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An Experimental Study of Clayey Soil with Rice Husk Ash using Triaxial Test

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Abstract : *In present study clayey soil is being used and tested along with solid waste namely Rice Husk Ash to demonstrates the effect of RHA on the geotechnical properties of clayey soil. Various laboratory tests such as Liquid limit, Plastic limit and Standard Proctor Test were performed on original clayey soil i.e. without RHA. The Triaxial test were performed for different % of RHA content along with two strain rates 1.25mm/min and 0.05mm/min. The clayey soil is replaced by RHA in three different percentage such as 10%, 20% and 30%.*
These test results show that as the % of RHA increases, there is an increases in cohesion parameter while decreases in the angle of internal friction. Cohesion as well as angle of internal friction with 1.25mm/min strain rate is comparatively more than 0.05mm/min strain rate. Analysis of bearing capacity for square footing is carried out by employing Terzaghi's method. Safe bearing capacity is maximum for replacement of 10% RHA with 1.25mm/min strain rate and for replacement of 30% RHA with 0.05mm/min strain rate.

Keywords: *Clayey soil, Cohesion, Rice Husk Ash, Strain rate, Triaxial test*

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I. Introduction

The rapid industrialization and urban development has led to a scenario where we are in short of land for constructional activities. Hence we are forced to construct our buildings and structures on the available land, which may not have the required engineering properties. In order to have good construction there needs to be a strong foundation. To achieve a stable foundation it is necessary to have soil with high bearing capacity.

Clayey soil has poor strength characteristics and also causes problem in the construction, causing large differential settlement. Clayey soil exhibits property of high swelling and shrinkage and hence it is found out to be troublesome from engineering considerations. The stabilization of clayey soil is done by using various admixtures so as to improve the characteristic strength. Rice Husk Ash is an agricultural by product that causes environmental pollution. RHA being an agricultural by product is getting importance because of presence of silica in it. Silica have highly pozzolanic properties which helps in binding particles together and makes the overall stabilization process economical. The incorporation of Rice Husk Ash for soil stabilization helps to reduce overall cost of stabilization, provides a better way for disposing the waste product.

1.1 Objectives of the Study

1. To study the index properties of clayey soil.
2. To determine the shear strength parameters of clayey soil under varying shear rate.
3. To check the effect of RHA on safe bearing capacity of soil.
4. To investigate the behavior of clayey soil with addition of RHA.

II. Materials Used For Study

2.1 Clay

In this study, the locally available clayey soil is obtained from, farm near Akurdi, Pune. It was collected from shallow depth. Disturbed clayey soil was placed in plastic gunny bags and transported to the laboratory for testing. The experimental investigation on clayey soil sample is done to understand the index and engineering properties of the collected soil sample. Various laboratory tests were performed for finding out the index properties of clayey soil such as liquid limit, plastic limit, plasticity index and specific gravity.

2.2 Rice Husk Ash

Rice Husk Ash is collected from farm which is located in Sangli District. It is blackish grey in colour. The Rice Husk itself has a very rough surface which is abrasive in nature. RHA improved the quality and bearing capacity of soil due to its physical and chemical properties. It contains various chemicals such as silicon dioxide, Aluminium dioxide, Iron oxide, Calcium oxide, Magnesium oxide, Sodium oxide and potassium oxide.

Fig. 1: Clayey Soil

Fig.2: Rice Husk Ash

III. Methodology

To classify the soil index properties such as specific gravity, liquid limit, plastic limit and plasticity index are determined. Density of soil increases with the compaction. Maximum dry density and optimum moisture content is carried out by performing standard proctor test on clayey soil. Shear strength parameters of clayey soil and clayey soil with 10%, 20% and 30% rice husk ash along with two different strain rates are determined.

IV. Results And Discussion

Table 1- Summary of Index Properties

Sr. No	Test	Result
1	Specific gravity	2.372
2	Liquid limit	69%
3	Plastic limit	40.75%
4	Plasticity index	28.25%

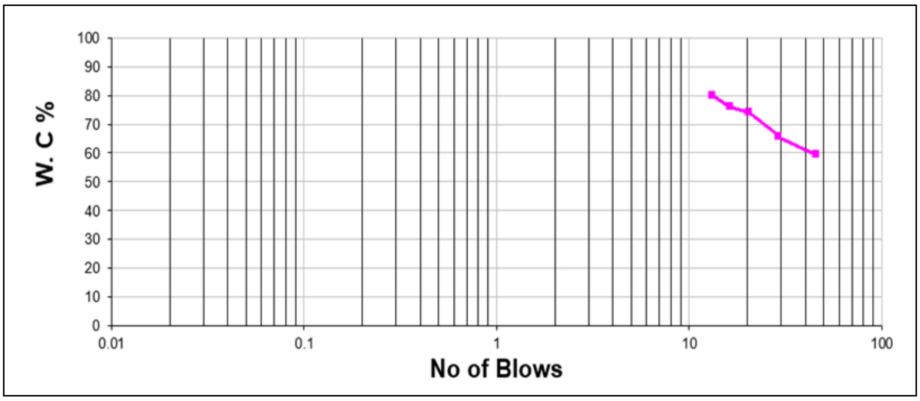

Fig. 3: Liquid limit graph

From the above graph Liquid limit of soil is 69%.

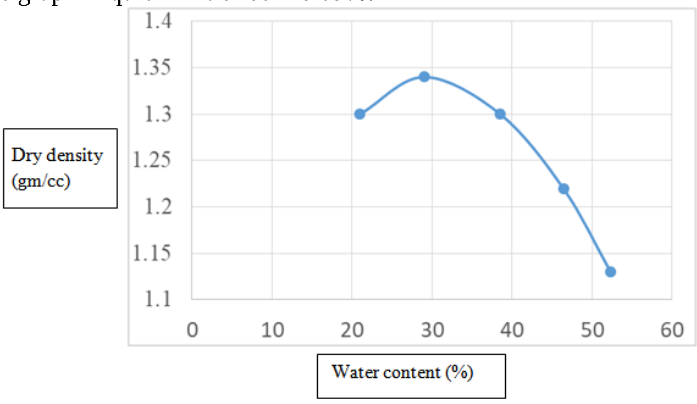

Fig. 4: Compaction Curve

The maximum dry density (MDD) obtained is 1.34gm/cc and the optimum moisture content (OMC) is 29%

Table 2- Triaxial test for clayey soil

Sr. No	**Sample**	**Strain Rate (mm/min)**	**Cell Pressure (kg/cm^2)**	**Deviatoric Stress (kg/cm^2)**	**Normal Stress (kg/cm^2)**	**Cohesion (kg/cm^2)**	**Angle of internal friction (◦)**
1	Clay	1.25	1.2	0.895	2.095	0.29	6.37
			2.4	1.380	3.750		
			3.6	1.490	5.090		
		0.05	1.2	0.810	2.010	0.44	0.29
			2.4	0.853	3.253		
			3.6	0.895	4.495		

Graph of Mohr's Circle:

Without RHA for 1.25 mm/min strain rate

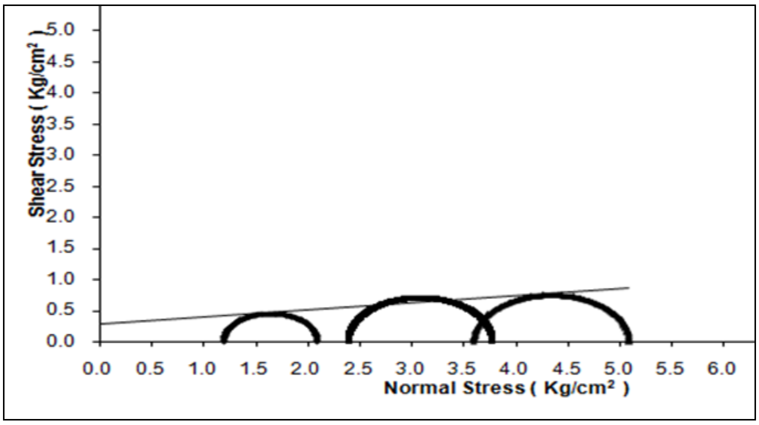

Fig.5: Shear stress vs Normal stress

Cohesion parameter of tested sample was found 0.29 kg/cm^2 and the angle of internal friction was found out to be 6.37°

Without RHA for 0.05 mm/min strain rate

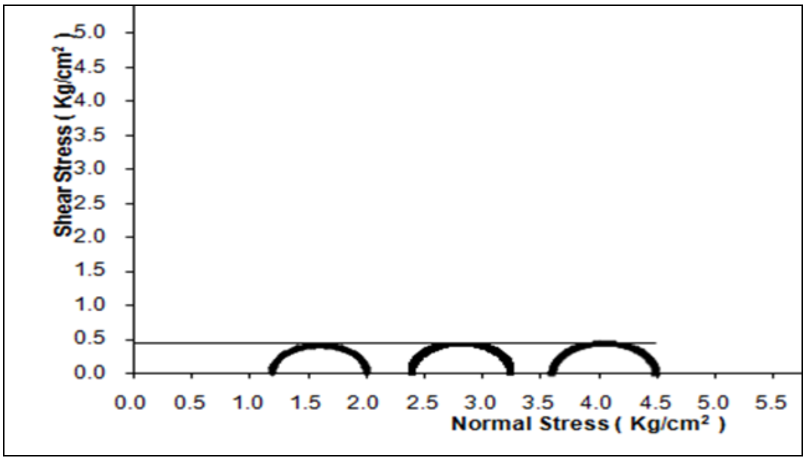

Fig.6: Shear stress vs Normal stress

Cohesion parameter of tested sample was found 0.44 kg/cm^2 and the angle of internal friction was found out to be 0.29°.

With 20 % RHA for 1.25mm/min strain Rate

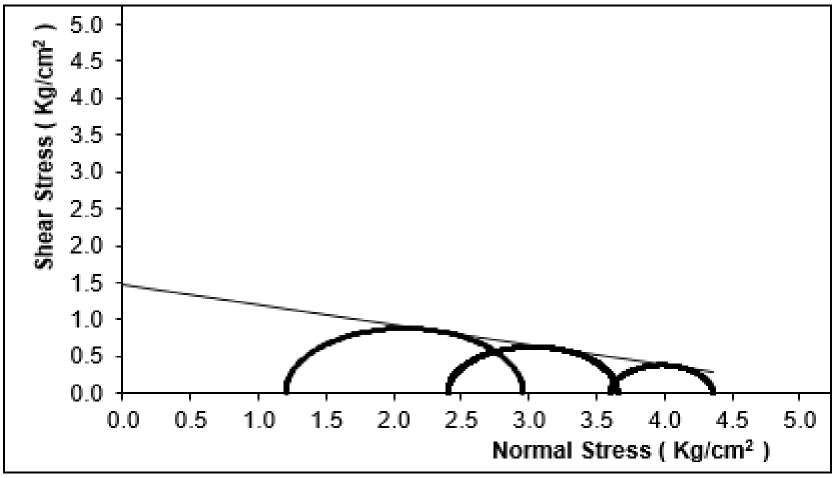

Fig.7: Shear stress vs Normal stress

Cohesion parameter of tested sample was found 1.48 kg/cm^2 and the angle of internal friction was found out to be -15.26°.

With 30 % RHA for 0.05mm/min strain Rate

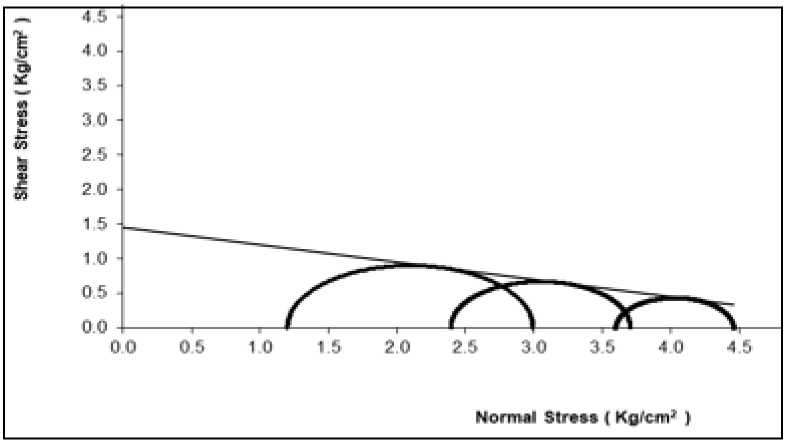

Fig.8: Shear stress vs Normal stress

Cohesion parameter of tested sample was found 1.45 kg/cm^2 and the angle of internal friction was found out to be -14.09.

Table 3 - Shear strength parameters for 1.25mm/min strain rate

Sample	Analytically values		Graphically values		Average values	
	C (kg/cm^2)	**ϕ (◦)**	**C (kg/cm^2)**	**ϕ (◦)**	**C (kg/cm^2)**	**ϕ (◦)**
Without RHA	0.268	6.33	0.24	7.21	0.25	6.77
10% RHA	1.451	-6.52	1.46	-6.52	1.455	-6.52
20% RHA	1.484	-15.368	1.48	-15.26	1.482	-15.314
30% RHA	1.354	-7.725	1.35	-7.74	1.352	-7.732

As the percentage of RHA increase the cohesion parameter increases and it is maximum for 20% replacement of RHA.

Table 4 - Shear strength parameters for 0.05mm/min strain rate

Sample	Analytically values		Graphically values		Average values	
	C (kg/cm^2)	**ϕ (◦)**	**C (kg/cm^2)**	**ϕ (◦)**	**C (kg/cm^2)**	**ϕ (◦)**
Without RHA	0.377	1.0	0.381	1.0	0.379	1.0
10% RHA	0.90	-7.837	0.92	-7.70	0.91	-7.768
20% RHA	0.64	-4.55	0.64	-4.59	1.21	-4.57
30% RHA	1.453	-14.11	1.44	-14.00	1.446	-14.05

As the percentage of RHA increase the cohesion parameter increases and it is maximum for 30% replacementof RHA

Table 5 - Bearing capacity calculations for 1.25 mm/min strain rate

Sample	C (kN/m^2)	ϕ (◦)	Q_u (kN/m^2)	Qs (kN/m^2)
Without RHA	24.525	6.77	323.076	126.442
10% RHA	142.735	6.52	1546.856	534.368
20% RHA	145.384	-15.31	1105.42	387.223
30% RHA	132.63	-7.73	1010.91	355.72

Ultimate bearing capacity as well as Safe bearing capacity is maximum for 10% RHA with 1.25mm/min strain rate.

Table 6 - Bearing capacity calculations for 0.05mm/min strain rate

Sample	C (kN/m^2)	ϕ (◦)	Q_u (kN/m^2)	Q_s (kN/m^2)
Without RHA	37.179	1	323.58	126.61
10% RHA	89.271	-7.77	689.623	248.62
20% RHA	118.701	-4.57	907.699	321.316
30% RHA	141.85	-14.06	1079.23	378.493

Ultimate bearing capacity as well as Safe bearing capacity is maximum for 30% RHA with 0.05mm/min strain rate.

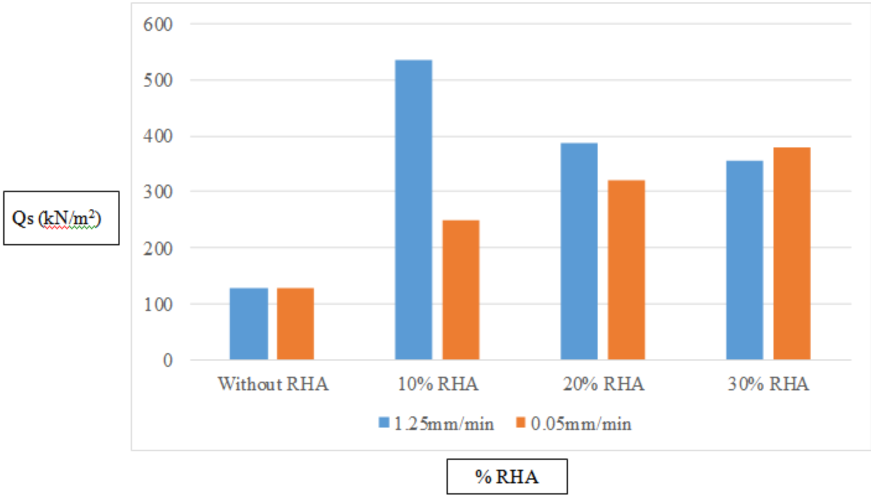

Fig. 9: Comparison of Safe Bearing Capacity for 1.25 mm/min and 0.05mm/min Strain rate

Safe bearing capacity (SBC) increases with addition of RHA. There is negligible effect of strain rate on SBC of clayey soil without RHA. Maximum value of SBC is obtained for 1.25 mm/min strain rate when 10 % RHA is added. Safe bearing capacity values are more for 1.25 mm/min strain rate than 0.05 mm/min.

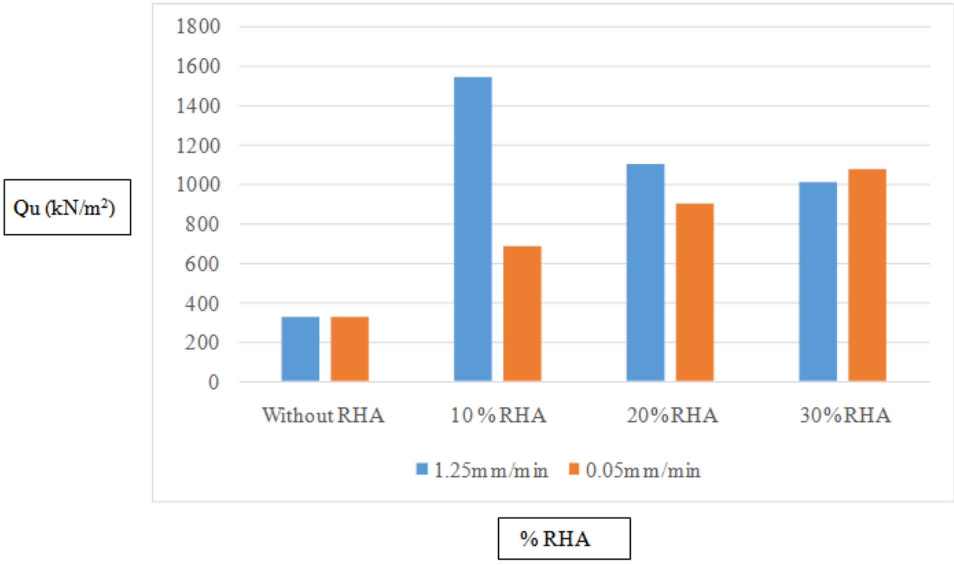

Fig.10: Comparison of Ultimate Bearing Capacity for 1.25 mm/min and 0.05 mm/min Strain rate

V. Conclusions

In the present study, a series of Triaxial Compression Test with replacement of different % of RHA under varying strain rate was performed on clayey soil. Effect on cohesion and angle of internal friction due to variation of strain rate was observed. The main conclusions are summarized as follows.

1. As the percentage of RHA increase the cohesion parameter increases.
2. If the percentage of RHA increase the angle of internal friction decreases.
3. There is change in shear strength parameters as strain rate changes.
4. Maximum value of cohesion is 1.482 kg/cm^2 with 1.25 mm/min strain rate for 20% replacement of clayey soil by RHA.
5. Maximum value of angle of internal friction is 6.77° for 1.25 mm/min strain rate for without replacement of clayey soil.
6. Ultimate bearing capacity and safe bearing capacity are more with 1.25mm/min strain rate as compared to 0.05mm/min strain rate.
7. Ultimate bearing capacity and Safe bearing capacity are maximum for 10% replacement of clayey soil by RHA.

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