Stabilisation of Clayey Soil by using Lignosulfonate

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Abstract *- Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Ground improvement is a rapidly developing field because good sites for construction are becoming limited day by day. Researches are always finding innovative methods for ground improvement using sustainable and environmental friendly materials. Lignosulfonate is a lignin based polymeric stabilizer derived as a waste by-product from the wood/paper industry. Lignosulfonate has shown a promising prospect as a stabilizing agent especially for soft soils. It is an environmental friendly, non-corrosive and non-toxic chemical that does not alter the soil pH upon treatment. This paper reviews the results of investigations on the effect of adding lignosulfonates on geotechnical properties of soil such as compaction characteristics, U.C.C, C B R,Atterberg limits. Test results indicated that the stabilization of soil with lignosulfonate has the potential to be used in the pavement industry.*

Keywords *- Lignosulfonate, Stabilization, compaction, UCC value, Atterberg Limits.*

I. Introduction

Ground improvement is a rapidly developing field because good sites for construction are becoming limited day by day. The main objective of the ground improvement is to improve the characteristics of soil at the site. Now the researchers have focussed more on the use of potentially cost effective and locally available materials from industrial and agricultural waste so as to improve the properties of deficient soils and also to minimize the cost of construction.

Increase in population has increased the demand for land. Ground improvement becomes necessary at sites, where the soil available is weak. Researches have been carried out to utilize the industrial and agricultural wastes to stabilize the soils. Since, the dumping of these wastes creates a serious problem in the environment. The disposal of these wastes also affects the environment. By utilizing these wastes as a stabilizer for soil, it improves the ground as well as reduces the pollution in the environment.

Many studies have been conducted around the world to understand the changes in the various properties of the soil due to the addition of different materials to the soil. This paper reviews the results of investigations on the effect of adding lignosulfonates on geotechnical properties of soil such as compaction characteristics, and U.C.C.

II. LITERATURE REVIEW

[3]Susan et al. (2017) studied on marine clay replaced with sodium lignosulfonate and cement. Marine clay is identified as the one with high organic content and as an expansive soil which shrinks and expands rapidly causing damage to foundations. This paper presented the modification of modulus of elasticity in terms of E/qu with strain for marine clay stabilized with sodium lignosulfonate and it is compared with cement treated clay. It was observed that for an optimum percentage of lignosulfonate (5%) there has been significant increase in unconfined compressive strength. The variation of E/qu with strain showed that the failure strain of lignosulfonate treated soil is more than that of cement treated clay and thus makes it less brittle. Traditional admixtures such as cement and lime are found to cause brittle nature in soil and also induce toxicity to the soil to a level that vegetation on the land is affected. The usage of lignosulfonate has found to be a solution to this problem.

Bahram and Noorzad (2017) done stabilization of clayey soil by adding lignosulfonates. Several basic properties of high plasticity clay, such as Atterberg limits, proctor compaction, unconfined compressive strength (UCS), effect of cyclic wetting/drying on the strength properties, stress-strain behavior and secant modulus of elasticity (E50) were assessed. The LS contents were 0.5, 0.75, 1, 2, 3 and 4% by weight of the dry soil and specimens were cured for 0, 4, 7, 14, and 28 days. Results showed that the LS treatment leads to a considerable reduction in plasticity index (PI) of the soil. Also, stabilization with LS has slightly increased the optimum water content and slightly decreased the maximum dry unit weight of the soil. This stabilization has increased the stiffness and UCS of the soil without leading to a considerable brittle behavior. The increase in strength properties is ascribed to the electrostatic reaction that occurs between the mixture of LS-water and soil particles.

[6]Mahamud et al. (2012) studied the results of Unconfined Compressive Strength tests (UCS) carried out on clay soils stabilized with Lignosulfonate (LS). Laboratory studies

indicate that lignosulfonate can increase the stiffness of the treated soils. Moreover, the influence of clay minerals on the LS stablisation is investigated using Fourier Transform Infrared (FTIR) Spectroscopy and Electrical Conductivity (EC). The analysis confirms that the clay mineralogy plays an important role in the stabilization of clay soils. The stabilization mechanism is mainly due to the formation of lignosulfonate-clay amorphous compounds through the electrostatic reaction process.

[4]Konnur et al. (2017) study conducted to check the performance by individual (i.e. parent soil) and combinations of both chemical and Pond Ash with soil. It was expected that, the combination of soil with Pond Ash and Sodium Lignosulphonate may improves Engineering Properties (by means of strength) with respect to parent soil. Black cotton soil is stabilized with the Pond Ash and Sodium Lignosulphonate. The quantities of Pond Ash and Sodium Lignosulphonate contents are varied gradually as 6%, 12%, 18%, 24% and 1%, 2%, 3%, 4% respectively by weight of total mix. Optimum quantity of Pond Ash is determined. Optimum amount of Pond Ash is kept constant and percentage of chemical is varied to study the properties of soil such as Consistency limits, MDD.

[5]Alazigha et al. (2015) done an experimental investigation involved a laboratory evaluation of the efficacy of LS admixture in controlling the swell potential of a remoulded expansive soil. The swell potential was examined in terms of percent swell and swell pressure of the soil. In addition to these engineering properties, the Atterberg limits, unconfined compressive strength, durability (wet/dry and freeze/thaw), compaction characteristics, permeability, consolidation characteristics, and shrinkage behaviours were also investigated. Furthermore, the mechanism by which the remoulded soil was modified or altered by the LS admixture was probed and identified. The optimum content of LS admixture was found to be about 2% by dry weight of the soil. Standard geotechnical laboratory tests performed on untreated and treated compacted soil specimens showed significant and consistent changes in the swell potential and other engineering properties such that the percent swell decreased by 22% while maintaining the soil's pH. In some instances, identical specimens treated with 2% cement were prepared and tested for comparison. Although the specimens treated with cement recorded a 33% reduction in the percent swell, the ductile characteristics were replaced by brittleness and a significant increase in pH.

III. MATERIALS

A. Kaolinite clay

In this analysis, kaolinite clay is collected from Thonnakkal, Thiruvananthapuram district in Kerala. The soil sample is shown in the figure 1 taken for stabilization

Fig 1 Kaolinite clay

The property of the kaolinite clay is shown in Table 1.

Table 1 Natural Properties of Kaolinite Clay

SOIL PROPERTY	OBTAINED VALUE
Specific gravity	2.67
UCS Strength (kg/cm2)	0.634 kg/cm2
Liquid limit (IS 2720 part 51985)	33%
Plastic limit (IS 2720 part 51985)	20.66%
Plasticity index (IS 2720 part 51985)	12.34%
Shrinkage limit (IS 2720 part 51985)	19.06%
Optimum moisture content (IS 2720 part 7)	24.5%
Maximum dry density (IS 2720 part 7)	1.65g/cc
Percentage of clay (IS 2720 part 4)	68%
Percentage of silt (IS 2720 part 4)	24.8%
Percentage of sand (IS 2720 part 4)	7.2%
IS classification	CL

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The hydrometer analysis is carried out to determine the particle size distribution of clay as per IS 2720 part IV is shown in figure 2.

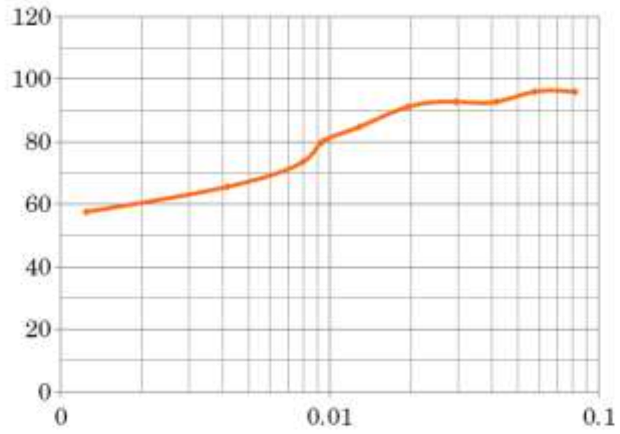

Fig 2 Particle size distribution of Kaolinite Clay

The plasticity chart for kaolinite clay is plotted as per IS 2720 part 51985 is shown in figure 3.

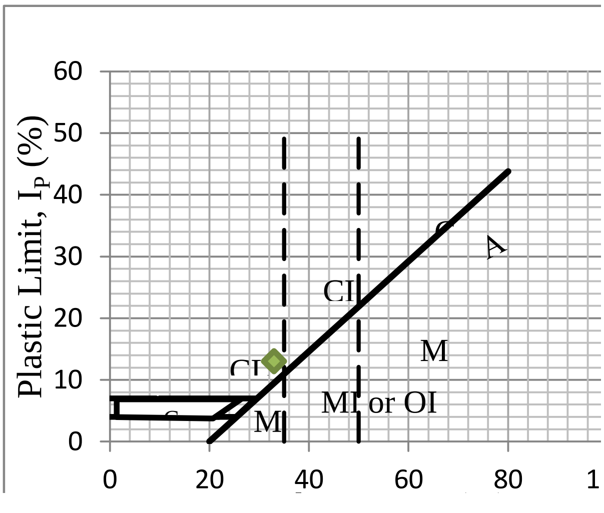

Fig 3 Plasticity chart of Kaolinite Clay

B. *Lignosulfonate*

Lignosulfonate (figure 4) is a lignin based polymeric stabilizer derived as a waste by- product from wood/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.

Fig 4 Lignosulfonate

a) The main advantages of lignosulfonate over traditional stabilisers are non-toxicity and non-corrosiveness. 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.

IV. Methodology

A. *COMPACTION TEST*

The test to determine the optimum moisture content and maximum dry density were done using standard proctor test according to IS 2720. 1980 (part VIII). The variation in optimum moisture content and maximum dry density was studied with the addition of various percentages of lignosulfonates (1, 2, 3, 4, 5, 6%).

B. *UNCONFINED COMPRESSIVE STRENGTH*

The unconfined compressive strength tests are conducted on kaolinite clay as per IS 2720 part 10 (1973). All the samples are prepared by static compaction using split mould at optimum moisture content and maximum dry density to maintain same initial dry density and water content.

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The compaction results shows, by the addition of lignosufonate OMC decreases and maximum dry density increases from zero to four percentage and then decreases. So the optimum dosage of lignosulfonate was obtained as 4%. The variation of OMC and maximum dry density is shown in figure 5 and figure 6.

The shear strength of soil increases by the addition of lignosulfonates. The optimum value of lignosulfonate is 4%. The variation of shear strength with the addition of lignosulfonate is shown in figure 7.

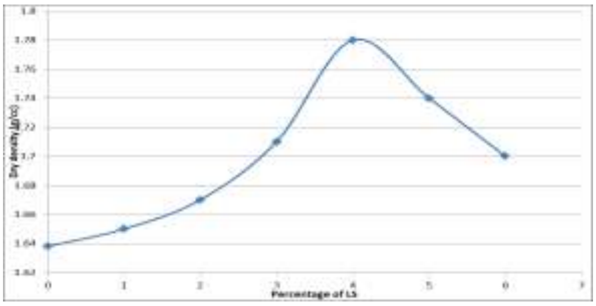

Fig 5 Variation of dry density with the addition of lignosulfonate

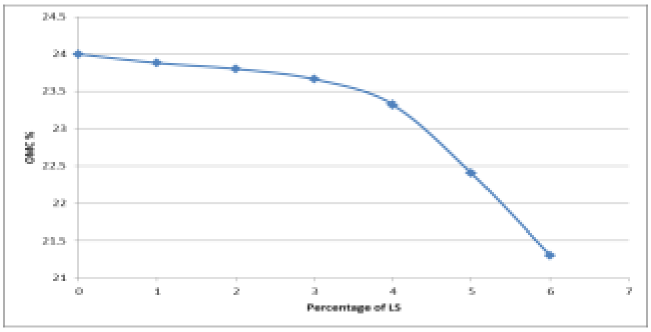

Fig 6 Variation of OMC with the addition of lignosulfonate

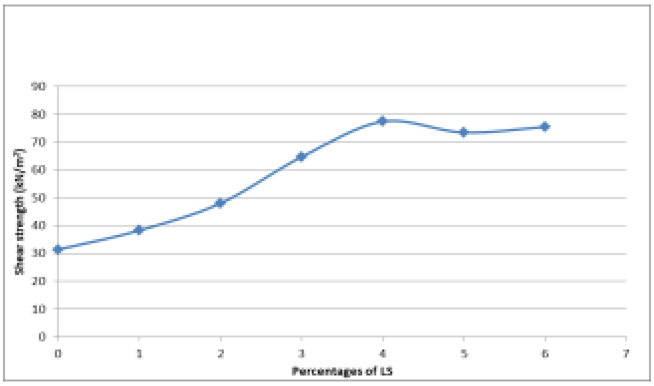

Fig 7 Variation of shear strength with the addition of lignosulfonate

C. **ATTERBERG LIMITS**

The results discussed in this section are the test results for the soil samples for liquid limit tests, plastic limit tests.

The variation of liquid limit and plastic limit is shown in figure 8 and figure 9. The liquid limit decreases with the addition of varying percentage of lignosulfonate. The plastic limit of soil increases with the addition of Lignosulfonate.

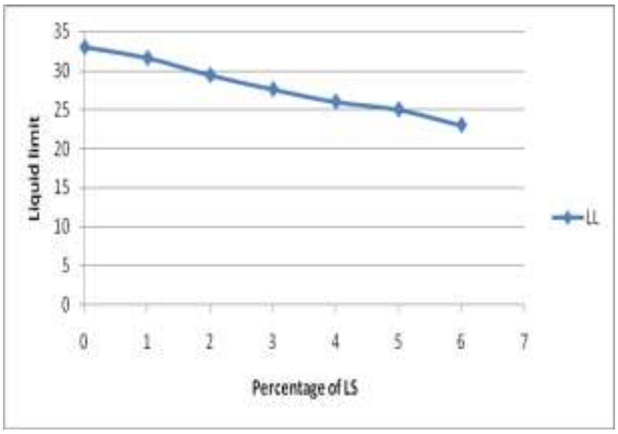

Fig 8 Variation of Liquid limit with the addition of lignosulfonate

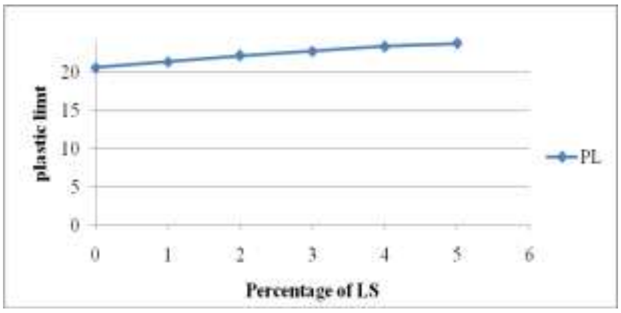

Fig 9 Variation of Plastic limit with the addition of lignosulfonate

V. CONCLUSIONS

- ✓ The geotechnical properties of the kaolinite clay were studied.
- ✓ The optimum moisture content decreases with the addition of lignosulfonate.
- ✓ The maximum dry density increases with the addition of lignosulfonate.
- ✓ The shear strength increases with the addition of lignosulfonate.

- ✓ The liquid limit decreases with the addition of lignosulfonate.
- ✓ The plastic limit increases with the addition of lignosulfonate.
- ✓ The optimum dosage of lignosulfonate is obtained as 4%.

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