Laboratory Investigations To Address The Influence of Non- Conventional Additives on Expansive Soil Stabilization

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Abstract- *The infrastructure is a major part that enhances overall development of the Indian financial system. Fast emergent population needs new roads bigger cities and industrialization to produce source of revenue, stabilization of soil becomes necessary as it improves soil properties to withstand the loads from infrastructure one of the common approaches of subgrade stabilization is to remove the soft and replace it with a stronger material of crushed rock. The high cost of replacing has found forced highway agencies to evaluate alternative method for highway construction on soft subgrade. Pavement performance can be largely attributed to the performance of its foundation, which comprises of the subgrade and base layers. Base and subgrade layers must provide enough shear strength, stiffness modulus, resistance to moisture, stability, and durability. One of the main reason for the failure of pavement is due to lack of strength. Strength can be increased by adding additive materials to the sub-grade in different proportions. The work presented in this paper deals with the strength properties of natural and stabilized subgrade. In this research, Silica fume, Jute fibre and Zycobond are used as stabilizers in improving engineering properties of soil. The aim of this study is to evaluate the effect of different percentages of Silica fume, Jute fibre and Zycobond are used as stabilizers to improve the sub-grade characteristics of locally available soil.*

Keywords- clayey soil, Zycobond, Jute fibre, Silica fume, 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.

Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique foundation of a building or road is an essential part for effective transmission of load to the subsoil present beneath it. The quality of soil has large impact on type of structure and its design. They show alternate swelling and shrinkage properties. It expands during rainy season and shrinks during summer season. Expansive soil covers nearly 20% of the land mass in India. Therefore it is important to remove the existing weak soil and replaced it with a non-expansive soil or improves the properties of weak soil by stabilization.

Soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the

underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This project report deals with the complete analysis of the improvement of soil properties with Jute fibre and its stabilization using different materials like Silica fume and Zycobond.

1.2 OBJECTIVES OF THE STUDY

The study is focused on

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using different ratio of Silica fume, Zycobond and treated Jute Fibres
- Determination of appropriate soil, Silica fume, Zycobond content ratio to achieve the maximum gain in strength from the mixture..

II. LITERATUREREVIEW

2.1PREVIOUS RESEARCH PAPERS AND CONCLUSIONS

Practice of ursfnization and industrialization is so rampant these days. Though there is bountiful supply of soil, the cheapest construction material , it may exhibit some uncovered properties for intended construction purpose at .Such as construction on soft soil like clay appears to be difficult and it causes substantial distress to the overlying structure as it possesses low shear strength , high compressibility. The ‘shrink-swell’ behavior of clayey soil can endanger the construction work causing excessive settlement at the site. Again soil can be collapsible or liquefiable which are difficult to handle.

In search of the suitable site, interference with natural stability is not recommended. Extirpation or Destruction of forest and agrarian land, natural slope results in imsflance in wildlife, natural calamities like sudden flood (spate), land-slides etc. This is certainly minatorious to mankind and their survival. This problem needs serious attention.

Dayakar, Sree, Prasad and Madhurimanmadha, (2003) conducted laboratory investigation for stabilization of expansive soil using silica fume and tannery sludge with percentage of solid wastes varying from 0, 10, 20,30, 40, 50, 60- 70%. The addition of wastes did not improve the index properties and maximum dry density but there was gain in strength of the expansive soil with both tannery sludge and silica fume up to 15%.

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 content and also the cohesion and friction angle was increased at the optimum fibre content of 1.5%.

Singh, (October 2012) Soil reinforZycobond technique is one of the most popular techniques used for improvement of poor soils. Metal strips, synthetic geotextiles, geogrid sheets, natural geotextiles, randomly distributed, synthetic and natural fibres are being used as reinforcing materials to soil. Further, the soil reinforZycobond causes significant improvement in tensile strength, shear strength, other properties, bearing capacity as well as economy.

Jagdish Chand and AdityaAgarwal (Dec, 2013): discussed about the use of Silica fume and fly ash combination for the stabilization of highly compressible clay. Clay was stabilized by taking 5%, 10%, 15%, 20% and 25% of fly ash and Silica fume and effect of stabilization on index properties like shrinkage limit, plastic limit, liquid limit, and compaction were studied. A general decrease in shrinkage limit was observed when clay was stabilized using rice husk and fly ash. A large decrease in compression index and increase in stiffness was observed with increase in percentage of Silica fume and fly ash as stabilizer. It was also observed that OMC increase and MDD decrease using Silica fume while MDD increase and OMC decrease using fly ash. However, a general increase in shear strength was observed when soil was stabilized using Silica fume and fly ash.

Chibuikem C. Okoro ,JohnVongtman (2011): focused on the consolidation characteristics of two soils stabilized with Silica fume , lime and plastic waste. Three groups of specimens were prepared: the first group consisted of specimens prepared with 10% Silica fume and 6% lime and then cured for 28 days; the second set of specimens was prepared with recycled plastic waste with a plastic to soil ratio

(PSR) one; and the last group consisted of specimens prepared with raw soils and compacted at near optimum moisture content and maximum dry unit weight. The last group was considered a sfseline to assess the effect of SF, lime and plastic waste on the consolidation characteristics. Results showed that SF, lime and plastic waste stabilization reduced the compressibility of soil. In addition, both the compression index (Cc) and swelling index (Cs) decreased due to SF, lime and plastic waste stabilization. The percentage changes in Cc and Cs varied with the type of stabilizing agents.

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 swell Index (%)	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)	1.45
	ii) Optimum Moisture Content (%)	27.5
8	Penetration Parameters	
	i) CBR - Soaked (%)	2.68
	ii) CBR -UnSoaked (%)	4.1
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

3.3Jute fibre

Jute geo textile abbreviated as JGT has come out as the best as well as strong alternative to synthetic geo textiles. Jute geotextile fabric is widely used for varied civil engineering applications like separation, drainage and filtration over synthetic one. Jute geo textile is available with inherent advantage of being designed from natural fibre that is completely biodegradable. Jute is an organic fibre that brings eco friendly nature to the textile. A user can easily discard them by decomposing them without any pollution.

Today, jute geo textile fabric is available in two different varieties, one is woven and other is non-woven fabric. Both the varieties are reckoned for high moisture absorption capacity. Their flexibility and excellent drainage

properties are the reason behind their usage in agricultural sector to conserve soil erosion. Their long life span makes them perfect to be used in those sectors that required long-term applications. Due to their high durability and long life performance, they are in huge demand to be used as separator, vegetation growing mesh, vertical drains, etc.

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 marineclay.

- 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 replacing different percentages of Silica fume and Zycobond in the Expansive soil and also further stabilizing it with treated Jute fibres. Liquid Limit, Plastic Limit and Compaction, CBR and UCS tests were conducted with a view to determine the optimum combination of Silica fume and as addition in weak Expansive soil and Zycobond as a binder and CBR and UCS are conducted for durability studies.

The influence of the above said materials on the Index, Compaction and Strength properties 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, and strength behaviour. Experimental Investigations have been carried out on expansive soil with the addition of varying percentages of Zycobond and jute fiber. 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.

5.2 EFFECT OF ZYCOBOND ON THE PROPERTIES OF EXPANSIVE SOIL

The individual influence of Zycobond on the Properties of expansive soil is clearly presented in tables and Figures. The percentage of Zycobond was varied from 0%, to 8% with an increment of 2%. From the above graphs, it was observed that the swelling behaviour of Expansive is decreasing for the percentage addition of Zycobond from 0 to 8%.

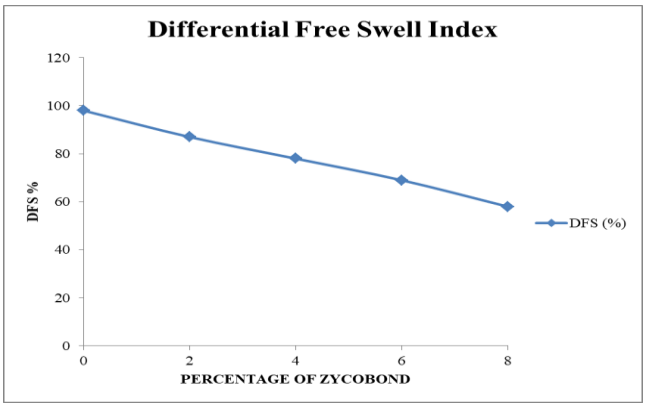

Fig 5.1: Variation of DFS with percentages of zycobond

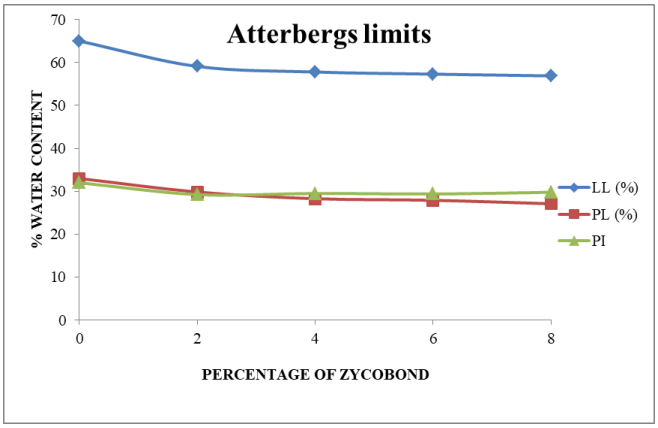

Fig 5.2: Variation of Atterberg Limits with different percentages of zycobond

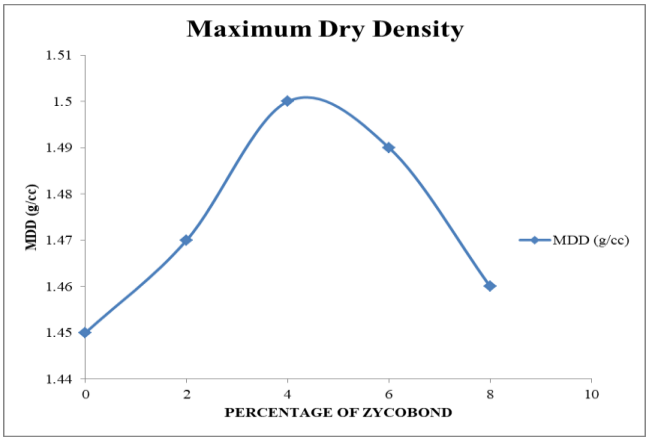

Fig 5.3: Variation of MDD with different percentages of zycobond

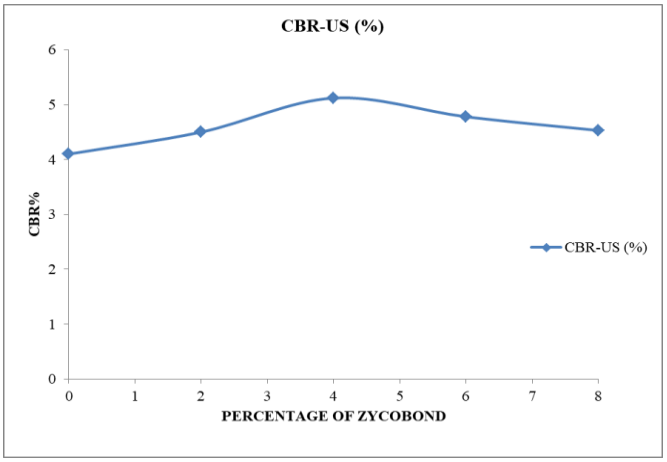

Fig 5.6: Variation of CBR with different percentages of zycobond

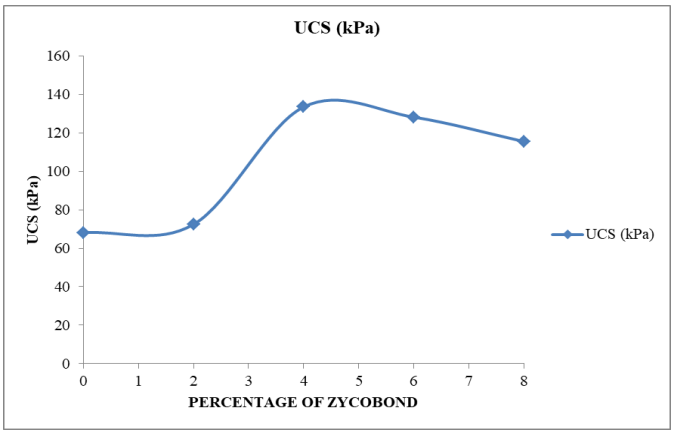

Fig 5.7: Variation of UCS with different percentages of zycobond

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.

Table 5.1: Evaluating the Optimum Content of Silica fume Content with 4% zycobond

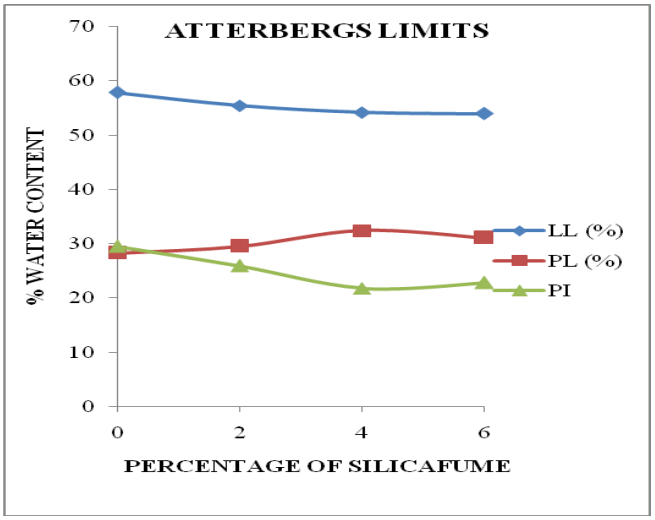

Fig 5.8: Variation of Atterberg Limits with different percentages of Silica fume

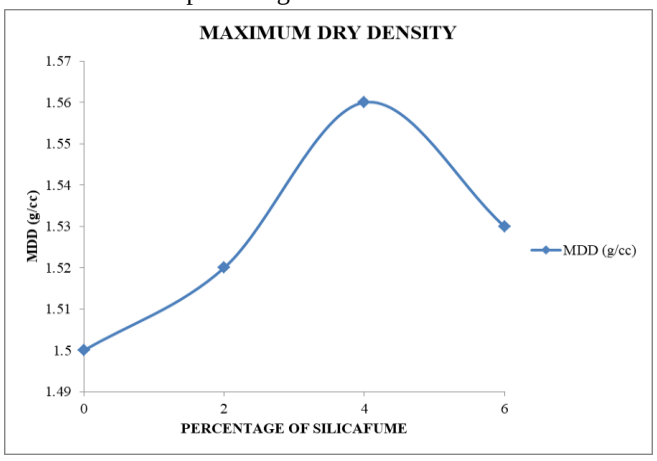

Fig 5.9: Variation of maximum dry density with different percentages of Silica fume

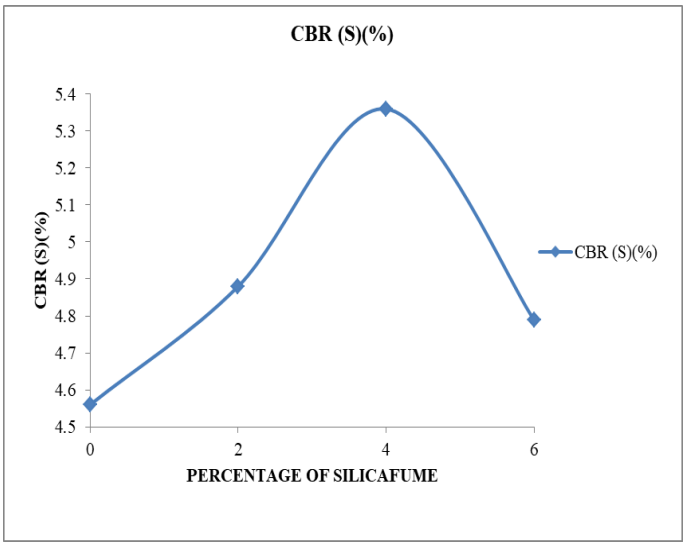

Fig 5.10 Variation of CBR Soaked with different percentages of Silica fume

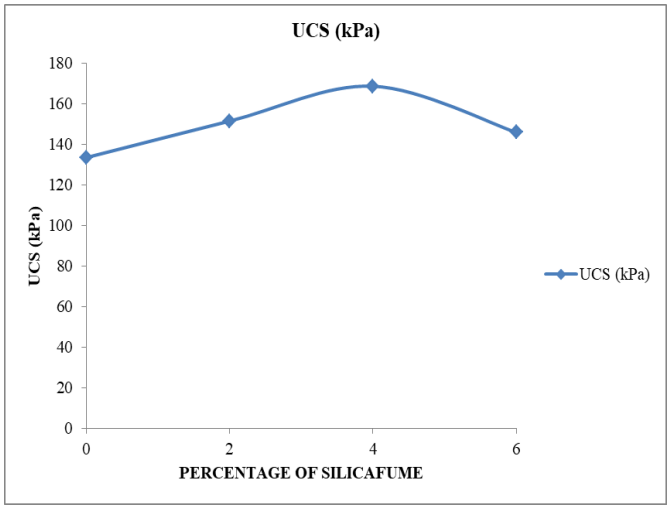

Fig 5.11: Variation of UCS with different percentages of Silica fume

From the above results the 4% addition of Expansive Soil with zycobond and silica fume can be considered. Finally from the above discussions, it is clear that there is improvement in the behaviour of Expansive soil stabilized with silica fume and zycobond. It is evident that the addition of silica fume and 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 and silica fume can be considered.

5.3EFFECT OF FIBRE CONTENT ON EXPANSIVE SOIL WITH 4% ADDITION OF ZYCOBOND AND 4% OF SILICA FUME ON THE STRENGTH CHARACTERISTICS OF EXPANSIVE SOIL

The influence of jute fibre as a reinforcing material on the properties of expansive soil is clearly presented in table and Figures. The percentage of jute fibre was varied from 0%, to 3% with an increment of 1%. From the above graphs, it was observed that the treatment as percentage addition of jute fibre to the zycobond and silica fume mixed expansive soil with 2% has moderately improved the expansive soil.

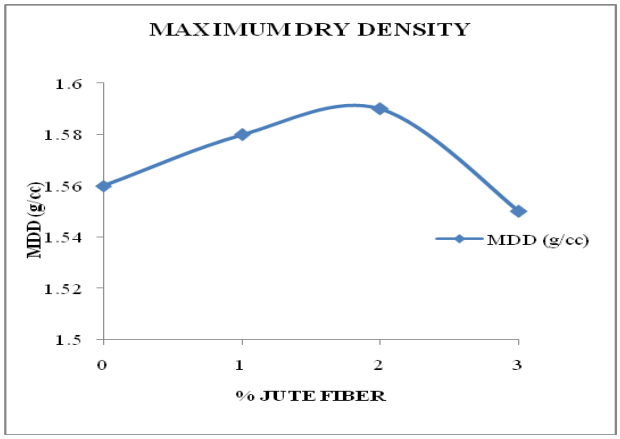

Fig 5.12: Variation of MDD with different percentages of Jute fiber

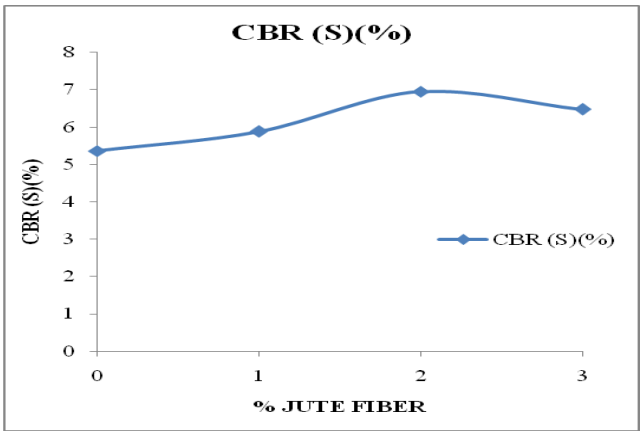

Fig 5.13: Variation of CBR soaked with different percentages of Jute fiber

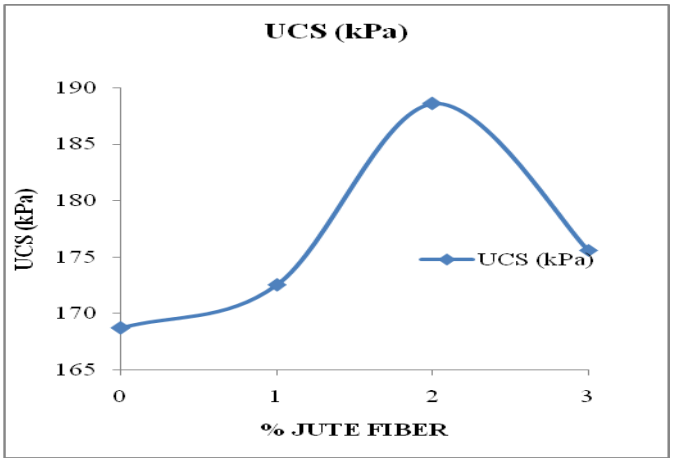

Fig 5.14: Variation of UCS with different percentages of Jute fiber

From the above discussions, it is clear that there is improvement in the behaviour of Expansive soil replaced with Silica fume and addition of Zycobond and jute fibre. It is evident that the addition of jute 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 Jute fibre with 4% Zycobond as addition of Expansive Soil is 3%.

VI. CONCLUSIONS

The following conclusions are made based on the laboratory In this chapter the summary of the work carried out is presented along with the conclusions drawn from the laboratory study. 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 3.45% and further stabilized with silica fume the strength characteristics increases about 7.58%.
- There is a gradual increase in CBR values with an increment in the % addition of Zycobond up to 4% with an improvement of about 2% and it was absorbed that for the addition of 4% there is an increment of 70% for CBR(S) and 96 % for UCS on expansive soil.
- Further blending with silica fume with an percentages of 0% to 6% with an increment of 2% there is a gradual increase in CBR values and for 4% silica fume the CBR value increased to 6.53% for unsoaked and 5.36% for soaked CBR. There is an increment of 4.79 % for UCS on expansive soil for the addition of 4% silica fume.
- There is an improvement in Strength characteristics with an increase in the jute fibre from 0% to 3% with an improvement of 1%. There is an improvement in properties for 2% of Jute fiber.
- It is evident that the addition of zycobond and silica fume to the virgin Expansive soil showed an improvement in properties to some extent and on further addition of jute fibre, the improvement was more pronounced. Thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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