International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 03, March-2017

Expansive Soil Stabilization using Coconut Shell Powder and Lime

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***Abstract*— Expansive soils denote clayey soil that not only possess the tendency to swell but also to shrink when the prevailing moisture condition is allowed to change. There are various methods for improving the properties of expansive soil. The main objective of this paper is to investigate the effectiveness of coconut shell powder and lime in stabilizing the expansive soil collected from Chittoor of Palakkad district, Kerala. Coconut shell powder (CSP) and lime are commonly available materials and are also economical. This paper presents the improvement of compressive strength of expansive soil when stabilized with different dosages of coconut shell powder (0%, 3%, 6%, 9% and 12%) and lime (3%, 6% and 9%). The tests were conducted for various dosages of coconut shell powder and lime after curing periods of 0, 7 and 28 day in order to study the drying and wetting properties. From the results we inferred that coconut shell powder and lime are effective in improving the properties of expansive soil.**

Keywords*— Coconut shell powder(CSP); lime; unconfined compressive strength; drying and wetting properties

I. INTRODUCTION

In developing countries like India, the construction work is gaining huge demand. This forces the engineers to carry out the construction in unstable soils like the black cotton soil or the expansive soil. Expansive soils are fine grained soil or decomposed rocks that show huge volume change when exposed to the fluctuations of moisture content. The expansive soils are most likely to be unsaturated and have montmorillonite clay minerals. Most of severe damage in relation to expansive soils is depended on the amount of monovalent cations absorbed to the clay minerals. These makes the necessity to stabilize the soil before the commencement of construction works. Thus the stabilization of expansive soil is important in various geotechnical engineering works such as building foundation, pavement structures, irrigation systems etc to reduce the alternate swelling and shrinkage of expansive soil. Many soil stabilizers are available in world wide. But the challenge involved is to select the one which is easily available and also economical. Cost effective and locally available stabilizers such as coconut shell powder and lime are used for the stabilization in this project. Kerala, the land of coconut is rich for coconut shell powder.

The aim of this research is to utilize coconut shell powder and lime to improve the engineering properties of expansive soil and to increase the compressive strength of the compacted expansive soil.

A. Literature Review

Soil stabilization is the technique used to improve the engineering properties of soil and to make it perform the intended use. Several materials have been used as stabilizers which include lime, rice husk, bagasse fibres, chemical additives etc.

II. MATERIALS

A. Expansive soil

It is a clay or soil that is prone to large volume changes (swelling and shrinking) that are directly related to changes in water content. Soils with a high content of expansive minerals can form deep cracks in drier seasons or years; such soils are called vertisols. Soils with smectite clay minerals, including montmorillonite and bentonite, have the most dramatic shrink-swell capacity. The soil used in this study was obtained from Chittur of Palakkad district, Kerala, where it is used in the cultivation of cotton.

B. Coconut shell powder

Kerala is the land of coconut trees. Coconut trees provide various advantages in which the influence of CSP is noticeable. CSP is applied as raw material for activated carbon industries, compound filler in the manufacture of Phenolic moulding powder, filler for synthetic resin glues etc. The chemical properties of CSP are shown in Table 1.

Table 1. Chemical properties of CSP

Chemical Composition	Value
Lignin	29.4%
Pentosam	27.7%
Cellulose	26.6%
Moisture	8%
Solvent Extractives	4.2%
Uronic Anhydrides	3.5%
Ash	0.6%

C. Lime

Lime is a commonly used stabilizer for the stabilization of expansive soil for controlling the swelling and shrinkage properties due to climatic changes. Lime reacts with expansive soil in the presence of water and changes the physico-chemical properties of the soil.

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Table 2. Chemical properties of Lime

Chemical composition	Values
Silica	4.02%
Insoluble matter	5.64%
Ferric oxide	1.92%
Alumina	1.36%
Calcium oxide	59.42%
Magnesia	0.92%
Loss on ignition	26.72%

III. EXPERIMENTAL PROGRAM AND RESULTS

Swelling index test was conducted to identify the soil as expansive. All engineering properties of the soil sample were determined. The main aim of this study is to determine the increase in compressive strength and maximum dry density of the soil sample with the addition of stabilizers. The unconfined compressive strength was determined using UCC apparatus and the result showed that the sample has low compressive strength. The optimum moisture content and maximum dry density were determined from standard proctor test. Soil stabilization is a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose. The prime objective of soil stabilization is to improve the compressive strength of soil in order to eliminate the settlement in building foundation and also in the road pavements. This study aims at improving the properties of expansive soil with different dosages of coconut shell powder and lime. The various geotechnical properties of the expansive soil were determined as per Indian Standards (IS 2720).

Table 3. Basic properties of soil

Sl. No	Physical Property	Value
1.	Natural Water Content	9.3
2.	Specific Gravity	2.2
3.	Liquid Limit(%)	56
4.	Plastic Limit(%)	30
5.	Plasticity Index	26
6.	Shrinkage Limit	12
7.	Free Swell Index	60
8.	Gravel(%)	0
9.	Sand(%)	32
10.	Silt(%)	37
11.	Clay(%)	31
12.	OMC(%)	18
13.	MDD(g/cc)	1.75
14.	UCS(kN/m^2)	5.24

A. *Standard proctor test*

Maximum dry density and optimum moisture content was determined using standard proctor test. The result of standard proctor test conducted on the expansive soil treated with CSP and lime showed an increase in maximum dry density.

B. *Unconfined compression test*

Unconfined compression test was conducted on the soil sample treated with various dosages of coconut shell powder and lime. Trial tests with 3, 6, 9 and 12% CSP were conducted and 9% was obtained as the optimum dosage.

Table 4. Compressive strength for various % of CSP

Strain	Compressive Strength for various % of CSP (kN/m^2)			
	3%	6%	9%	12%
0.007	2.77	1.38	2.77	2.77
0.013	4.09	2.73	4.09	4.09
0.02	4.07	5.43	5.43	6.78
0.027	5.39	6.74	6.74	6.74
0.033	6.69	8.03	6.69	8.03
0.04	8.23	9.3	7.98	9.3
0.047	7.9	9.23	9.28	10.6
0.053	9.18	10.49	10.5	11.8
0.06	9.11	11.71	11.7	13.02
0.067	10.33	12.92	12.9	12.9
0.073	11.6	12.84	12.8	-
0.08	-	-	14	-
0.087	-	-	15.2	-
0.093	-	-	15.1	-

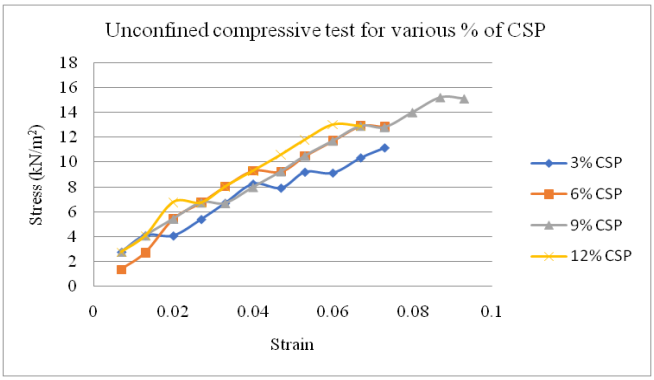

Fig. 1. Stress-Strain curve for various % of CSP

Soil sample treated with CSP showed an increase in compressive strength with increase in % of CSP. The compressive strength increased up to an optimum value of 9% and then it decreased with further addition of CSP. The graph showing variation of compressive strength with % of CSP is shown in Table 5.

Table 5. Compressive strength (q) for various % of CSP

%Stabilizer added	Unconfined compressive strength q (kN/m^2)	Cohesion c (kN/m^2)
3	11.6	5.8
6	12.92	6.46
9	15.2	7.6
12	13.02	6.51

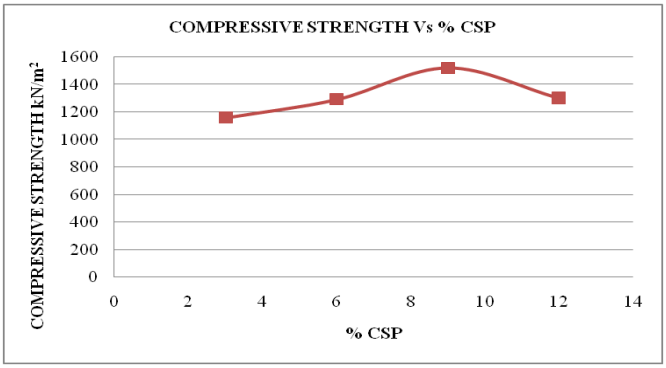

Fig. 2. Compressive strength Vs % CSP

International Journal of Engineering Research & Technology (IJERT)
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The sample with 9% CSP was further treated with varying percentage of lime (3, 6 and 9%). The alternate drying and wetting properties of the sample was obtained by curing the sample for 0, 7 and 28 days. The maximum compressive strength was obtained for 9% CSP and 6% lime after 28 days of curing.

Table 6. Compression strength for various % of stabilizer with curing period q (kN/m^2)

%Stabilizer added	Unconfined compressive strength (kN/m^2)		
	0	7	28
9%CSP+3%LIME	16.3	23.1	55.08
9%CSP+6%LIME	17.2	69.8	61.63
9%CSP+9%LIME	15.85	107.8	120.4

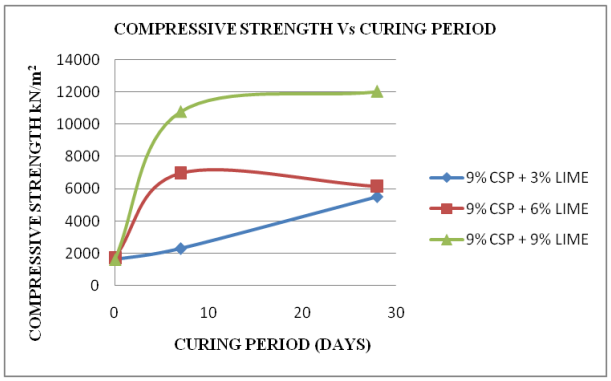

Fig. 3. Compressive strength Vs curing period

IV. CONCLUSION

The expansive soil was treated with coconut shell powder and lime to improve its properties. Coconut shell powder and lime are natural materials available locally and are moreover cost effective. Following results were obtained from the tests:

- The optimum compressive strength was obtained for 9% coconut shell powder.
- The compressive strength was further increased when treated with both coconut shell powder and lime.
- The optimum compressive strength was obtained for 9% CSP and 6% lime.
- The wetting and drying behaviour was studied by keeping the sample for curing.
- The compressive strength was found to be maximum after 28 days of curing.
- Standard proctor test was conducted and the result showed an increase in maximum dry density for soil sample treated with coconut shell powder and lime.
- In overall the compressive strength of the expansive soil increased by 228% when treated with coconut shell powder and lime.

ACKNOWLEDGEMENT

The authors wish to express an acknowledgement to Assistant professor Sowmya V Krishnankutty for valuable guidance and support. The authors also wish to acknowledge technical and economical support from Civil engineering department, Federal Institute of Science and Technology, Kerala.

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