A Study on The Strength Enhancement of Soft Soils Using Polymeric Stabliser Lignosulfonate

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Abstract- *Many structures constructed on soft soils faces a risk of failure due to excessive settlement and insufficient strength. Soft soils are typically replaced by some other strong materials like cementing material for better engineering properties. Increase in population has increased the demand for land. Ground improvement becomes necessary at sites, where the soil available is weak. Researchers have been carried out to modify the clayey soil by Industrial waste and agricultural waste for stabilizing the clayey soils. The lignosulfonate mainly comprises of positive ions and these reacts with the negative ions present in clay minerals to form stable aggregates by reducing the double layer thickness of clay particles. The variation in atterberg limits and strength parameters were studied with the addition of various percentages of lignosulfonate 0, 2, 4, 6 and 8%. The soil samples in natural state and when mixed with varying percentages of lignosulfonate were used for the laboratory tests that included atterberg limits tests, grain size analysis, standard Proctor compaction tests and shear strength tests.*

Keywords- clayey soil, lignosulfonate, Lime, standard Proctor compaction test, California bearing ratio.

I. INTRODUCTION

Expansive soils are highly problematic and cause severe damage to the structures founded in them because of their potential to react to changes in moisture regime. Nowadays, the development of constructions projects in India is rapidly increasing. However, the development of construction projects has to be followed by the development of the quality of the building. 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 soft 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.

Stabilization of expansive soils is an alternative for geotechnical engineers considering the economics of construction with expansive clay soils. Mechanical stabilization, such as compaction, is an option; however many engineers have found it necessary to alter the physicochemical properties of clay soils in order to permanently stabilize them.

1.2 OBJECTIVES OF THE STUDY

The objective of the present work is to study the experimental programme undertaken to investigate the strength of soft soils using polymeric stabilizer lignosulfonate

- In view of the current understanding and the incomplete research to date, this study was conducted to determine the stabilization mechanism and performance of the coastal soft soil mixed with additives. Hence, the following objectives had been established to achieve the aim of the research:
- The objectives of present experimental study are to develop correlations between engineering characteristics of coastal sandy soils. 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 materials like lime and lignosulfonate.

- Determination of appropriate lime and lignosulfonate content ratio to achieve the maximum gain in strength of soil.

II. LITERATUREREVIEW

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 soil using different types of admixture at different percentages. A brief review of previous studies on residual soil is presented in this section and past efforts most closely related to the needs of present work.

Bhasin et al. (1988) had studied the stabilizing of black cotton soil as a pavement material using rice husk ash, along with other industrial wastes like lime sludge, black sulphite liquor independently with and without lime, fly ash and bagasse ash,. The rice husk ash causes greater improvement than that caused by other wastes due to presence of higher percentage of reactive silica in it. In combination with lime, rice husk ash improved the properties of black cotton soil significantly.

Muntohar and Hantoro (2000) made a laboratory study on the stabilization effects of rice husk ash and lime on engineering properties of black cotton soil and had found improvement in engineering properties like index properties, California bearing ratio and shear strength parameters.

Basha et al. (2003) had studied the effects of rice husk ash and cement on plasticity and compaction properties of black cotton soil and had recommended that 10-15% of rice husk ash and 6-8% of cement as optimum percentages for stabilization.

Ramakrishna and Pradeep Kumar (2006) had studied combined effects of rice husk ash and cement on engineering properties of expansive soil. From strength characteristics point of view they had recommended 8% cement and 10% rice husk ash as optimum dose for stabilization.

Sharma et al. (2008) had investigated the behavior of black cotton soil stabilized with lime, calcium chloride and rice husk ash. The optimum percentage of lime and calcium chloride was found to be 4% and 1% respectively in stabilization of expansive soil without addition of rice husk ash. From unconfined compressive strength and California bearing ratio point of view when the soil was mixed with lime or calcium chloride, rice husk ash content of 12% was found to be the optimum. In expansive soil – rice husk ash mixes, 4% lime and 1% calcium chloride were also found to be optimum.

Rao et al. (2011) had studied the effects of rice husk ash, lime and gypsum on engineering properties of black cotton soil and found that unconfined compressive strength increased by 548% at 28 days of curing and California bearing ratio increased by 1350% at 14 days curing at rice husk ash-20%, lime -5% and gypsum -3%.

Sabat (2013) made a laboratory study on lime sludge on compaction, California bearing ratio, shear strength parameters, coefficient of compression, Ps and durability of an black cotton soil stabilized with optimum percentage of rice husk ash after 7days of curing. The optimum proportion soil: rice husk ash: lime sludge was found to be 75:10:15.

Ashango and Patra (2014) made a laboratory study on static and cyclic properties of clay subgrade stabilized with rice husk ash and Portland slag cement. The optimum percentage of rice husk ash was found to be 10% and Portland slag cement as 7.5% for stabilization of expansive soil. They concluded that the stabilized expansive soil was found suitable for subgrade of flexible pavement as, there was significant increase in strength and the stabilized soil was durable.

Jairaj and Prathap Kumar (2015), studied the effect of length of coir fiber on the strength of black cotton soil treated with lime. It was concluded that increase in length of fiber increases peak deviator stress for a given percentage of fiber content. However, when the length of fiber exceeds 20mm, there is marginal reduction in peak deviator stress. Singh and Mittal (2014) conducted an experimental study on clayey soil mixed with coir fibers in varying percentage. The test results indicate that both unsoaked and soaked values of CBR of soil increase with the increase in fiber content.

2.1 STABILIZATION

Soil stabilization may be defined as a modification of an existing soil so as to improve its bearing or load absorbing characteristics. Such an effect may be accomplished by mechanical consolidation (compaction) or by the incorporation within the soil of certain additives which would provide the desired qualities of permanent stability. Ever since the beginning of road building, it has been recognized that some soils were extremely unstable, particularly in the presence of moisture, and that other soils were stable and would support traffic with less deformation.

METHODS OF SOIL STABILIZATION

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

III. METHODOLOGY

The overall flow of research is as illustrated in the given below table. The tests were conducted in accordance with Indian standard. Several physical tests had been conducted for clay sample, lime sample and mixes of clay, lime and lignosulfonate. The tests mentioned were Atterberg Limits test, Specific Gravity test, Sieve analysis, Compaction, CBR and unconfined compressive strength test. In Atterberg Limit tests, Liquid Limit (LL) and Plastic Limit (PL) were obtained. Then, Plasticity Index was determined based on Plasticity chart. The Liquid limit of clay, lime and lignosulfonate mixes is obtained by testing varies of percentages.

MATERIALS USED AND THEIR PROPERTIES

3.1 SOIL

The soil used was a typical black cotton soil collected from the soil used was a typical black cotton soil collected from Appaniramuni Lanka, Near Dindi village, SakhinetipalliMandal, 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.

Table 5.1 Proprieties of Expansive clay

S. NO.	PROPERTY	VALUE
1	Specific gravity	2.66
2	Differential free swell Index (%)	105
3	Atterberg's Limits	
	i) Liquid limit (%)	70.5
	ii) Plastic limit (%)	26.9
	iii) Plasticity index (%)	43.6
5	Grain Size Distribution	
	i) Sand Size Particles (%)	13
	ii) Silt & Clay Size Particles (%)	87
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.41
	ii) Optimum Moisture Content (%)	28.2
8	Penetration Parameters	
	i) CBR - Soaked (%)	1.7
9	Unconfined compressive strength (kPa)	80

3.2 Lignosulfonate

Lignosulfonate is a lignin based polymeric stabilizer derived as a waste by- product from wood or paper industry. It consists of both hydrophilic groups including sulfonate, phenyl hydroxyl and alcoholic hydroxyl and hydrophobic groups including carbon chain. Lignosulfonate has shown a promising prospect as a stabilizing agent especially for soft soils.

The main advantages of lignosulfonate over traditional stabilisers are non-toxicity and noncorrosiveness. Stabilisation mechanism of traditional stabilizer such as lime includes cation exchange, flocculation, agglomeration, lime carbonation and pozzolanic reaction resulting in stable soil mass. The lignosulfonate mainly comprises of positive ions and these reacts with the negative ions present in clay minerals to form stable aggregates by reducing the double layer thickness of clay particles.

Lignosulfonate has shown a promising prospect as a stabilizing agent especially for soft soils. It belongs to a family of lignin based organic polymers derived as a waste by-product from the wood and paper processing industry. It is an environmental friendly, non-corrosive and non-toxic chemical that does not alter the soil pH upon treatment.

Table 3.2Chemical properties of Lignosulfonate

Name	Description
Appearance	Yellow brown powder
PH value	5 to 7
Dry matters	95% min
Water insoluble	2.50%
Sulphate	2% min
Total Calcium magnesium (sulfate)	5% - 6%
Lignosulphonate	50% min
Sugar	10 - 12%
Reducing sugar	7% around
Ash	18% - 21%
Bulk Density (kg/m3)	205
Moisture	7%

3.3 Lime

The commercial Birla lime taken from market for the purpose of stabilizing soil, which imparts cementing property to the soil mix.

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 sizedistribution

- Specificgravity
- Index properties –liquid limit, plasticlimit
- Compaction tests
- Penetration tests-California bearing ratiotest.
- Unconfined CompressionTest-Triaxial

V. RESULTS AND DISCUSSIONS

5.1GENERAL

In the laboratory, various experiments were conducted by replacing different percentages of Lignosulfonate and Lime in the Expansive clay. Liquid Limit, Plastic Limit and Compaction, California bearing ratio and unconfined compressive strength tests were conducted with a view to determine the optimum combination of Lignosulfonate and as addition in weak Expansive clay and Lime as a binder and California bearing ratio 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.

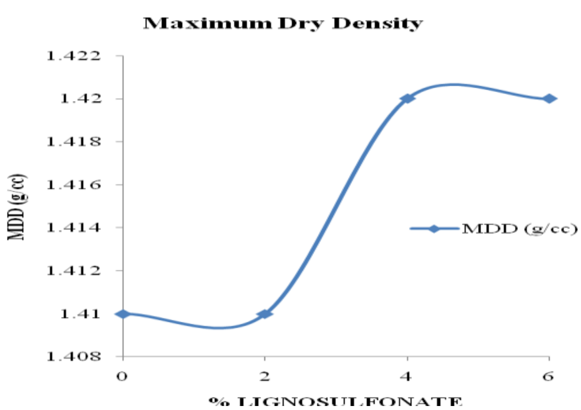

Fig 5.1 Plot showing the variation in MDD with % addition of lignosulfonate to 0 % lime

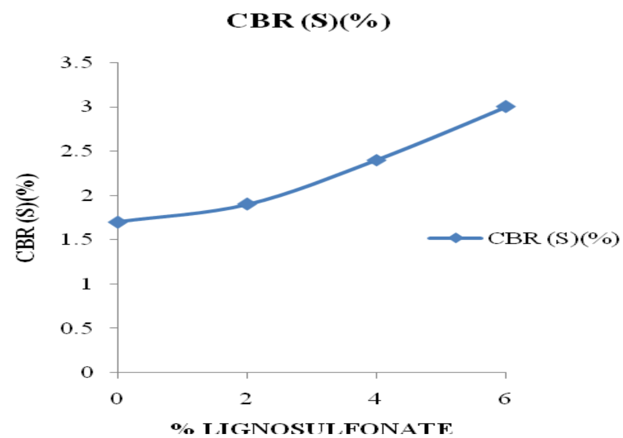

Fig 5.2 Plot showing the variation in CBR with % addition of lignosulfonate to 0 % lime

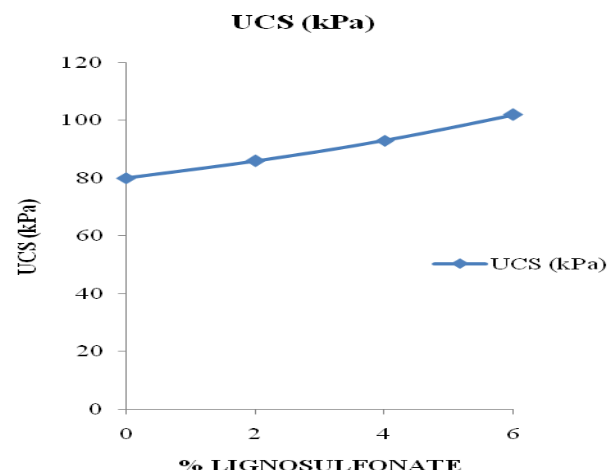

Fig 5.3 Plot showing the variation in UCS with % addition of lignosulfonate to 0 % lime

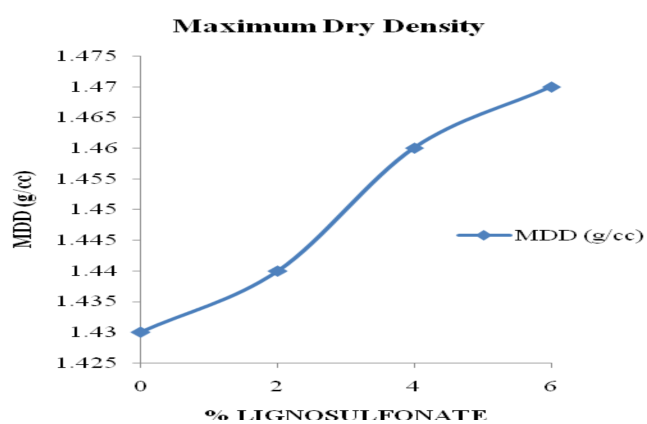

Fig 5.4 Plot showing the variation in MDD with % addition of lignosulfonate to 2 % lime

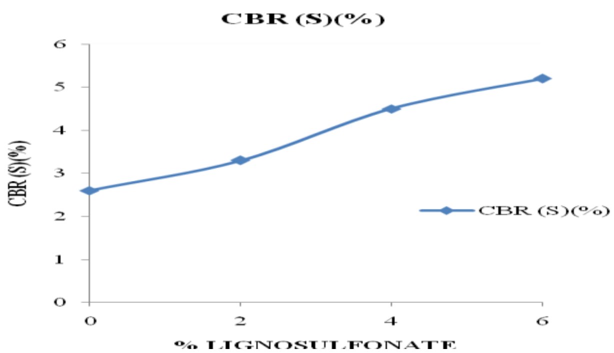

Fig 5.5 Plot showing the variation in CBR with % addition of lignosulfonate to 2 % lime

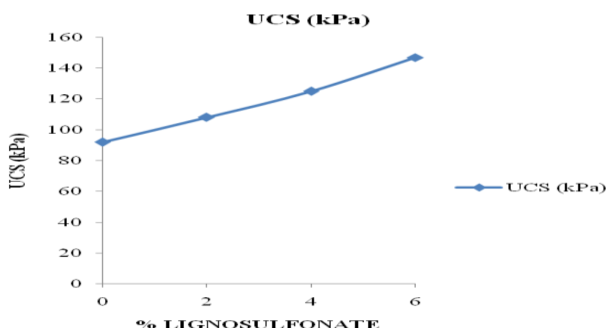

Fig 5.6 Plot showing the variation in UCS with % addition of lignosulfonate to 2 % lime

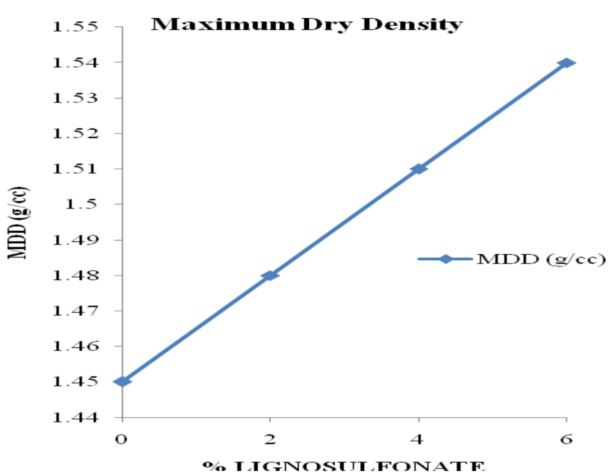

Fig 5.7 Plot showing the Variation in MDD with % addition of lignosulfonate to 4 % lime

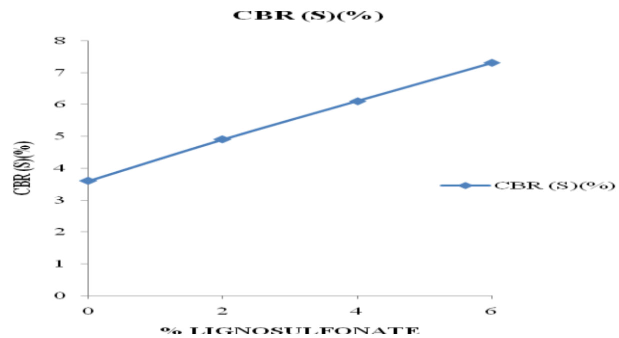

Fig 5.8 Plot showing the Variation in CBR with % addition of lignosulfonate to 4 % lime

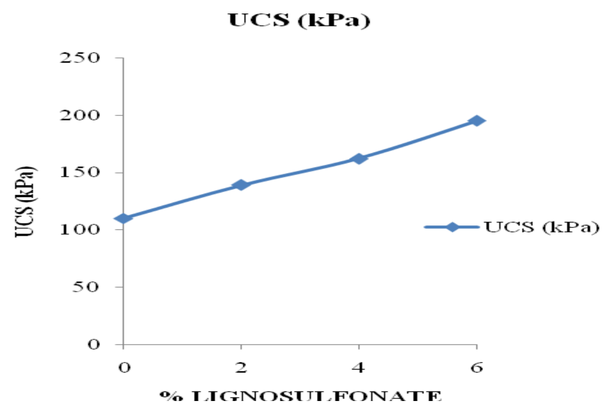

Fig 5.9 Plot showing the Variation in UCS with % addition of lignosulfonate to 4 % lime

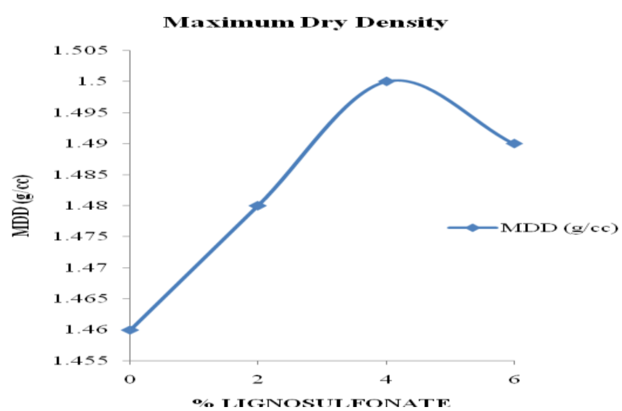

Fig 5.10 Plot showing the Variation in MDD with % addition of lignosulfonate to 6 % lime

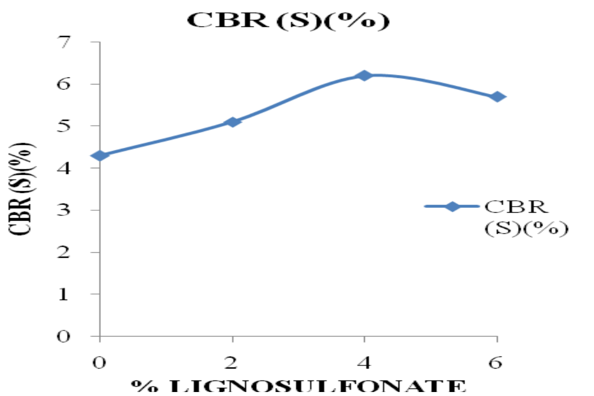

Fig 5.11 Plot showing the Variation in CBR with % addition of lignosulfonate to 6 % lime

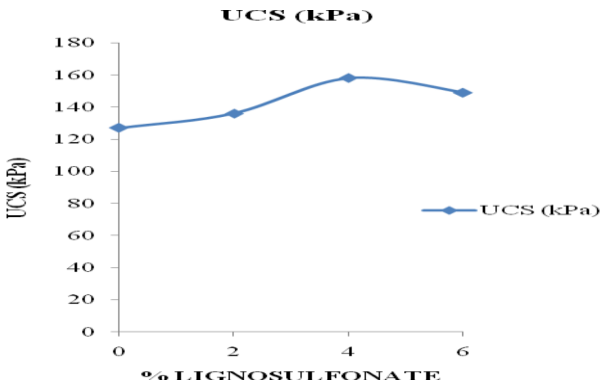

Fig 5.12 Plot showing the Variation in UCS with % addition of lignosulfonate to 6 % lime

IT CAN BE INFERRED FROM THE ABOVE RESULTS FROM THE ABOVE RESULTS, **6% LIME + 4% LIGNOSULFONATE** CAN BE CONSIDERED AS OPTIMUM COMBINATION AS ADDITIVES IN IMPROVING THE VARIOUS PROPERTIES OF PROBLEMATIC EXPANSIVE CLAY.

VI. CONCLUSIONS

The following conclusions are made based on the laboratory experiments as per the tests conducted based on IS 2720, the results are concluded as

- From the laboratory studies, it is observed that the soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- The lime and lignosulphonate additive has an adverse effect on the property of soil indices by increasing Liquid limit and Plasticity index which implied by the increasing clay content.
- Lime and lignosulphonate treated soils reduces the plasticity of the virgin soils. It can be inferred from the graphs, the treatment as combination with 4% lignosulfonate + 6% lime has moderately improved the soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index improvement of about 42%.
- Influence of lime and lignosulphonate on density and compaction, test results shows that the taken materials increases the compacted dry density and decreases the optimum moisture content of soft soils. Maximum dry density is improved by an amount of 7% and it was about 97% for UCS and 264% for Soaked CBR respectively.
- Finally it can be summarized that the materials Lignosulfonate and Lime had shown promising influence on the properties of Weak soils, thereby giving a two-fold advantage in improving problematic clay and also solving a problem of waste disposal.

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