Studies on Coir Fibre stabilized Expansive Soil with Calcium Chloride

Chebrolu Veera Durga Prasad[1], Sri B Ganesh[2]
[1, 2] Civil Engineering Department
[1, 2] Lenora College of Engineering, Rampachodavaram.

Abstract- *Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. For centuries mankind was wondering at the instability of earth materials, especially expansive soil. Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. One day they are dry and hard, and the next day wet and soft. Swelling soil always create problem for lightly loaded structure, by consolidating under load and by changing volumetrically along with seasonal moisture variation. As a result the superstructures usually counter excessive settlement and differential movements, resulting in damage to foundation systems, structural elements and architectural features. Extensive laboratory / field trials have been carried out by various researchers and had shown promising results for application of such expansive soil after stabilization with additives such as sand, silt, lime, fly ash, etc. A relatively new solid waste, Coir Fibre (CF), a by-product from Coconut, can be used for stabilization of expansive soils for various uses. In combination with Calcium Chloride. The present study was planned to access the role of Calcium Chloride inclusions in improving the weak expansive soil besides stabilizing it with Coir Fibre in different proportions.*

Keywords- Engineering properties, Expansive soil, Stabilization, Coir Fibre, Calcium Chloride.

I. INTRODUCTION

In India, the area covered by expansive soils is nearly 35% of the total area. They normally spread over a depth of 2 to 20m. In Rainy season, structures on this soils experience large-scale damage due to heaving accompanied by long strength, where as in summer season, they shrink and gain density and become hard. Their alternative swelling & shrinkage damages structure severely. This is severe for lightly loaded structures.

The deformations produced as a result of swelling or shrinkage is significantly greater than elastic deformation and classical elastic or plastic theory cannot predict them. During summer, POLYGONAL SHRINKAGE CRACKS appear at surface, which may extend to a depth of about 2m indicating the active zone in which volume change occurs.

Because of the swelling of black cotton soils during rainy season & their shrinkage during summer, extensive damages have been carved such as “Building Cracks”, canal LANDSLIDES, beds of canal heave, healing &rutting of pavements, damage to conduits etc.

Soil is a natural body consisting of layers (soil horizons) that are primarily composed of minerals which differ from their parent materials in their texture, structure, consistency, and colour, chemical, biological and other characteristics. It is the unconsolidated or loose covering of fine rock particles that covers the surface of the earth. Soil is the end product of the influence of the climate (temperature, precipitation), relief (slope), organisms (flora and fauna), parent materials (original minerals), and time. In engineering terms, soil is referred to as regolith, or loose rock material that lies above the 'solid geology'. In horticulture, the terms 'soil' is defined as the layer that contains organic material that influences and has been influenced by plant roots and may range in depth from centimetres to many metres.

1. Scope of the Study

The experimental study is concerned with the selection of approximate type of soils to achieve a very high degree of compaction and to expose the compaction properties of clay. The clayey soils are difficult to compact in the initial stages of compaction, but as the moisture content increases the compaction becomes quite easy. The results of the study can provide thoughts for applying clay soil in various applications of soil stabilization process.

2. Objectives of the study

The following are the main objectives of our project work.

- To increase the load bearing capacity of the soil.
- To increase resistance against the temperature and moisture changes.

- To increase the shear strength and therefore bearing capacity.
- To increase the stiffness and therefore reduce future settlement.
- To decrease void ratio and so permeability, thus reducing potential frost heave.

II. LITERATURE RIEVIEW

The history of the study of soil is intimately tied to our urgent need to provide food for ourselves and forage for our animals. Throughout history, civilizations have prospered or declined as a function of the availability and productivity of their soils. The scientists who studied the soil in connection with agricultural practices had considered it mainly as a static substrate. However, soil is the result of evolution from more ancient geological materials. Other scientists later began to study soil genesis and as a result also soil types and classifications.

Extensive studies have been carried out on the stabilization of problematic soil (such as marine clay and swelling soil, etc.) using various additives such as lime, fly ash, and Fiber P. R.

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For any structure, the foundation is very important and it has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. To work on soils, we need to have proper knowledge about their properties and factors which affect their behavior. Expansive soils always create problems more for lightly loaded structures than moderately loaded structures. By consolidating under load and changing volumetrically along with seasonal moisture variation, these problems are manifested through swelling, shrinkage and unequal settlement. In this paper the experimental results obtained in the laboratory on expansive soils treated with low cost materials (lime and fly ash) are presented. A study is carried out to check the improvements in the properties of expansive soil with fly ash and lime in varying percentages. The results show that the stabilized clay has lesser swelling potential whereas increase in optimum moisture content has been observed.

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In the present research the unconfined compressive strength of stabilized clayey soil by compacting to different densities at particular moisture content, at different curing period and varying copper slag and cement content. Cylindrical specimens stabilized with copper slag and cement was subjected to determination of unconfined compressive strength method. The low strength and high compressible soft clay soils were found to improve to various degrees by addition of copper slag and cement. The overall test results indicate that copper slag and cement is effective in stabilizing the soil, where significant improvement in unconfined compressive strength. A relatively good strength prediction can be derived from a compilation of the strength and , on condition a reliable number of data are made available. From the test results of unconfined compressive strength method could be easily established for quality control and assurance of stabilization work.

III. METHODOLOGY

Expansive Soil

The Clay that has been used in this study was a typical BC soil collected from Rampachodavarm, East Godavari District. The soil used for the investigation was dried, pulverized and then sieved through 4.75mm size sieve. The properties of black cotton soil experimented, based on relevant I.S. code provisions are given in the Table 1 below.

Table 1. Physical properties of Black Cotton Soil

Laboratory Experimentation	Value
Specific gravity	2.72
Compaction Parameters	
Maximum Dry Density(g/cc)	1.52
O.M.C. (%)	28.8
Atterberg's limits	
Liquid limit (%)	66.4
Plastic limit (%)	23.5
Plasticity index(%)	42.9
IS classification	CH
Differential Free Swell (%)	105
CBR- Unsoaked	3.4
Soaked	1.6

Coir Fibre - CF

Coir Fibre is obtained from the husk of coconut and belongs to the group of hard structural fibres. The fibrous husks are soaked in pits or in nets in a slow moving body of water to swell and soften the fibres. The long bristle fibres are separated from shorter mattress fibres underneath the skin of nut, a process known as wet milling. The coir Fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. It is an important commercial product used in mattress. Shorter mattress fibres are separated from the long bristle fibres which are in turn a waste in the coir Fibre industry. The coir is purchased from market. It is the fibrous portion of the coconut extracted mainly from the green nut. Coir extracted consists of rotting the husk in water and removing the organic material binding the fibre. Diameter is 0.5mm. The coir is cut into pieces of 3cm to 5cm.

Table 2. Physical properties of Coir Fibre (CF)

Length in inches	6-8
Density (g/cc)	1.40
Tenacity(g/Tex)	10.0
Breaking Elongation %	30%
Diameter in mm	0.1 to 0.5
Rigidity of Modulus	1.8924dyne/cm^2

Properties of Calcium Chloride:

- Calcium chloride can serve as a source of calcium ions in an aqueous solution, as calcium chloride is soluble in water. This property can be useful for displacing ions from solution. For example, phosphate is displaced from solution by calcium:

  $3\ CaCl_2(aq) + 2\ K_3PO_4(aq) \rightarrow Ca3(PO_4)_2(s) + 6\ KCl(aq)$

- Molten calcium chloride can be electrolysed to give calcium metal and chlorine gas: $CaCl_2(l) \rightarrow Ca(s) + Cl_2(g)$
- Calcium chloride has a very high enthalpy change of solution. A considerable temperature rise accompanies its dissolution in water.

IV. RESULTS AND DISCUSSION

In the laboratory, various experiments were conducted by adding different percentages of Coir Fibre (CF) in the expansive soil and also further stabilizing it with Calcium Chloride as a binder. Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Coir Fibre (CF) as replacement in expansive soil and Calcium Chloride as a binder.

EFFECT OF % COIR FIBRE (CF)AS ADDITIVE ON THE STRENGTH CHARACTERISTICS OF EXPANSIVE SOIL

The individual influence of Coir Fibre (CF) on the Compaction and Strength characteristics of expansive soil are clearly presented in Figures below. The percentage of Coir Fibre (CF) was varied from 0%, to 4% with an increment of 1%. From the above graphs, it was observed that the treatment as individually with 2% CF has moderately improved the expansive soil. It can be inferred from the graphs, that there is a gradual increase in maximum dry density with an increment in the % replacement of CF up to 15% for strength characteristics. The addition of CF had mobilized little amount of friction to the pure Clayey soil without friction

Properties of Expansive Soil with Coir Fibre

Table 3.

ES+CF	DFS	MDD	OMC	C	Ø
100+0	140	1.52	30.4	42	0^0
100+1	126	1.53	30.6	48	1^0
100+2	115	1.55	30.3	67	2^0
100+3	91	1.54	29.8	65	2^0
100+4	84	1.54	29.6	62	1^0

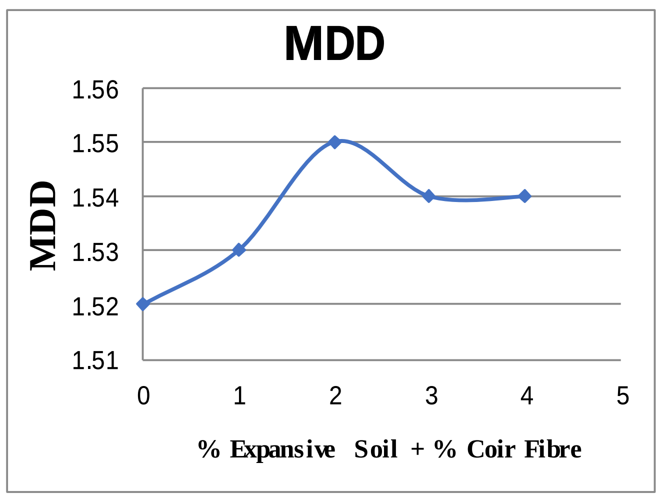

Figure 1. Plot showing the variation of Maximum Dry Density with % replacement in Expansive soil with Coir Fibre.

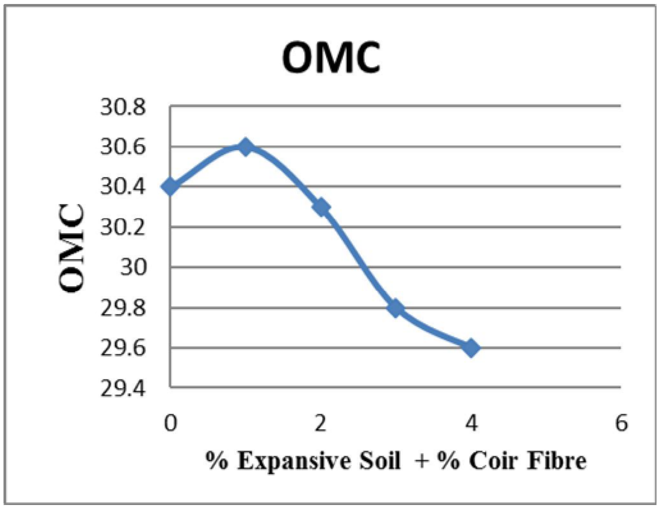

Figure 2. Plot showing the variation of Optimum Moisture Content with % replacement in Expansive soil with Coir Fibre.

Table 4. Properties of Optimum Mix with Calcium Chloride

ES+CF+$Cacl_2$	MDD	OMC	C	Ø	Unsoaked CBR	Soaked CBR
100+2+0	1.55	30.3	67	20	3.8	2.7
100+2+1	1.56	30.3	86	30	4.2	2.9
100+2+2	1.57	29.6	94	40	4.5	3.4
100+2+3	1.58	29.4	112	50	5.2	3.8
100+2+4	1.56	28.2	108	50	4.9	3.8

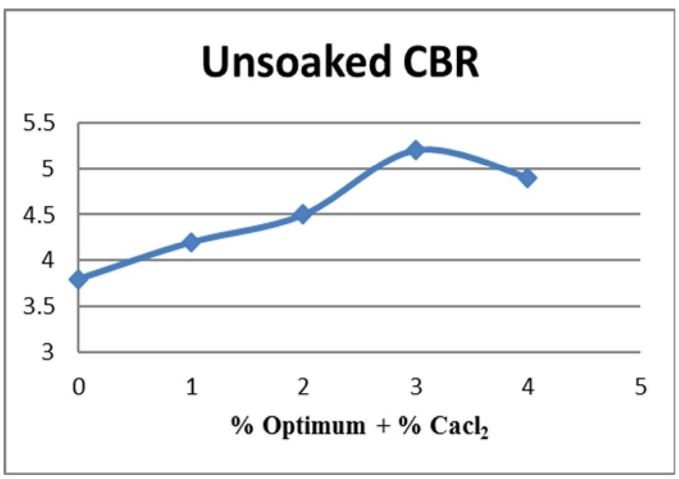

Figure 3. Plot showing the variation of Unsoaked CBR values with % Calcium Chloride inclusions in Optimum Content of CF with Expansive Soil

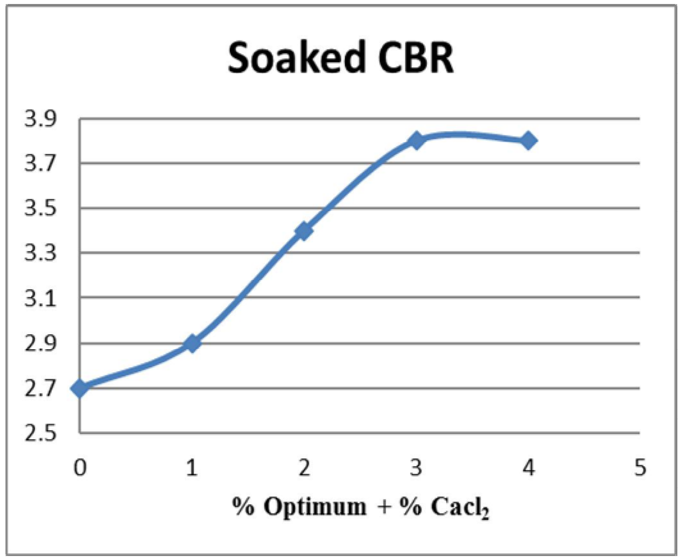

Figure 4. Plot showing the variation of Soaked CBR values with % Calcium Chloride inclusions in Optimum Content of CF with Expansive Soil

V. CONCLUSION

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- From the laboratory studies, it is observed that the Expansive Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- The addition of Coconut coir Fibre into the Expansive soil has changed the compaction parameters. The OMC of the Expansive soil has decreased and the maximum dry density (MDD) increased with the addition of Coconut coir Fibre. The soaked CBR values have also increased significantly with the addition of Coconut coir Fibre content. The addition of 2% Coconut coir Fibre into the Expansive soil, increase the values.
- Later Calcium Chloride is added to the optimum content of Expansive Soil with Coconut Fibre increase the Density and Cohesion values with CBR Values.

From the above laboratory investigation it can be concluded that the industrial waste like Coconut coir Fibre has a potential to modify the engineering behavior of Expansive soil with that calcium chloride is acts as a binder and brings that soil to make it suitable in many geotechnical application

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