Study on the properties of expansive clayey soil using Coconut Husk Ash (CHA) as stabilizer

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Abstract- ***The worldwide problem of expansive soils is a threat to civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Such soils swell when given an access to water and shrink when they dry out. Soil stabilization has been implemented for improving the properties of these soils. Since the volume of wastes generated in the world has increased over the years due to increase in population, socioeconomic activities and social development hence utilization of these waste materials in the improvement of soils is a cost efficient and environmental friendly method. In this paper, coconut husk ash (CHA) is used as a stabilizer to improve the properties of expansive clayey soils. Various engineering tests like Unconfined Compressive Strength (UCS), California Bearing Ration (CBR), Proctor Test, Free Swell Index Test (FSI) were performed at varying percentage of CHA (2, 4, 6, 8, 10) and at varying curing periods (2 days, 4 days and 7 days) to find the optimum range of CHA to use as stabilizer. It is found that with the increase in the percentage of CHA the UCS and CBR values increases upto 8% at a curing period of 7 days. It is finally concluded that the optimum range for percentage of CHA to be used as soil stabilizer is found to be 8%.***

Keywords- ***Expansive Soil, Soil Stabilization, Coconut husk ash, Environment friendly, Curing Periods.***

I. INTRODUCTION

With the rapid growth in population and enormous development in infrastructure the demand for land has increased significantly for the past few decades. This has led to limited availability of land resources. Hence an engineer is forced to carry out the numerous construction activities even on problematic soil. There comes the importance of ground improvement techniques. Thus different soil stabilizations are gaining more importance in the present scenario. Moreover, due to the increase in population, social development and socioeconomic activities the volume of wastes (industrial, agricultural, domestic, etc.) generated in the world has increased over the years and hence utilization of these waste materials in the improvement of soils is a cost efficient and environmental friendly method. Cement and lime have been the two main materials used for stabilizing soils over the years. These materials are highly expensive which increases the cost of construction (*Neville 2000*). The excessive dependence on the utilization of industrially manufactured soil improving additives such as cement, lime and others have kept the cost of construction of stabilized road financially high. Thus the use of agricultural waste materials like Coconut husk ash (CHA) will not only reduce the cost of construction but also reduce the environmental hazards they cause. It has been shown by *Sear (2005)* that Portland cement produces large quantities of CO_2 for every ton of its final product which contributes to the depletion of the ozone layer covering the earth surface. Since CHA has been categorized as pozollanic material, with 67-70 % silica (SiO_2) (*Oyetola and Abdullahi, 2006*) therefore, replacing proportions of the Portland cement in soil stabilization with a material like CHA will reduce the overall environmental impact of the stabilization process. Also there are instances where stabilization of soil is done by using agricultural wastes. *Amu et al. (2011)* studied the potentials of coconut shell and husk ash on the Geotechnical Properties of Lateritic Soil for road works. They concluded that 4% addition of coconut shell husk ash increases the CBR values of the soil and hence it can be effectively used as stabilizer for stabilizing lateritic soil for road works. *Oluremi et al. (2012)* studied the stabilization of poor lateritic soil with coconut husk ash and concluded that coconut husk ash is suitable for improving the CBR value of soils having low liquid limit. *Shabana et al. (2014)* studied on CBR values of soil with crushed coconut shells (CCS). They found an improvement in the CBR values of soil due to the interaction of soil with CCS. They also found

that 16.12 % as the optimum percentage improvement per unit material consumption of 1 cm of CCS. *Oyediran and Fadamoro (2015)* studied the strength characteristics of genetically different rice and coconut husk compacted shales and concluded that 10 % of Rice husk ash and 6-10% of coconut husk ash can significantly increase the strength of soil. In this paper, an attempt is being made to improve the properties of expansive clayey soils by varying the percentage of coconut husk ash with varying curing period. The aim of this study is to find a cost effective and environment friendly method for improving the soil properties and also to find the optimum range of using coconut husk ash as stabilizer.

II. MATERIALS AND METHODS

The materials used in the study were soil sample and coconut husk ash. The soil sample was collected from Sunsali, Noonmati-Kharguli Road from a depth of 2 m below the natural ground level. They were air dried for two weeks to allow partial elimination of water which may affect sieve analysis and then sieved with 4.76mm IS Sieve to obtain the final soil samples for the tests. After drying, lumps contained in the samples were slightly pulverized with minimal pressure. The coconut husk was collated from a local vendor. They were spread out on the ground and air dried to facilitate easy burning. After air drying, the coconut husk was burnt openly into ash and collected in polythene bags, stored under room temperature until used. The CHA was sieved through 90µ IS Sieve to get the very fine ash. The chemical composition of CHA is given in Table 1. It was ensured that the CHA used is remained covered to prevent moisture and contaminations from other materials. The physical properties of the soil is given in Table 2.

The following tests were carried out by varying the percentage of CHA (2%, 4%, 6%, 8% and 10%) and by varying the curing periods (2 day, 4 day and 7 day):

1. Unconfined compression test (UCS): The UCS tests were performed according to IS: 2720 (Part 10) – 1991. The sample sizes were 40 mm diameter and 80 mm length. The tests were performed at the OMC and the MDD values of the natural soil.
2. California Bearing Ratio test (CBR): The CBR tests were conducted according to IS: 2720 (Part 16) – 1987. The sample sizes were 152 mm diameter and 126 mm length. The tests were performed at the OMC and the MDD values of the natural soil.
3. Free Swelling Index test (FSI): The FSI tests were conducted in accordance with IS: 2720 (Part 40) – 1977.

Table 1. Chemical Composition of CHA

Element	Percentage
CaO	0.42
MgO	12.7
SiO_2	57.8
Fe_2O_3	10.4
Al_2O_3	11.8
Na_2O	0.36
MnO	0.12
ZnO	0.38
K_2O	0.48

Table 2. Physical Properties of Soil

Test	Parameters	Description
Sieve Analysis	Sand	13.37 %
	Clay	86.63 %
Atterberg Limits	Liquid Limit	75 %
	Plastic Limit	24.7 %
	Plasticity Index	50.30 %
Classification of Soil		CH
Free Swell Index		57.32 %
Unconfined Compressive Strength	UCS value	0.62 kg/cm^2
California Bearing Ratio	CBR value	2.52 %
Proctor Test	MDD	1.42 kg/cm^3
	OMC	25.5 %

III. RESULTS AND DISCUSSION

The results of the various engineering tests were given in the graph below. The tests were performed by varying the percentages of CHA and at varying curing periods. From Figure 1, it is found that when CHA is increased to 8 %, the 7 day UCS strength becomes 1.6 times the original strength of the untreated soil sample. Similar is the case for CBR values (Figure 2) which is 1.7 times more than the untreated soil sample. It is found that in both the tests, UCS and CBR, the strength of the soil specimen increases with the increase in the percentage of CHA upto 8 %. The increase in the values of UCS and CBR with increasing percentage of CHA is due to the presence of SiO_2 which makes it a pozzolanic material. This pozzolanic material helps in formation of cementitious material thereby increasing the strength of the soil. But with further increase in the percentage of CHA, the strength starts reducing. This indicates that the degree of compaction is less and hence requires higher compactive effort to achieve the desired degree of compaction with increasing percentage of CHA beyond 8%. The swelling index values decreases with the increase in the percentage of CHA. From Figure 3, it is found that the FSI values reduces by 50% when CHA is increased to 8 % at 7 days and then it becomes constant with the further increase in the CHA percentage. The decrease in the percentage of swelling property is due to the flocculation and cementation of the soil particles. Hence it can be concluded that the optimum percentage of CHA to be used as a soil stabilizer is found to be 8 % with a curing period of 7 days.

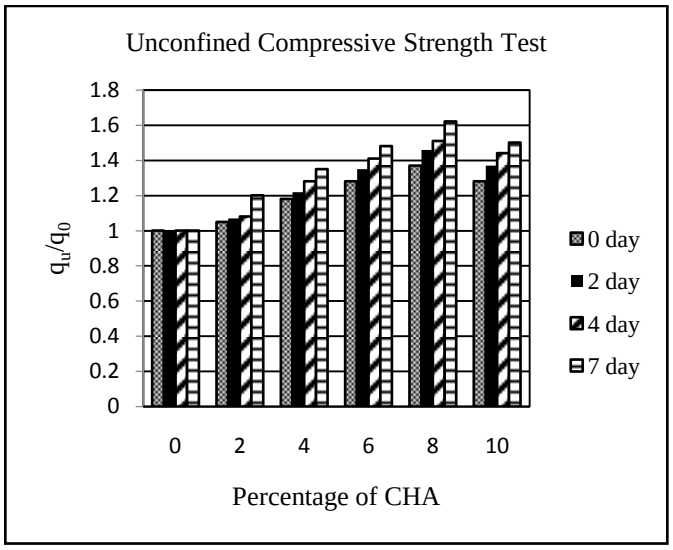

Figure 1. Comparison of UCS values for treated and untreated soil

IV. CONCLUSION

With the rapid increase in the population and urbanization, the amount of waste generated from factories, industries, agriculture etc. has increased significantly. As a result of this increase in the waste materials India is facing a serious problem in dumping of these wastes and eventually contributing a lot in creating environmental pollution. With the use of agricultural wastes in construction it not only reduces the cost of construction but also reduce the environmental hazard they cause. In this paper coconut husk ash (CHA) is used as a stabilizing material for the expansive clayey soil. The following conclusions can be made out from this research.

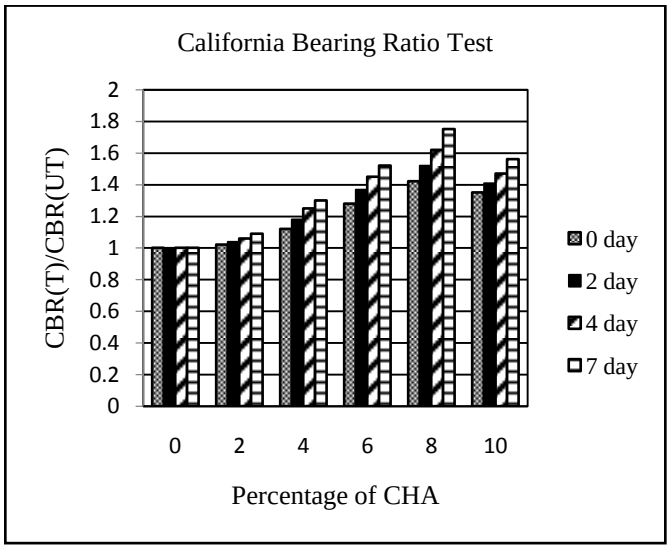

Figure 2. Comparison of CBR values for treated and untreated soil

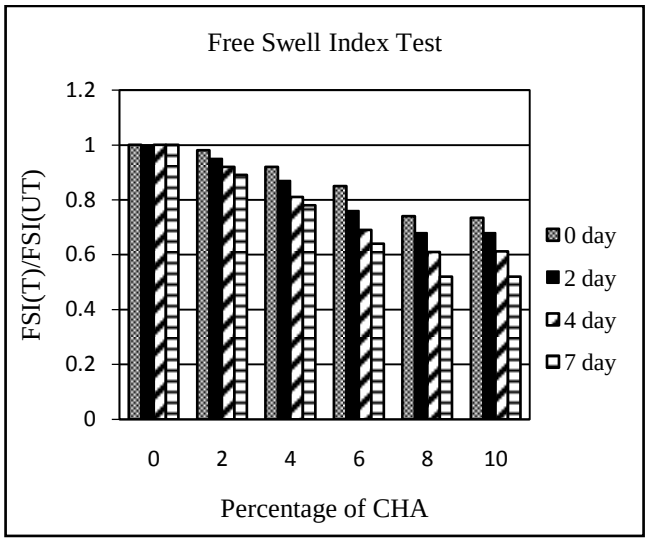

Figure 3. Comparison of FSI values for treated and untreated soil

- By conducting the UCS test for treated and untreated soil, it is found that the strength of the soil increases by 1.6 times the untreated soil when CHA is increased to 8% at 7 days curing period.
- The CBR value of treated soil increases by 1.7 times the untreated soil with the increase in the percentage of CHA to 8% for a curing period of 7 days.
- The swelling property of the soil decreases by about 50% when CHA percentage is increased to 8% for 7 days curing period.
- The UCS and CBR value increases with the increase in the curing period while the swelling index value decreases with the increasing curing period.
- The optimum range of CHA to be used as a soil stabilizing agent in 8%.

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