

# Experimental Study of Clayey Soil Stabilized with Rice husk ash and Calcium Chloride

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**ABSTRACT :** Chemical stabilization is a technique commonly used to improve the expansive nature of soil. In this experimental study, a strive has been made to evaluate the influence of calcium chloride (CaCl<sub>2</sub>) stabilizer and rice husk ash (an agricultural waste product) on the engineering properties of expansive soil. A series of laboratory tests including consistency limits, compaction, UCS, and CBR tests have been conducted to investigate the effect of RHA and CaCl<sub>2</sub> collectively with virgin soil as it makes some improvement on geotechnical properties of clayey soil. The huge amount of silica in RHA and calcium in calcium chloride creates a pozzolanic and cementitious mixture. In this research, RHA and CaCl<sub>2</sub> are combined with different proportions like, RHA as 7%, 14%, 17%, and 21% along with CaCl<sub>2</sub> as 5% for improving the expansive nature of clayey soil. The results obtained shows that the increase in the percentage of CaCl<sub>2</sub> and RHA decrease the liquid limit, plastic limit leading to significant reduction in plasticity index. This in turn, increased the maximum dry density and decreased the optimum moisture content which results in greater strength. The unconfined compressive strength of soil stabilized with **5% CaCl<sub>2</sub> and 17% RHA** increased approx. by 64% and 3 to 4 times in CBR value as compared to virgin soil. So, it can be concluded that RHA and CaCl<sub>2</sub> has shown promising influence on the strength and swelling properties of expansive soil, thereby giving an advantage in improving problematic expansive soil.

**KEYWORDS:** Clayey soil, calcium chloride, Rice husk ash, chemical stabilization, UCS, CBR test, Improvement in expansive nature of clayey soil.

## I. INTRODUCTION

Understanding the behavior of expansive soil and adopting the appropriate control measures have been a great task for geotechnical engineers. Proper characterization and selection of suitable foundation is essential in case of problematic soils. Hence in the present study, experimentation is carried out to investigate the influence of electrolytes like calcium chloride and an agricultural waste Rice husk ash on the properties of expansive nature of soil. This research will determine the effectiveness of soil stabilization using Rice husk ash and calcium chloride. With the addition of chemical that is calcium chloride up to a certain percentage, the strength increases, after that it starts decreasing. At the same time Rice husk ash contents are limited to 7%, 14%, and 17% after that percentage like 21%. shows a declining results. Samples containing eight different concentrations of Calcium chloride ( 0%, 2%, 4%, 5%, and 6% ) and Rice husk ash 7%, 14%, 17% and 21%) while five merged samples were tested for strength at 3, 7, 14, and 28 cure days . it must be noted that calcium chloride percentages are based on dry solids weight, as under :

$$\% \text{ Calcium chloride} = \frac{W \text{ of Calcium Chloride}}{\sum W \text{ of soil+RHA+CaCl}_2}$$

Mixes to be investigated in this study are :

- Virgin soil
- Soil +17% Rice husk ash
- Soil + 2% calcium chloride + 17% Rice husk ash
- Soil + 4% calcium chloride + 17% Rice husk ash

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Vol. 8, Issue 4, April 2019

- Soil + 6% calcium chloride + 17% Rice husk ash
- Soil + 5% calcium chloride + 17% Rice husk ash

## II. LITERATURE REVIEW

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4. *Hilbrich, S.L.(2013).* “Soil Stabilization with Calcium Chloride Filter Cake and Class F Fly Ash”. ‘ME Paper, Texas A&M Univ., College Station, Texas.
5. *Ashango and Patra (2014)* had used the RHA and optimum content was found at 10% and 7.5% for RHA and Portland cement respectively. This optimum composite was found suitable for flexible pavements.
6. *Sharma & Kumar (2015)* used RHA and RBI grade 81 in combination with clay and after obtaining the results by performing various tests like UCS, CBR, alterberg’s limits etc., they concluded that optimum mix was found to be 86 % clay, 10 % RHA and 4 % RBI with the help of consistency limit tests and compaction tests. They also found that comparatively with clay optimum mix shows increased in percentage that is the CBR value of optimum mix increases in elastic.
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## III. MATERIALS AND EXPERIMENT

A. materials used:

1. SOIL :- In this research the soil used for experimental study is of clayey nature, obtained from chamba, district of Himachal Pradesh. The soil is dark brown stiff clay of high expansion in nature. It was dried, pulverized and then sieved through 4.75mm IS sieve. The measured properties of soil are as under :

**Table 1 Properties and results of virgin soil**

S No.	Properties	Results
1	Specific gravity	2.65
2	Clayey %	60
3	Liquid Limit (%)	46
4	Plastic Limit (%)	24
5	Plasticity index (%)	22
6	Classification of soil	CH
7	Maximum Dry Density (gm/cc)	1.59
8	Optimum Moisture Content (%)	20
9	UCS (Mpa)	.096
10	CBR value (%)	3.1

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Vol. 8, Issue 4, April 2019

**2. CALCIUM CHLORIDE:-** It is an ionic compound of calcium and chloride. It is a salt that behaves as a typical ionic halide, being solid at room temperature and highly soluble in water because of its hygroscopic nature, anhydrous calcium chloride must be kept in tightly sealed, air containers. It is used for numerous purposes at different concentrations depending on its use. This research used its highest percentage calcium chloride products. The properties of calcium chloride ( $\text{CaCl}_2$ ) products are given below in table :-

**Table 2 Physical properties of Calcium Chloride**

S No.	Properties	Value
1	Form	A white odorless granule or flake
2	Assay	94% - 97% by weight $\text{CaCl}_2$
3	Density	2.15 g/mL
4	Ph	6.5 – 10
5	Melting point	782 °C
6	Boiling point	1600 °C
7	Loss on drying	10 %

**3. RICE HUSK ASH :-** In order to introduce another material which enhance the engineering properties of soil and reduce cost of chemical stabilization, one can considered Rice husk ash which is a waste material from paddy crop. After burning, it gives rich amount of silica which may be used as a chemical stabilizer for clayey soil stabilization. To study the effect of rice husk ash on soil as a stabilizer it is mixed in various proportions with soil like 7%, 14%, 17%, 21% etc. These mixes are tested individually and then with calcium chloride in order to find optimum proportion. The following table gives the chemical properties of Rice husk ash :-

**Table 3 Chemical properties of Rice husk ash**

S No.	Constituent	%age
1	Silica	85 – 90
2	Alumina	2.5 – 2.6
3	Carbon	2.2 -2.3
4	Calcium oxide	1.55 – 1.6
5	Magnesium oxide	0.5 -0.55
6	Potassium oxide	0.4 -0.45
7	Ferric oxide	0.20

### IV. METHODOLOGY

#### Tests Conducted

Following are the tests conducted in the lab

1. Specific gravity of soil
2. Determination of soil by its consistency limits
  - i. Liquid limit by Casagrande's apparatus
  - ii. Plastic limit
3. Determination of maximum dried density and the corresponding optimum moisture content of the soil by standard proctor test
4. Determination of soil by UCS test

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Vol. 8, Issue 4, April 2019

5. Determination of soil strength by CBR test

**Table 4:- Comparison of OMC,MDD, UCS and CBR% of virgin soil , 7% RHA, 14% RHA and 21% RHA**

Property	Soil without RHA	Soil with 7% RHA	%Increase/d ecrease	Soil with 14% RHA	%Increase/d ecrease	Soil with 21% RHA	%Increase/de crease
OMC(%)	16.5	19	15.15	24	26.3	27.5	14.6
MDD(gm/cc)	1.59	1.51	-5	1.49	-1.3	1.48	-0.7
UCS (Mpa)	.061	.069	13	.093	34.7	.094	1.07
CBR%(soaked) for 2.5mm Penetration	3.1	3.6	16	5.02	39.4	5.1	1.6

**Table 5:- Comparison of OMC,MDD, UCS and CBR% of virgin soil, with 3% CaCl<sub>2</sub> , 5% CaCl<sub>2</sub> and 6% CaCl<sub>2</sub>**

Property	Soil without CaCl <sub>2</sub>	Soil with 3% CaCl <sub>2</sub>	%Increase/d ecrease	Soil with 5% CaCl <sub>2</sub>	%Increase/d ecrease	Soil with 6% CaCl <sub>2</sub>	%Increase/de crease
OMC(%)	16.5	16	-3.03	15	-6.2	14.8	-1.33
MDD(gm/cc)	1.59	1.65	3.8	1.72	4.24	1.75	1.74
UCS (Mpa)	.061	.065	6.5	.07	7.7	.069	-1.4
CBR%(soaked) for 2.5mm	3.1	4.5	45	4.9	8.9	4.6	-6.1

**Table 6:- Detail Summary of Test Results.**

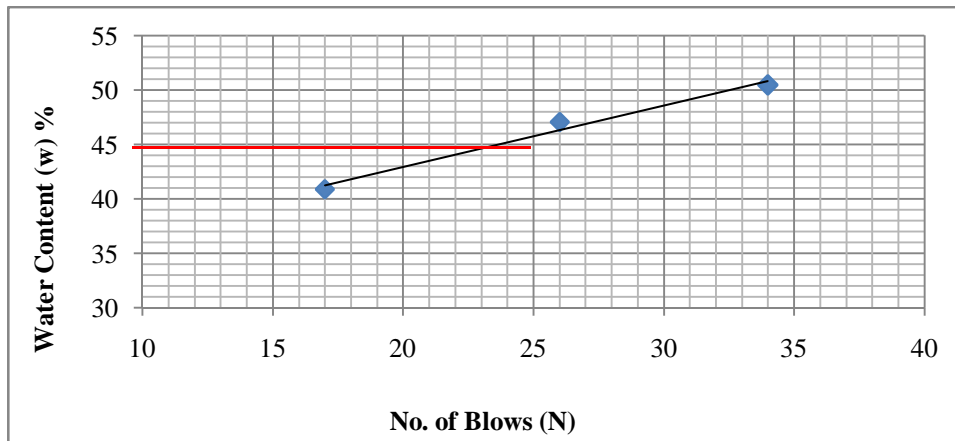
CS:RHA:CaCl <sub>2</sub>	LL (%)	PL (%)	PI (%)	OMC (%)	MDD (g/cc)	UCS (Mpa)	C <sub>u</sub> (Mpa)	CBR (%)
100:00:00	46	24	22	16.5	1.59	.061	.0305	3.1
81:17:2	37.6	22.6	15	17	1.62	.082	.041	5.58
79:17:4	36.1	21.8	14.8	17.5	1.69	.091	.0455	7.9
78:17:5	33.5	19.6	13.9	18.4	1.67	.10	.05	11.3
77:17:6	34.6	18.9	15.7	22.5	1.61	.098	.049	10.1

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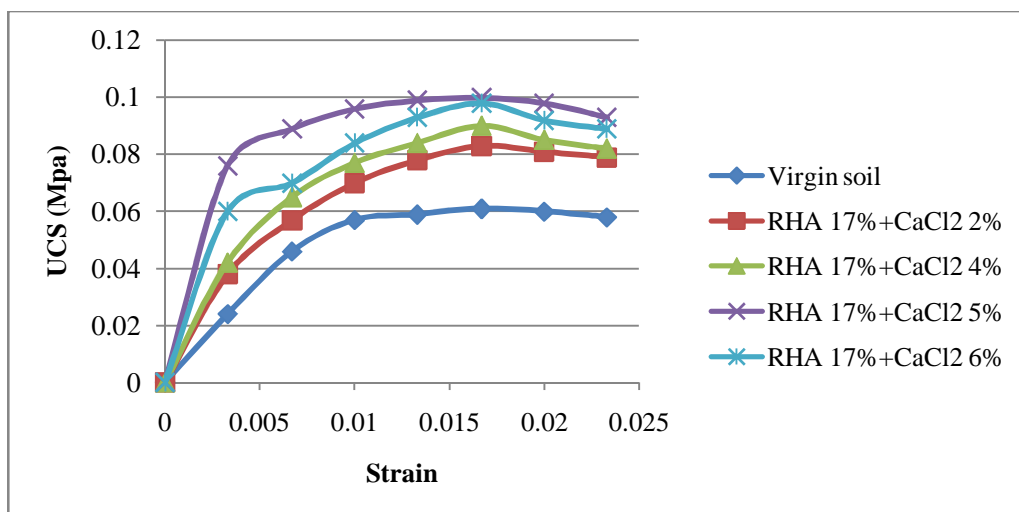
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Vol. 8, Issue 4, April 2019



Graph 1- Liquid limit and Plastic limit of virgin soil.

**A. Consistency Limit:** The variation of liquid limit, plastic limit and plasticity index individually with RHA is shown in above table 1 whereas graph shows the comparative results of Liquid limit of RHA and CaCl<sub>2</sub> in different proportions. The LL, PL and PI continuously decreases with the addition of RHA and CaCl<sub>2</sub> up to 17% and 5% respectively. Further increase in ratio will start to increase their values. The initial reduction may be attributed to the cementitious properties of RHA due to high content of silica present in it which aid flocculation and aggregation of the soil particles. The increase in LL, PL and PI this optimum mix is attributed to the extra water required to turn the soil-RHA mix to fluid. It is observed that the LL, PL of soil treated with 5% CaCl<sub>2</sub> and different percentage of RHA decreases due to chemical reaction soil of RHA and CaCl<sub>2</sub>, also RHA absorbs more amount of water.



Graph 3:- Effect of RHA and CaCl<sub>2</sub> on UCS value of soil.

**B. Unconfined Compressive Strength:** Initially UCS of stabilized soil using both the stabilizer and combination of RHA and CaCl<sub>2</sub> increases with increasing the percentage of stabilizer and with increasing the days of curing. The increase in UCS value could be attributed to ion exchange at the surface of clay particles. The Ca<sup>2+</sup> in the additives reacts with the lower valence metallic ions in the clay microstructure which resulted in agglomeration and flocculation

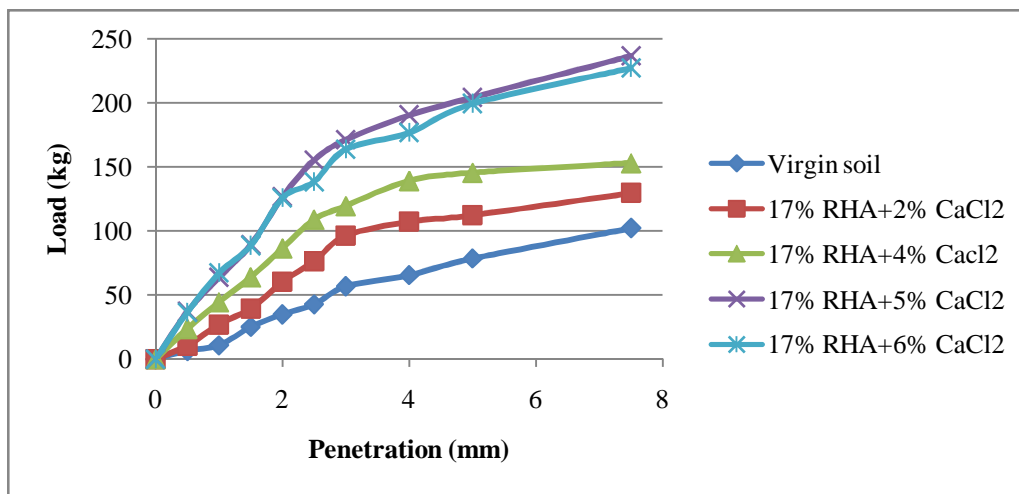
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Vol. 8, Issue 4, April 2019

of the clay particles. The gain in strength of specimen with age was done primarily to the long term hydration reaction that resulted in the formation of cementitious compounds.



Graph 4:- Effect of RHA and CaCl<sub>2</sub> on CBR value of soil.

**C. California Bearing Ratio:** The CBR value of soil increases with increasing percentages of combination of RHA and CaCl<sub>2</sub> as compare to RHA alone. The content of CaCl<sub>2</sub> having binding property due to which the soil particles bind together and the CBR value of mix increases. Other reason for increases of CBR value is due to calcium present in CaCl<sub>2</sub> which acts as a base stabilizer and dust suppressant for soil of unpaved roads.

### V. CONCLUSION

1. The liquid limit, plastic limit, plasticity index are decreasing by the addition of RHA and CaCl<sub>2</sub> up to 17% and 5% respectively and then further increases with the increase in RHA percentage. Overall with this optimum mix, a total of 58% plasticity index is reduced in comparison to virgin soil which is a positive results.
2. Initially with the increase in moisture content, dry density is also increasing up to a certain water content (17.5%) which is also the optimum water content but after this increment in water content results a decrease in dry density, that means 1.69 g/cc is the Maximum Dry Density with respect to 17.5 % Optimum Moisture Content.
3. The Unconfined Compressive Strength (UCS) of treated sample are much higher than that of untreated samples. The maximum increase is 64% on addition of 17% RHA and 5% CaCl<sub>2</sub> which is optimum mix for curing periods of 28 days.
4. Soaked California bearing ratio (CBR) value of soil shows an enormous increase, 3 to 4 times higher values on addition of optimum mix that is 17% RHA and 5% CaCl<sub>2</sub> with respect to untreated soil sample.

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**Vol. 8, Issue 4, April 2019**

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