containing soil and saw dust. The maximum dry density is decreased from 2.115 to 1.861 g/cm³ after the addition of 5% of rice husk ash and optimum moisture content is also increased from 0.671% to 1.655%. Later the addition of 4% of sawdust to the soil containing 10% of rice husk ash, the maximum dry density is increased from 1.861 to 1.926 g/cm³ and the optimum moisture content start increasing from 1.655% to 3.43%. The shear stress at failure is also increased from 0.0594 to 0.0738 kg/cm² under the normal stress of 0.5 kg/cm². Later, the addition of 2% of sawdust to the soil and rice husk ash, the bearing capacity is increased from 59.829 to 65.057 KN/m² and the shear stress at failure is also increased from 0.0738 to 0.0748 kg/cm² under the normal stress of 0.5 kg/cm². The angle of friction is decreased after the addition of rice husk ash from 35⁰ to 9⁰ and later on the addition of sawdust to the soil containing RHA, the angle of friction tend to increases from 9⁰ to 11⁰. To the contrary we can conclude that addition of admixture to the soil in the form of by products, waste products, cement etc changes the engineering properties of the soil by manifolds which can be brought to desired use as per specific need.

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