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Effect of Marble Dust On Strength Characterstics of Rice Husk Stabilized Soil

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Abstract. The construction expenses can be widely reduced by selecting locally available resources for the lowermost layers of the pavement. In the present urbanization and industrialization circumstance, which has formed several hazardous and non-perilous wastes. This propmts draining landfill space, soil contamination, and many different dangerous effects; henceforth in this study use of waste (i.e., Rice husk ash) for enhancing the soil properties is made. In the present study influence of Marble dust on the quality characteristics of Rice husk ash stabilized expansive soil to increase the features of subgrade soil were determined. Atterberg's limit, compaction, unconfined compressive strength (UCS), direct shear strength and California bearing ratio (CBR) experiments were carried out on the specimens of native soil and expansive soil with stabilizers. The optimum percentage of RHA was found to be 10% based on UCS tests. Marble dust was added to RHA stabilized expansive soil up to 30%, by dry weight of the soil, at an increment of 5%. The maximum dry density (MDD) of expansive soil goes on increasing up to 25% and optimum moisture content (OMC) goes on decreasing irrespective of the percentage of the addition of marble dust to RHA stabilized expansive soil. The UCS, direct shear strength and soaked CBR of RHA stabilized expansive soil increased up to 15% addition of marble dust; the cohesion clearly increased. The UCS and CBR of the mixtures were 120.05% and 199.42% greater than for the untreated soil. Further addition of marble dust had negative effects on these properties. The results established less value of strength parameters for expansive soil, but after the stabilization expansive soil indicated increased value of UCC, Shear Strength and CBR. For better stabilization result, the optimal percentage of Soil: Rice husk ash: Marble dust was found to be 75: 10: 15.

Keywords: Marble Dust, Rice Husk, OMC, UCS, CBR.

1 Introduction

Due to peculiar cyclic swell shrink behavior of expansive soil always creates a problem for civil engineers on construction area. The soil swells when it absorbs moisture and

shrinks when the moisture goes out. It creates severely damaged on lightly loaded structures Due to this movement of water such as foundations, pavements and linings and residential building. An Estimate conducted regarding annual damage of civil engineering structures on expansive soil, which shows that, In UK £150 million, In USA $1000 million, and many billion pounds worldwide. In India This occupied more than 20% of total soil. The presence of clay mineral montmorillonite widely responsible for this nature of soil. Different methods are conducted to modify the soil for construction purpose, stabilization using industrial wastes is one of them. The Densification of expansive soil using Phosphogypsum (a waste product from phosphoric acid industry) and observed that different proportions of Phosphogypsum when mixed with soil reduces its plasticity and liquid limit there by making the soil more workable [8].The CBR value of the soil increased from 2% to 9 % and free swell of the soil reduced considerably when 40% Phosphogypsum was added. the mix could not be compacted properly, When the proportion of Phosphogypsum was increased beyond 40%. Rice husks are the shells produced during dehiscing operation of paddy, which varies from 20% [9] to 23% [5] by weight of the paddy. The rice husk is a waste material and disposed by dumping or burning in the boiler for processing paddy. About 20% of its weight as ash generate due to burning of rice husk [9]. Silica is the main constituent of rice husk ash (RHA) and the quality (% of amorphous and unburnt carbon) depends upon the burning process [11]. The RHA is defined as a pozzolanic material due to its high amorphous silica content [9]. Generally, In India, 100 million tons of paddy produced and more than 4 million tons of RHA generating annually. to lack of cementations properties Rice husk ash cannot be used alone for Modification of soil [7]. So, it is used as a binder with Lime, cement, lime sludge, Calcium chloride etc.[10][7][15][2][3][17].Marble dust are the wastes generated during marble cutting and polishing. The stabilizing effect of marble dust on engineering properties of expansive soil and has found varied success[18][1][13]. The main objective of this paper is to study the effect of Marble dust on UCS, Compaction, Soaked CBR, swelling pressure and durability characteristics of an expansive soil stabilized with optimum percentage of Rice husk ash.

From the review of the available literature it is observed that various efforts have been found to study the possible utilization of different industrial wastes for stabilization of expansive soil. However, study related to the stabilization of expansive soil using RHA is Limited particularly in conjunction with Marble dust that is why an attempt has been made in this experimental work to know the effect of Marble dust on expansive soil stabilized with optimum percentage of Rice husk ash.

2 Experimental Work and Methodology

ln geotechnical constructions will reduce the problems faced by the rice mill for its disposal mostly because of its Large-scale utilization of rice husk ash and its property closely related with the natural earth material. So, assessment to check the behavior rice husk ash at different condition before its use as a construction material in Civil engineering structure. Even through adequate substitute for full scale field tests are not

available; tests at laboratory scale provide a measure to control many of the variable encountered in practice. Details of sample preparation, material used, and testing procedure conducted have been outlined below.

2.1 Expansive soil

The soil sample used for this study is collected from local area of Balasore. The overall geotechnical properties of soil classified as Clay with high plasticity (CH) in the IS Soil Classification System. The properties of the soil used in the investigation are given in Table 1.

Table 1. Properties of the natural expansive soil

Soil Properties	Value
Specific-Gravity	2.47
Free swell index (%)	70
IS classification of soil	CH
Liquid- limit (%)	66.65
Plastic- limit (%)	32.25
Plasticity-Index (%)	28.38
Maximum Dry Density (g/cc)	1.5
Optimum moisture content (%)	23.04
UCS(KN/m²)	75.3
CBR (%) (unsoaked)	4.67
CBR (%) (soaked)	1.72

2.2 Rice husk ash (RHA)

The RHA was collected from Ma Tarini Rice Mill at Balasore (Odisha). Well-burnt RHA passing through 425 µm aperture before use. The chemical composition RHA is given in table 2.

2.3 Marble dust

The marble dust was obtained from marble cutting and polishing industry at Balasore (Odisha). The chemical composition of Marble dust is given in table 3.

Table 2. Chemical Composition of RHA and Marble dust

Constituent	Chemical composition of RHA (%)	Chemical Composition of Marble Dust (%)
SiO2	75.2	5.2
Al2O3	5.2	3.8
Fe2O3	1.02	0.9
CaO	1.4	32.1
MgO	1.75	17.7
Loss on Ignition	15.43	40.3

2.4 Sample preparation and experimental program

First the soil was air dried and it was pulverized with the help of wooden hammer. Then it was sieved with 425µm I.S sieve. Before performing the various tests on materials, the proportioning of ingredients was ascertained. The guidance on proportioning was taken the literature. The amount of RHA Was varied from 5 percent to 20 percent by dry weight of soil in step of 5 percent and Marble powder from percent to 5 percent by dry weight of soil. For combination of both materials with soil 10 percent of RHA was mixed with 0 to 30 percent Marble powder for the laboratory study total 5 mixes were prepared. For conducting different tests on Standard Proctor Compaction tests, UCS tests, stabilized expansive soil with Marble powder, the Marble powder was added from 0 to 25% at an increment of 5%.

Table 3. Proportioning of Soil-RHA-Marble dust mixes

SI. NO	Proportioning of Soil-RHA mixes		Proportioning of Soil-RHA-Marble dust mixes			
	Soil (%)	RHA (%)	Mix No.	Soil (%)	RHA (%)	Marble Dust (%)
1	100	0	M1	90.00	10.00	0.00
2	95	5	M2	85.00	10.00	5.00
3	90	10	M3	80.00	10.00	10.00
4	85	15	M4	75.00	10.00	15.00
5	80	20	M5	70.00	10.00	20.00
6	-	-	M6	65.00	10.00	25.00
7	-	-	M7	60.00	10.00	30.00

3 Results and Discussions

The main aim of this project is to analyze the improvement in geotechnical properties like compaction characteristics, unconfined comprehensive strength tests, direct shear tests and CBR tests etc. The variation in the properties of marble dust treated rice husk ash are discussed in this section. Different types of samples/mixes were prepared for the test, described earlier in desired proportion, weight etc.

3.1 Geotechnical properties of Soil-RHA mix

RHA is a very fine pozzolanic, light, bulky, and highly porous material. This material is solidified while suspended in exhausted and collected in the rice mill industry. It is produced fluidized bed systems, a great furnace, and a suspension/entrained combustion reactor. Reactive of RHA is attributed to its high content of amorphous silica, and to its very large area governed by the porous structures of the particles .

Table 4. Summary of geotechnical properties of Soil-RHA mix

SI. No.	Mixes	Atterberg Limit			Compaction Test		UCS (kN/m²)	DST		CBR (Soaked) (%)
		LL (%)	PL (%)	Pl (%)	OMC (%)	MDD (g/cc)		Cohe-sion (kPa)	Angle (°)	
1	100% s	66.65	32.25	34.40	23.04	1.50	75.30	68.00	31.88	1.72
2	95%S+5%R	62.15	30.20	31.95	23.51	1.48	83.50	89.00	32.86	2.55
3	90%S+10%R	58.35	27.30	31.05	24.92	1.45	87.30	114.00	34.61	3.24
4	85%S+15%R	57.20	26.70	30.50	25.38	1.43	80.50	103.00	30.20	2.97
5	80% S+20%R	55.90	26.50	29.40	26.54	1.40	77.50	94.00	28.99	2.25

3.1.1 Effect of RHA on Atterberg's limit of expansive soil

It is observed that the liquid limit of expansive soil alone was 66.65%. Adding various proportions of Rice Husk Ash has significant effects on the liquid limit of soil. The liquid limit decreased from 66.65% to 55.9% as Rice Husk Ash content is increased from 0% to 20%. Similarly, the plasticity index of soil decreased from 34.4% to 29.4% with the increase of Rice Husk Ash content in the soil.

3.1.2 Effect of RHA on compaction characterstics of soil

Increase in percentage of RHA the MDD of soil goes decreasing, decreases to 1.4 g/cc from 1.5 g/cc when 20% RHA was added which is attributed to the lower value of specific gravity of Rice Husk Ash as compared to soil . The OMC goes on increasing irrespective of percent addition of RHA. The OMC increases to a value of 26.54% when

20% RHA was added. The increase in the optimum moisture content may be caused by the absorption of water by the RHA.

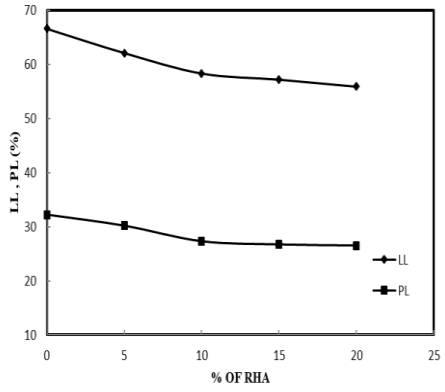

Fig. 1. Variation of LL & PL with varying percentage of RHA

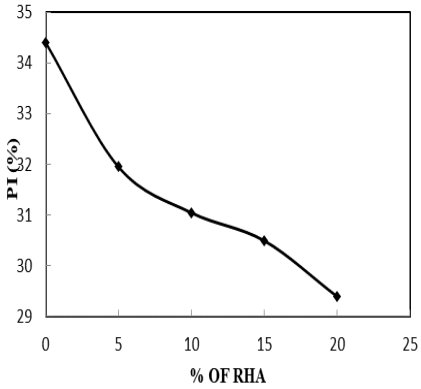

Fig. 2. Variation in PI with varying percentage of RHA

3.1.3 Effect of RHA on UCS of soil

RHA the UCS of soil goes on increasing up to 10% By increasing the percentage, further addition of RHA, decreases the UCS of the soil. The UCS of soil increases 87.3kN/m² from 75.3 kN/m² of native soil, when10% RHA was added.

3.1.4 Effect of RHA on direct shear test of soil

It is observed that cohesion and angle of internal friction of the soil initially increased as the RHA increased, peaking at a RHA content of 10%. The angle of internal friction increases considerably from 31.88° to 34.61° for 10% RHA content, then decreased with higher content. The increased shear strength of the treated soil was attributed to the additional friction produced by the coarse particles of the RHA embedded on the shear plane.

3.1.5 Effect of RHA on CBR test of expansive soil

The UCS of soil goes on increasing up to 10% of addition of RHA, further addition of RHA, decreases the CBR of the soil. The CBR of soil increases to 3.24% from 1.72% of native soil, when 10% RHA was added.

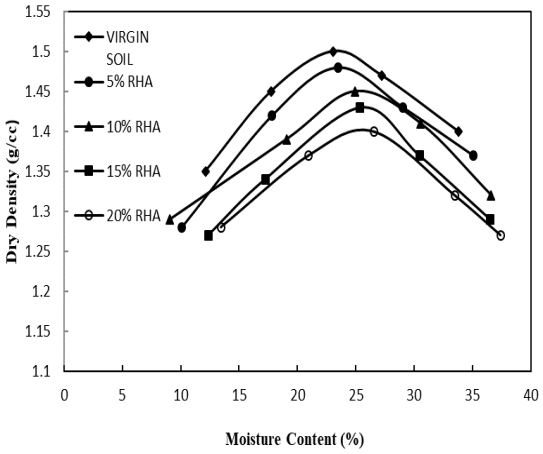

Fig. 3. Variation in compaction curve of soil with varying % of RHA

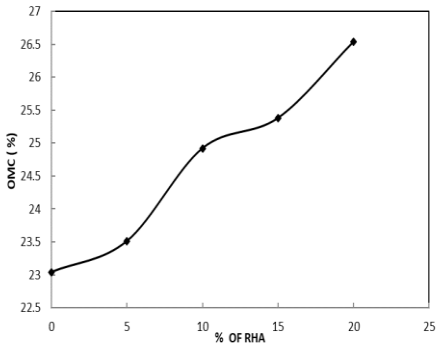

Fig. 4. Effect of RHA on OMC of soil

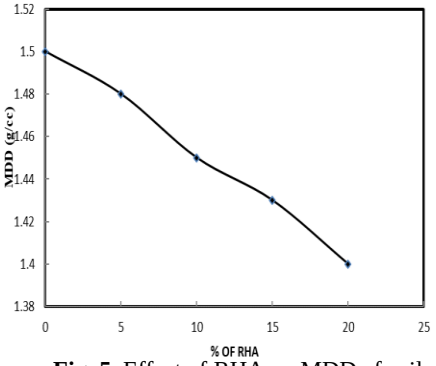

Fig. 5. Effect of RHA on MDD of soil

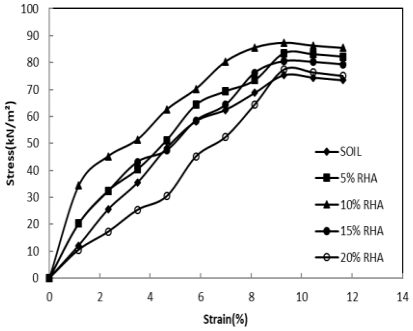

Fig. 6. Variation of RHA on the stress strain behavior of soil

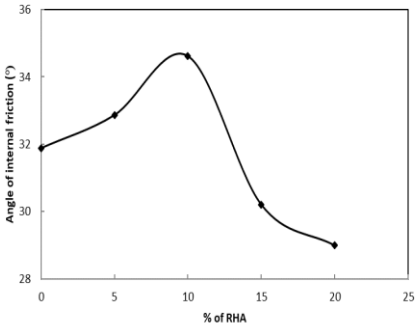

Fig. 7. Variation of RHA on Angle of internal friction of soil

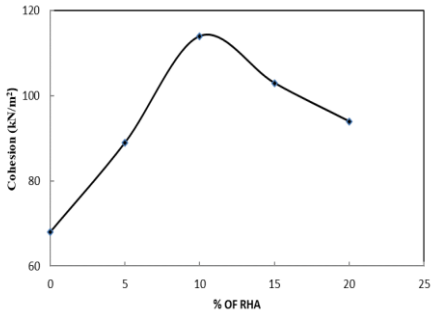

Fig. 8. Effect of RHA on cohesion of soil

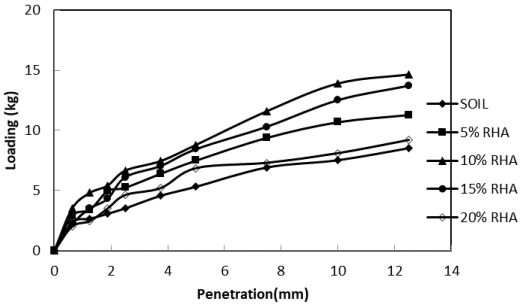

Fig.9. Variation in CBR of soil with varying percentage of RHA

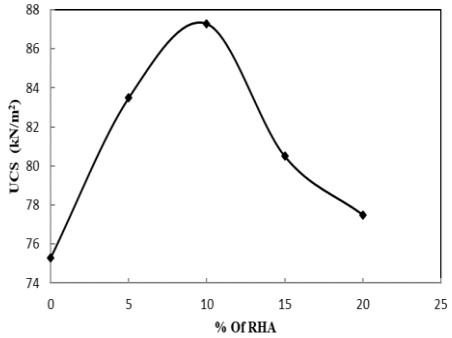

Fig. 10. Effect of RHA on UCS of soil

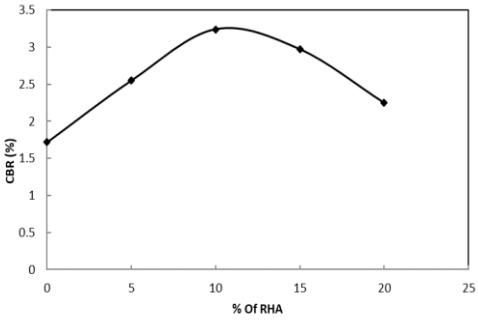

Fig. 9. Effect of RHA on CBR of soil

3.2 Geotechnical properties of Marble Dust treated RHA

The strength of Rice husk ash generally improves with time due to pozzolanic reactions. Reactive silica and free lime contents are necessary for pozzolanic reactions to take place. strength of rice husk ash can significantly improve,
When adding marble dust.

Table 5. Summary of Geotechnical properties of Soil-RHA-Marble Dust Mix

Mixes	Marble Dust (%)	Atterberg Limit			Compaction Test		UCS (kN/m²)	DST		CBR (Soaked) (%)
		LL (%)	PL (%)	Pl (%)	OMC (%)	MDD (g/cc)		Cohesion (kPa)	Angle (°)	
M1	0	58.35	27.30	31.05	24.92	1.48	87.30	114.00	34.61	3.24
M2	5	56.75	26.35	30.40	24.28	1.51	117.70	121.00	36.51	3.64
M3	10	54.85	25.20	29.65	23.27	1.55	139.40	128.00	40.27	4.72
M4	15	53.64	24.64	29.00	22.67	1.58	165.70	143.00	43.23	5.15

M5	20	53.03	24.53	28.50	22.18	1.64	153.60	132.00	38.47	4.78
M6	25	52.35	23.75	27.85	21.80	1.69	148.20	118.00	36.90	4.66
M7	30	50.87	22.50	26.77	21.09	1.67	135.10	112.00	35.55	4.58

3.2.1 Effect of RHA on Atterberg's limit of expansive soil

Marble Dust has significant effects on the liquid limit of the RHA stabilized soil; the liquid limit goes on decreases rapidly and plastic limit of Soil alone was 34.4%. Marble Dust has substantial effects on the plastic limit of the RHA stabilized soil, the plastic limit goes on decreases rapidly and the Plasticity index was found to decreases from 31.05% to 26.77% due to adding various fractions.

3.2.2 Effect of RHA on Compaction characteristics of soil

The MDD of soil goes on increasing, increases to 1.69g/cc from 1.48 g/cc when 25% Marble Dust was added with increase in percentage of Marble dust. Further adding of Marble Dust decreases the MDD of the soil goes on decreasing, decreases to 1.67g/cc from 1.69g/cc when 30 % Marble dust was added. The MDD of the soil increases to 1.69 when 25% Marble dust was added to soil stabilized with 10% Rice husk ash. The reverse thing happens incase OMC. The OMC decreases to 24.92% when 10% Marble dust was added to soil. The OMC goes on decreasing, decreases to a value of 21.09% when 30% Marble dust was added to soil stabilized with 10% Rice husk ash, With increase in different percentage of Marble dust

3.2.3 Effect of RHA on UCS of Soil

Addition of different percentage of Marble dust has considerable effects on the UCS of the RHA stabilized soil, it is observed that by addition of 10% Marble dust the UCS of soil increases to 139.4 kN/m2. With increase in percentage of Marble dust the UCS of soil further goes on increasing, increases to 165.7kN/m2 from 87.3kN/m2 when 15% Marble dust was added further addition of Marble dust decreases the UCS of the soil. when 30% Marble dust was added to soil stabilized with 10% Rice husk ash. The UCS of the soil decreases to 135.1kN/m2. The UCS attains the highest value when the percentage of Marble dust is 15%.

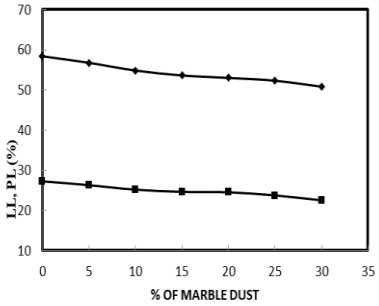

Fig. 10. Variation IN LL & PL for RHA stabilized soil varying % of marble dust

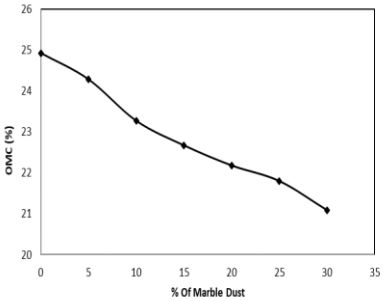

Fig. 13. Effect of Marble Dust on OMC of RHA stabilized expansive soil

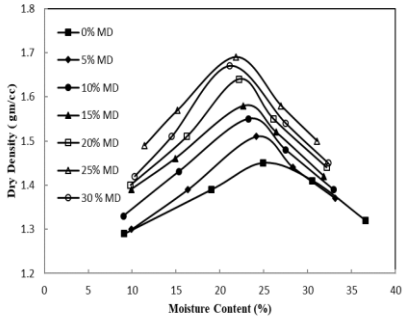

Fig.14. Variation in compaction curves for RHA stabilized soil with varying per centage of Marble Dust

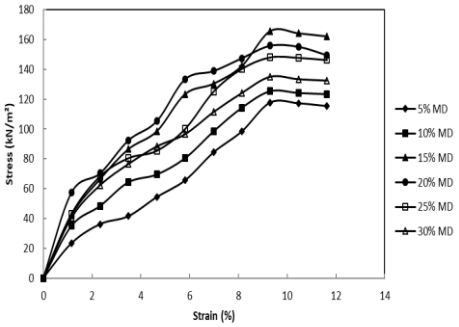

Fig. 15. Variation on the stress-strain be havior for RHA stabilized soil with varying percentage of Marble Dust

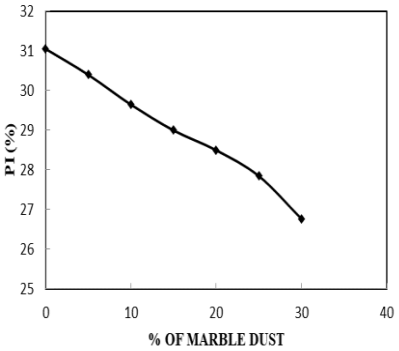

Fig. 16. Variation of PI for RHA stabi lized soil with varying % of marble dust

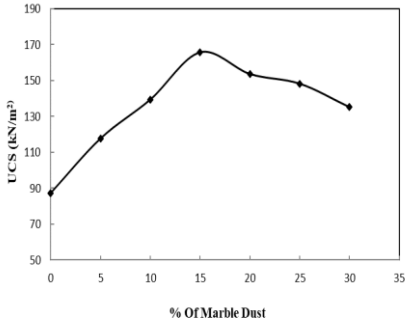

Fig. 17. Variation in UCS for RHA stabi lized soil with varying percentage of Mar ble Dust

3.2.4 Effect of RHA on direct shear test of soil

The angle of internal friction increased considerably to 43.23° from 34.61° when 15% Marble Dust content, then decreased with higher content. The increased shear strength of the treated soil was attributed to the additional friction produced by the coarse particles of the Rice Husk Ash embedded on the shear plane. However, the cohesion underwent obvious change when the proportion of soil: RHA: MD ratio was 75:10:15, which corresponded to the peak shear strength.

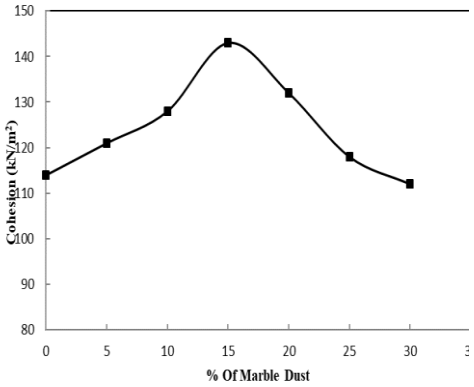

Fig.18. Variation in Cohesion for RHA stabilized soil with varying percentage of Marble Dust

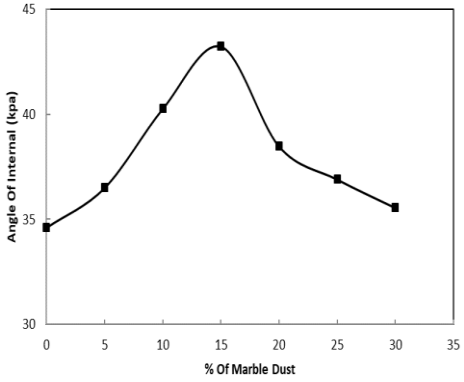

Fig. 11. Variation in Angle of internal friction for RHA stabilized soil with varying percentage of Marble Dust

3.2.5 Effect of RHA on CBR test of expansive soil

Addition of different percentage of Marble dust have considerable effects on the Soaked CBR of the RHA stabilized expansive soil. With increase in percentage of Marble dust the Soaked CBR of soil further goes on increasing, increases to 5.15% from 3.24% when 20% Marble dust was added further addition of Marble dust decreases the Soaked CBR of the soil. The Soaked CBR of the soil decreases to 4.58% when 30 % Marble dust was added to expansive soil stabilized with 10% Rice husk ash. The Soaked CBR attains the highest value when the percentage of Marble dust is 15%.

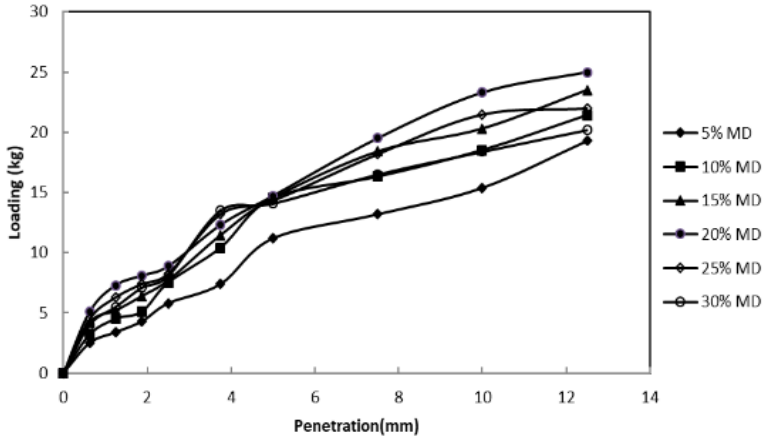

Fig. 12. Variation in CBR for RHA stabilized soil with varying percentage of Marble Dust

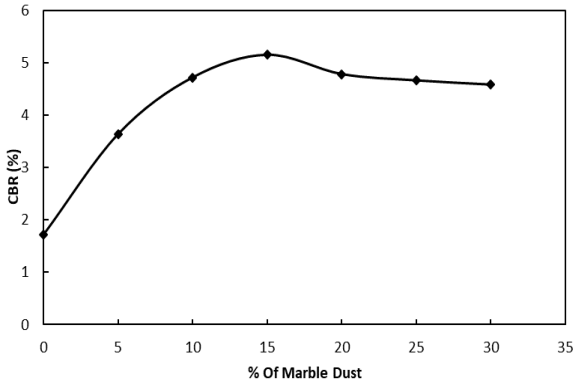

Fig. 13. Effect of Marble dust on Soaked CBR of RHA stabilized expansive soil

4 Conclusions

1. The optimum proportion of expansive soil: RHA was 90: 10 by weight. Based on direct shear strength and UCS test results,
2. The expansive soil stabilized with optimum ratio of rice husk ash; the plasticity index of the soil reduces from 31.05 % to 26.77% with the increase in the percentage of marble dust which was found to be promising on adding the various percentages of marble dust
3. The MDD starts to decrease and OMC starts to increase with the addition of RHA to expansive soil.
4. The cohesion and angle of internal friction of expansive soil both increased as the content of RHA increased, giving a peak value when the RHA content was 10%, while the cohesion showed no marked change.

5. The UCS of the expansive soil increased by 15.94% compared to untreated soil, With the addition of 10% RHA,
6. the MDD goes on increasing and OMC goes on decreasing up to 25% Due to Addition of different ratio of marble dust to the expansive soil stabilized with optimum ratio of rice husk ash. Both MDD and OMC goes on decreasing Further addition marble dust
7. An addition of 15% MD corresponded to the peak the strength and cohesion of soil- RHA blends increased as the content of MD increased.
8. Adding more Marble dust reduces the UCS of the expansive soil. Unconfined compressive strength improved nearly by 120.05% of the virgin soil after adding 15% Marble dust.
9. Adding the various ratio of marble dust to the expansive soil stabilized with optimum ratio of rice husk ash, for soaking condition the CBR value increased till 15% marble dust, further adding of marble dust reduces the CBR value of the expansive soil. There is a 199.42% increase CBR value in soaking condition when related with natural soil.
10. For better stabilization result, the optimal percentage of Soil: Rice husk ash: Marble dust was found to be 75: 10: 15.

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