A Study on The Performance Evaluation of Zycobond and Treated Coir Fibers (TCF) In Improving Expansive Soil

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Abstract- *Any soils have swelling and shrinkage nature it depends upon its presence of clay minerals. There are four types of clay minerals mainly montmorillonite, illite, kaolinite and Halloysite. The soil is showing expansive or shrinkage nature due to presence of basic mineral montmorillonite. Expansive soils, also termed as swelling soils or shrink-swell soils pose a major challenge to civil engineers all over the world as they cause severe distress to structures constructed on them. In India, these soils are also called as Black soils or Black cotton soils. Treatment of soils with Zycobond has been used recently get the desired strength. Zycobond is a liquid additive which acts on soil to reduce voids between soil particles and minimize adsorbed water in the soil to achieve maximum compaction. Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. In the present study, an attempt is made to conduct different types of experiments on soils stabilized with Zycobond and coir fibre with different percentages and study the engineering properties of the soils. Thus, the effectiveness of using Zycobond and coir fibre in stabilizing weak soil was investigated in the laboratory. The soil samples in natural state and when mixed with varying percentages of Zycobond and further with coir fibre were used for the laboratory tests that included atterberg limits tests, grain size analysis, standard Proctor compaction tests, unconfined compression tests and California bearing ratio tests.*

Keywords- clayey soil, Zycobond, Coir fibre, standard Proctor compaction test, California bearing ratio.

I. INTRODUCTION

The quality of the building is very important in constructions project. One of the important factors that affect the quality of the buildings is soil strength in the construction sites. Some of construction project in India are built on the site that consist of tropical soils. Clay is fine grain material that consists of very small particles. Because of its size, clay has small pore than other types of soils. In the construction projects, clay materials considered as bad base-soil material. Clay soils usually cause some problem on the constructions site. Mostly the problem of clay soils is related to bearing capacity, settlement, swelling and shrinkage.

Various remedial measures like soil admixture, moisture control, pre-wetting, lime stabilization have been practiced with varying degrees of success. However, these techniques suffer from certain limitations with respect to their adaptability, like longer time periods required for pre-wetting the highly plastic clays, difficulty in constructing the ideal moisture barriers, pulverization and mixing problems in case of lime stabilization and high cost for hauling suitable refill material for soil admixture etc.

Research about stabilization of the clay with adding stabilizer is usually done in order to increase the quality ofthe clay soils. The addition of stabilizer is usually intended to reduce the swelling on the clay soils that can reduce the strength. Clay has high plasticity index and swelling potential, so the stabilization is usually done in order to overcome the problems. Research about clay soils stabilization is commonly done with adding some additive such as lime, cement, and cane pulp ash. Nowadays, a research of clay stabilization is still interesting subjects to be observed. The development of industries in India brings welfare to its people. In the industrial process, fuel is needed to operate machines. Treatment of soils with Zycobond has been used recently get the desired strength. Zycobond is a liquid additive which acts on soil to reduce voids between soil particles and minimize adsorbed water in the soil to achieve maximum compaction. In the present study, an attempt is made to conduct different types of experiments on soils stabilised with Zycobond with different percentages and study the engineering properties of the soils further Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. Reinforcing the soil with fibre Coir Fibre may be a cost effective solution to the ground/soil

improvement issues. It is an important commercial product used in mattress. Diameter of the fiber is 0.3 to 0.5 mm.

1.2 OBJECTIVES OF THE STUDY

Treatment of soils with Zycobond has been used recently get the desired strength. Zycobond is a liquid additive which acts on soil to reduce voids between soil particles and minimize adsorbed water in the soil to achieve maximum compaction. Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. In the present study, an attempt is made to conduct different types of experiments on soils stabilized with Zycobond and coir fibre with different percentages and study the engineering properties of the soils. Thus, the effectiveness of using Zycobond and coir fibre in stabilizing weak soil was investigated in the laboratory. The soil samples in natural state and when mixed with varying percentages of Zycobond and further with coir fibre were used for the laboratory tests that included atterberg limits tests, grain size analysis, standard Proctor compaction tests, unconfined compression tests and California bearing ratio tests.

II. LITERATUREREVIEW

2.1PREVIOUS RESEARCH PAPERS AND CONCLUSIONS

Soil stabilization is a procedure where we improve engineering properties of soil with the use of natural or synthesized admixtures. In the past many researchers have carried out their research work for improving the strength of black cotton soil using different types of admixture at different percentages. A brief review of previous studies on black cotton soil is presented in this section and past efforts most closely related to the needs of present work.

Vasudevan and Babu (2008) conducted triaxial test for analysing the influence of coir fibre on strength and stiffness behavior of soil at various fibre content and at different fibre lengths, diameter and different confining pressure, it was concluded that stress-strain behaviour inclusion of coir fibre has improved by the use of coir fibre thus increasing the value of deviator stress increased up to 3.5 times with percentage inclusion of fibre in soil, the deviator stress increment of soil increases with the diameter of fibre and the maximum value of fibre length being fibre in between 15-25 mm and was also observed that stiffness of soil has increased and immediate settlement was minimized by inclusion of coir fibre in the soil.

Dasaka and Sumesh (2011) reinforced the soil with the coir fibre at various fibre content and found that unconfined compressive strength increases for fibre content of length and improves ductile behaviour of soil a well-defined failure surface could not be seen due to increased ductile behaviour also peak compressive strength increased at the fibre content of 1.5% and thereafter value compressive strength becomes constant . When triaxial tests were conducted in the Unconsolidated Untrained(UU) condition under the various confining pressure it was concluded that ductility increases with increase in the fibre contentand also the cohesion and friction angle was increased at the optimum fibre content of 1.5%.

Dutta et al. (2012) considered the impact of inclusion of coir fiber (15 mm long) in the unconfined compressive state of thesoil. For treatment of dry fiber, sodium hydroxide and carbon tetrachloride were used. The sample for the unconfined compressive tests was set up with the fiber percentage inclusion of 0.4%, 0.8% and 1.6%. The axial stress increased from 63.98kPa to 79.67 kPa was seen when clay was strengthened 0.4% dry fibre and with 1.6% inclusion of dry fibre strands increased up to 114.77 kPa. NaOH treated fiber the optimum value 0.4% axial stress of 81.47 kPa which on expanding the fiber substance to 1.6% raised to 130.03 kPa. Further, when the soil blend was fortified with 0.4% CCl4 treated filaments, the pinnacle pressure was 70.69 kPa, which again reached to 245.78 kPa when the fiber substance was increased to 1.6%.

Lekha B.M, et al. (2013) studied the behaviour of Black Cotton (BC) soil with and without chemical stabilizer. Terrasil was used as stabilizer and it was used for different dosages and cured for 7, 14 and 28 days. Due to the chemical reaction, the soil mass densifies by minimizing the voids between particles and it makes the soil surface impervious. The chemical compositions and microstructures of soils were analyzed using X Ray Diffraction (XRD) and Scanning Electron Microscope (SEM) respectively.

Ingles and Metcalf, Mitchell and Katti, Maher et al. , Brown and Edil et al.. In the nineteen eighties, the researchers viz. Chauhan et al, Consoli et al, Sadek et al, Chore et al and Gray and Ohashi etc., started using fibers in the utilization of the waste material in conjunction with the different types of soils in order to improve the strength and /or enhance certain properties thereof.

2.2 STABILIZATION

Soil stabilisation is artificially changing soil properties for construction purposes (by physical or chemical

methods) at the natural site. As a result of soil stabilization, the bearing capacity of the foundation of the structure is increased and its strength, water tightness, resistance to washout, and other properties are improved. Soil stabilization is achieved by injecting cementing materials or chemical solutions into the ground and also by applying electric currents to the ground or heating or cooling it.

METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. METHODOLOGY

MATERIALS USED AND THEIR PROPERTIES

3.1 SOIL

The soil used was a typical black cotton soil collected from Komarigiripatnam (Odalarevu) in East Godavari District, Andhra Pradesh State, India. The properties of soil are presented in the Table All the tests carried on the soil are as per IS specifications.

Table 3.1 shows properties of soil.

S. No.	Property	Value
1	Specific gravity	2.63
2	Differential free swellIndex (%)	98
3	Atterberg's Limits	
	i) Liquid limit (%)	65
	ii) Plastic limit (%)	33
	iii) Plasticity index (%)	32
5	Grain Size Distribution	
	i) Sand Size Particles (%)	10
	ii) Silt & Clay Size Particles (%)	90
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.5
	ii) Optimum Moisture Content (%)	30
8	Penetration Parameters	
	i) CBR - Soaked (%)	2.68
9	Unconfined compressive strength	68.1

3.2 Zycobond

Zycobond is a chemical stabiliser which is available commercially; it is a sub-micron acrylic co-polymer emulsion with long life for bonding of soil particles. Zycobond is a liquid additive which acts on soil to reduce voids between soil particles and minimize adsorbed water in the soil to achieve maximum compaction. It offers water resistance, strong bonding and imparts flexibility to the soil surface. The following table shows the properties of Zycobond.

Table 5.2 shows Properties of Zycobond

Colour	White
Odour	No
Solvent	Ethylene Glycol
Flash Point	800c
Solubility	Soluble in water
pH value	5-6

3.3Coir fibre

Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. Reinforcing the soil with fibre Coir Fibre may be a cost effective solution to the ground/soil improvement issues. It is an important commercial product used in mattress. Diameter of the fiber is 0.3 to 0.5 mm. The coir is cut into pieces of length varying from 3cm to 5cm. The fibers are mixed randomly in the soil-coal ash mixture during experiments in various percentages as 0.50, 1.0, 1.5 and 2%. Coir fibre was procured from local market in Kakinada, East Godavari District. Coir used for the study was cut into 30 mm to 50mm length.

IV. LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the marine clay to find the properties of virgin marine clay.

- Grain size distribution
- Specific gravity
- Index properties –liquid limit, plastic limit
- Compaction tests
- Penetration tests-California bearing ratio test.
- Unconfined Compression Test-Triaxial

V. RESULTS AND DISCUSSIONS

5.1GENERAL

In the laboratory, various experiments were conducted by adding different percentages of Zycobond in the expansive soil and also further stabilizing it with coir fibre as a

reinforcing material. Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Zycobond in expansive soil and further coir fibre as a reinforcing material.

The influence of the above said materials on the Compaction and Strength characteristics were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice.

Different tests can be used to characterize the index and engineering properties of stabilized soils. The present study focuses on evaluating the physical properties, compaction, strength behaviour. Experimental Investigations have been carried out on expansive soil with the addition of varying percentages of zycobond (1%, 2%, 3%, 4% and 5%) and coir fiber (0, 0.5, 1, 1.5, 2%). The specific gravity, Atterberg limits, compaction, unconfined compressive strength (UCS), consolidation and swelling characteristics of clay soil sample was determined according to the Indian Standards.

EFFECT OF ZYCOBOND ON THE SWELL PROPERTIES OF EXPANSIVE SOIL

The individual influence of Zycobond on the SWELL PROPERTIES of expansive soil are clearly presented in Figure 5.1. The percentage of Zycobond was varied from 0%, to 5% with an increment of 1%. From the above graphs, it was observed that the swelling behaviour of Expansive is decreasing for the percentage adddition of zycobond from 0 to 5%.

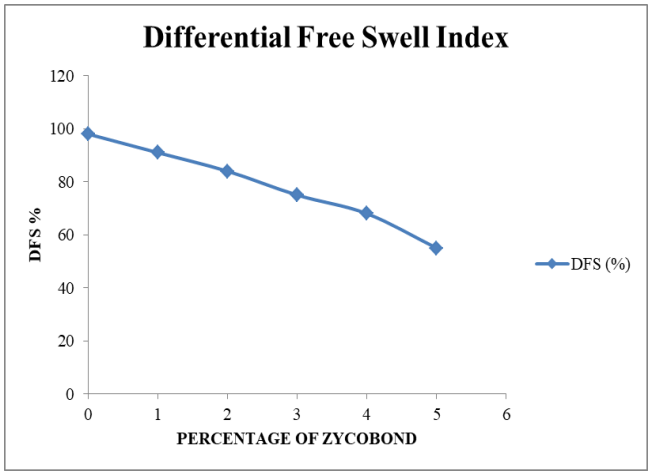

Fig 5.1: Variation of DFS with percentages of zycobond

EFFECT OF % ZYCOBOND ON THE ATTERBERG LIMITS OF EXPANSIVE SOIL

The individual influence of Zycobond on the ATTERRBERG LIMITS of expansive soil are clearly presented in Figure 5.2. The percentage of Zycobond was varied from 0%, to 5% with an increment of 1%. From the above graphs, it was observed that the treatment as individually with 4% Zycobond has moderately improved the expansive soil.

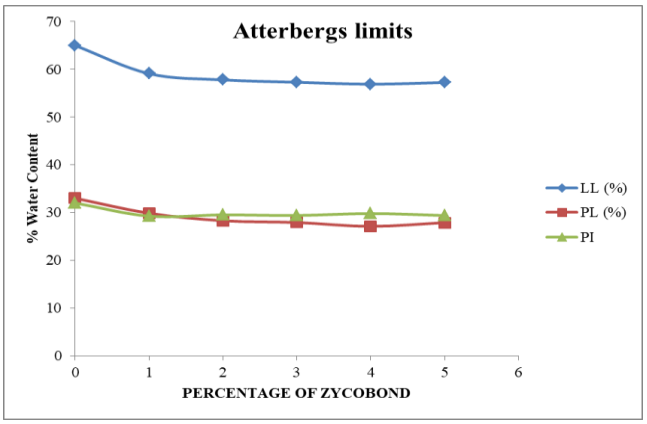

Fig 5.2: Variation of ATTERBERG LIMITS with different percentages of zycobond

EFFECT OF % ZYCOBOND ON THE COMPACTION CHARACTERISTICS OF EXPANSIVE SOIL

The individual influence of zycobond on the Compaction of expansive soil is clearly presented in Figures. The percentage of Zycobond was varied from 0%, to 5% with an increment of 1%.

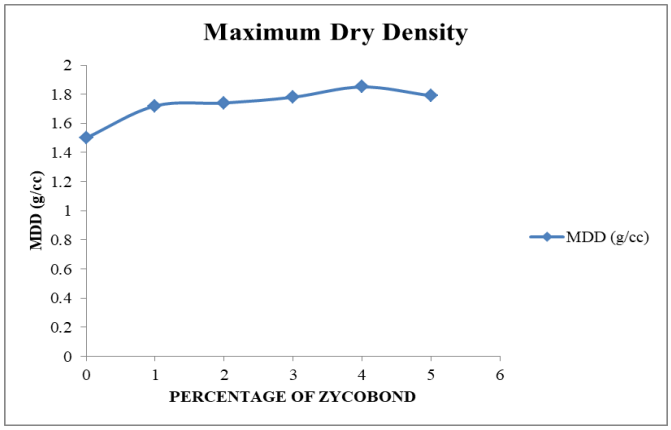

Fig 5.3: Variation of MDD with different percentages of zycobond

From the above graphs, it was observed that the treatment as individually with 4% Zycobond 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 % addition of Zycobond up to

4% with an improvement of about 1% and it was about 23.33% for strength characteristics.

EFFECT OF % ZYCOBOND ON THE CBR AND UCS OF EXPANSIVE SOIL

The individual influence of zycobond on the CBR and UCS of expansive soil are clearly presented in figure. The percentage of Zycobond was varied from 0%, to 5% with an increment of 1%. From the above graphs, it was observed that the treatment as individually with 4% Zycobond has moderately improved the expansive soil. It can be inferred from the graphs, that there is a gradual increase in CBR values with an increment in the % addition of Zycobond up to 4% with an improvement of about 1% and it was absorbed that for the addition of 4% there is an increment of 50% for CBR(S) and 147% for UCS on expansive soil.

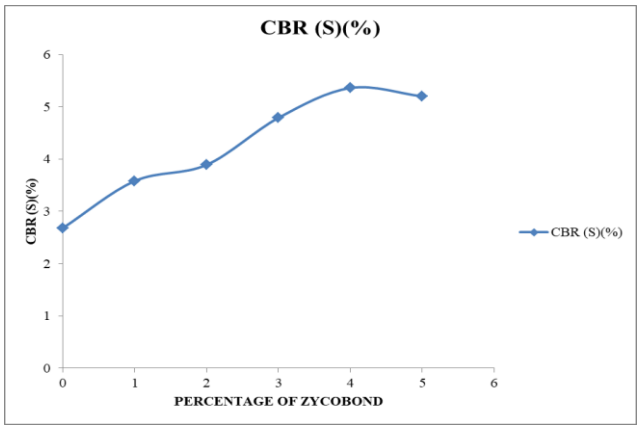

Fig 5.4: Variation of CBR with different percentages of zycobond

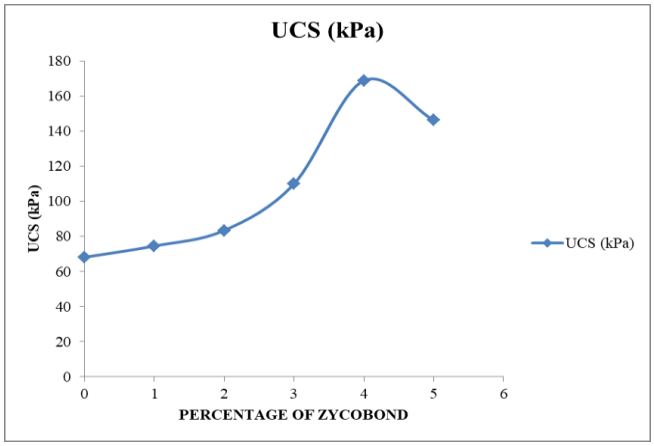

Fig 5.5: Variation of UCS with different percentages of zycobond

From the above results the 4% addition of Expansive Soil with zycobond can be considered. Finally from the above discussions, it is clear that there is improvement in the behaviour of Expansive soil stabilized with zycobond. It is evident that the addition of Zycobond to the virgin Expansive soil showed an improvement in Compaction and Strength characteristics to some extent. From the above results the 4% addition of Expansive Soil with zycobond can be considered and on further blending it with coir fibre with Different percentages from 0% to 2% with an increment of 0.5%.

Laboratory tests were done on the expansive soil and 4% addition of expansive soil and with percentage addition of coir fibre and the results are.

EFFECT OF FIBRE CONTENT ON EXPANSIVE SOIL WITH 4% ADDITION OF ZYCOBOND ON THE COMPACTION CHARACTERISTICS OF EXPANSIVE SOIL

The influence of coir fibre as a binder on the compaction characteristics of expansive soil is clearly presented in Figure. The percentage of coir fibre was varied from 0%, to 2% with an increment of 0.5%. From the above graphs, it was observed that the treatment as percentage addition of zycobond and coir fibre has moderately improved the expansive soil. It can be inferred from the graphs, that there is a increment in maximum dry density for the 1.5% addition of coir fibre to the 4% zycobond mixed expansive soil is about 4.86 %.

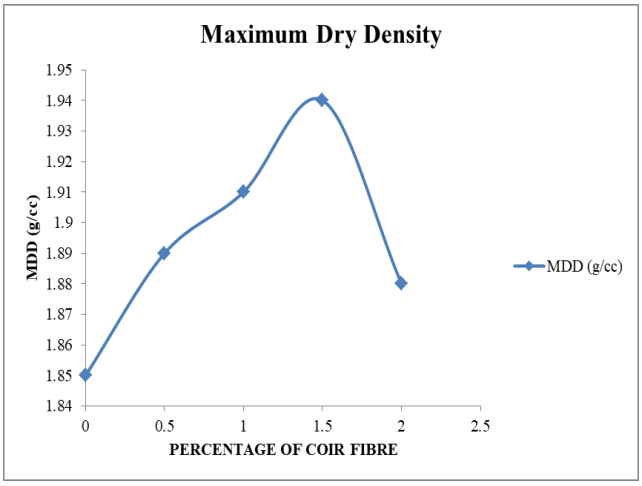

Fig 5.6: Variation of MDD with % addition of coir fibre

EFFECT OF COIR FIBRE CONTENT ON THE STRENGTH CHARACTERISTICS OF EXPANSIVE SOIL MIXED WITH 4% ZYCOBOND ON THE CBR AND UCS OF EXPANSIVE SOIL

The influence of coir fibre as a reinforcing material on the CBR and UCS of expansive soil are clearly presented in Figures. The percentage of coir fibre was varied from 0%, to

2% with an increment of 0.5%. From the above graphs, it was observed that the treatment as percentage addition of coir fibre to the zycobond mixed coexpansive soil with 1.5% has moderately improved the expansive soil and it was absorbed that for the addition of 1.5% coir fibre there is an increment of 11.8 % for CBR (US), 28.8 for CBR(S) and 32.18% for UCS on expansive soil.

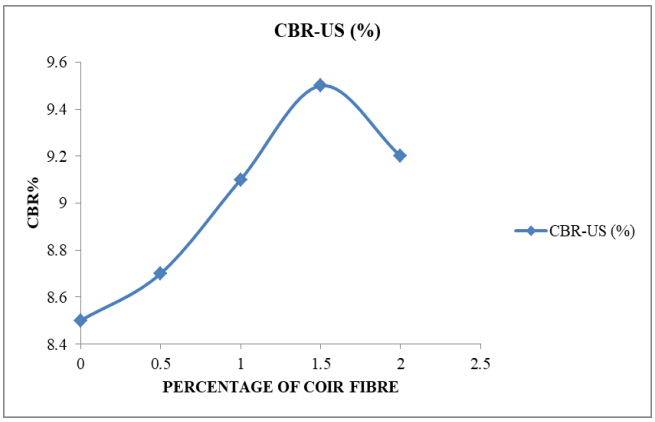

Fig 5.7: Variation of CBR unsoaked values with % addition of coir fibre

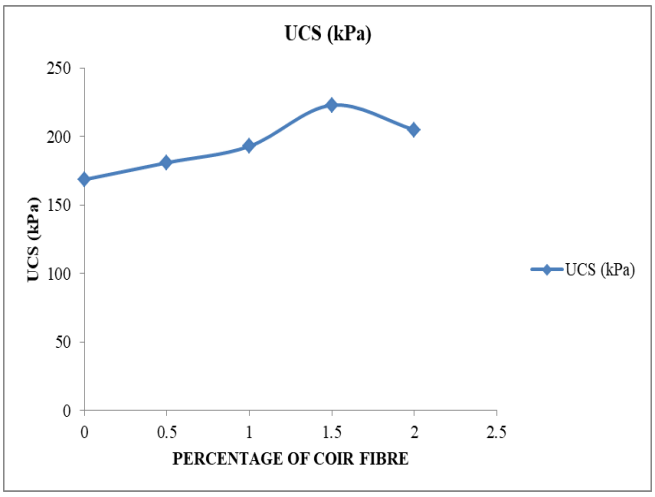

Fig 5.8: Variation of UCS with % addition of coir fibre

From the above discussions, it is clear that there is improvement in the behaviour of Expansive soil replaced with Zycobond and coir fibre . It is evident that the addition of coir fibre to the percentage addition of Zycobond to the virgin Expansive soil showed an improvement in Compaction and Strength characteristics to some extent. From the above results the Optimum Content of coir fibre with 4% Zycobond as addition of Expansive Soil is 1.5%.

VI. CONCLUSIONS

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.
- It was observed that the treatment as individually with 4% zycobond has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % addition of zycobond up to 4% with an improvement of about 1% and it was about 23.33% and further stabilized with coir fibre the strength characteristics increases about 4.86%.
- There is a gradual increase in CBR values with an increment in the % addition of Zycobond up to 5% with an improvement of about 1% and it was absorbed that for the addition of 4% there is an increment of 50% for CBR(S) and 147 % for UCS on expansive soil.
- Further blending with coir fibre an percentages of 0% to 2% with an increment of 0.5% there is a gradual increase in the dry density about 4.86% and there is a gradual increase in CBR values with an increment in the % addition of Zycobond and for 1.5% the CBR value increased to 11.8% for unsoaked and 28.8% for soaked CBR. There is an increment of 32.18 % for UCS on expansive soil for the addition of 1.5% coir fiber.

Finally it can be summarized that the materials zycobond had shown promising influence on the strength characteristics of expansive soil.

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