STUDY ON THE EFFECT OF GRAFT COPOLYMER MODIFIED JUTE FIBRE IN SOIL STABILIZATION

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ABSTRACT

This project focuses on enhancing the engineering properties of soil by reinforcing jute fibre in lime stabilized soil. The main objective of this study is to investigate how varying percentages of lime and jute fiber affect the soil's strength and behavior. Lime was used as a stabilizer and added in varying proportions of 2%, 3%, 4%, and 5% to study its effect on consistency and strength of soil. After proper mixing, the samples were tested for Unconfined Compressive Strength (UCC) at 0-day and 7-day of curing periods. The test results showed that the soil strength increased with lime addition up to 4%, beyond which a slight reduction was observed. Hence, 4% lime was identified as the optimum content for the poorly graded soil. The addition of lime improved the soil's workability, pH, and strength while reducing its plasticity and swelling characteristics. To further enhance the strength and ductility, jute fiber was incorporated into the lime-stabilized soil in varying percentages of 0.2%, 0.3%, 0.4%, and 0.5%. Unconfined Compressive Strength test was conducted fibre reinforced lime stabilized soil which showed that the optimum jute fiber content was 0.4%, which gave the highest compressive strength of 283.5 kN/m^2. This was 75% higher than the virgin soils strength. The combination of 4% lime and 0.4% jute fiber significantly improved the soil's strength, stability, and resistance to deformation. Overall, this study concludes that lime and jute fiber stabilization is an effective, eco-friendly, and economical method for improving weak soils, making them suitable for use as subgrade, embankment material and foundation layers in road and building construction. Jute fibre through a graft copolymerization process to enhance its bonding ability and durability when used in soil stabilization, improve surface properties and enhance its effectiveness in soil stabilization applications.

Keywords: Soil, Lime stabilization, Jute fiber reinforcement, Soil improvement, Unconfined compressive strength, Compaction, Sustainable construction, Grafting, Copolymerization.

1.INTRODUCTION

Soil is a naturally occurring material that serves as the foundation for most civil engineering structures such as roads, buildings, and embankments. However, not all soils possess desirable engineering properties. In many areas, soils exhibit low bearing capacity, excessive plasticity, high compressibility, or poor drainage characteristics, making them unsuitable for direct use in construction. Such weak soils can lead to structural instability, uneven settlement, and premature failure of structures.

One such approach is the reinforcement of soil with fibers. Fiber-reinforced lime stabilized soil has gained attention as a technique to improve the strength and deformation characteristics of weak soils. The inclusion of discrete fibers in soil helps to resist tensile stresses, minimize crack formation, and enhance ductility, toughness, and load-bearing capacity. This method is simple, cost-effective, and adaptable to various soil types and field conditions.

The use of natural fibers like jute, in soil stabilization has become increasingly popular due to their environmental benefits and local availability. Natural fibers are biodegradable, renewable, and inexpensive, making them an ideal replacement for synthetic fibers like polypropylene and polyester. Among these, jute fiber stands out as one of the most important materials for geotechnical applications.

2. NEED FOR STUDY

The stabilized soil reinforced with modified jute fiber improvements in mechanical behavior, making it suitable for infrastructure projects such as rural roads, embankments, and foundation layers where cost and sustainability are primary concerns.

The study have focused on untreated fibers. These untreated fibers, while initially improving soil strength, tend to degrade over time, leading to a reduction in performance. Hence, a systematic investigation is needed to evaluate how graft modification enhances the mechanical and durability characteristics of jute fiber-reinforced soil.

This study aims to the performance of soil reinforced with graft copolymer modified jute fiber under various conditions, such as different fiber contents, curing periods, and soil types. The findings will help in identifying the optimum dosage and treatment method for achieving maximum soil stabilization.

3.OBJECTIVE OF THE STUDY

The proposed project aims at understanding the influence of jute fibre on the index and engineering behavior of lime stabilized soil.

To evaluate the performance characteristics of lime stabilized soil with jute fibre treated by graft copolymerization process.

4.METHODOLOGY

This phase of project contains collection of soil from field, the testing of index properties of soil as per IS-2720 and effect of fibre reinforcement on the strength of lime stabilized soil. The following tests were carried out on soil. Lime was used for stabilization and jute fibres were used as reinforcements.

Index Tests

Specific gravity test on soil was conducted using specific gravity bottle as per IS: 2720 (Part 3 / sec-1) – 1980, for the soil used in this study. Specific gravity values here reported are an average of three tests.

Liquid limit test of soils and soil with lime was determined by using Casagrande apparatus as per IS: 2720 (Part 5) – 1985. As per IS: 2720. (Part 5) - 1985, the soil samples have to be sieved through 425 micron IS sieve and tested.

Plastic limit test of the soil and soil with lime inclusion was conducted by standard method (IS: 2720 (Part 5) - 1985) for all the soils. The plastic limit values reported is an average of three determinations.

The shrinkage limit of the soil and soil with additive lime was determined according to the bureau of Indian standard procedure IS: 2720 (Part 6) – 1972. The shrinkage values reported are the average of three tests. The free swell index test was determined as per IS: 2720 (Part 40) – 1972 expressed in percentage.

Compaction Test

Standard Proctor Compaction test as per IS: 2720 (Part 7) – 1980, was conducted for generating the compaction curves for all the soils and different percentages of lime.

Unconfined compressive strength test

Unconfined compressive strength tests, as per IS 2720 (Part 10) – 1973, were conducted for soil Standard Proctor Compaction test as per IS: 2720 (Part 7) – 1980, was conducted for generating the compaction curves for all the soils and different percentages of lime.
with different percentage of lime at their respective optimum moisture content in the proctor mould itself. Then the sample was retrieved by inserting a sampler tube and later the sample was trimmed to a standard UCC specimen size. Strength test was conducted immediately for soil alone after the preparation of specimen and 7days cured samples was also subjected to UCC test.

Curing

These identical samples were prepared for their maximum dry density at optimum water content based on compaction curves obtained. The samples are tested for immediate and 7 days curing. All the samples prepared were labelled according to the trial combination chosen. Samples were cured by sand bath method and covered with chute bag on top of the tank to maintain 100% humidity and to prevent loss of any moisture from the samples. All the samples intended for immediate testing were tested immediately.

Grafting

The graft copolymerization reaction process involves bonding polymer chains onto the backbone of natural polymer to improve its physical and chemical properties. In this process, a monomer is grafted onto a polymer jute fibre is a suitable initiator under controlled conditions. The initiator generates free radicals on backbone polymer, creating active sites where the grafting reaction takes place. The monomer molecules react with active sites forming the branches that attached with main chain.

5.MATERIALS COLLECTION

Fig 5.1 Clay soil

Fig 5.2 Lime

Fig 5.3 Jute Fibre

6. SOIL CLASSIFICATION

Since less than 50% of the soil is retained on the 75micron sieve, the soil is classified based on its grain size. The behavior of fine particles differs from that of coarse particles, so particle size is an important factor for soil classification. To classify soil property, the size of particles must be determined using sieve analysis. In India, the Bureau of Indian Standards (BIS) follows the IS soil Classification system. Therefore, in the study the soil is classified according to the IS classification system.

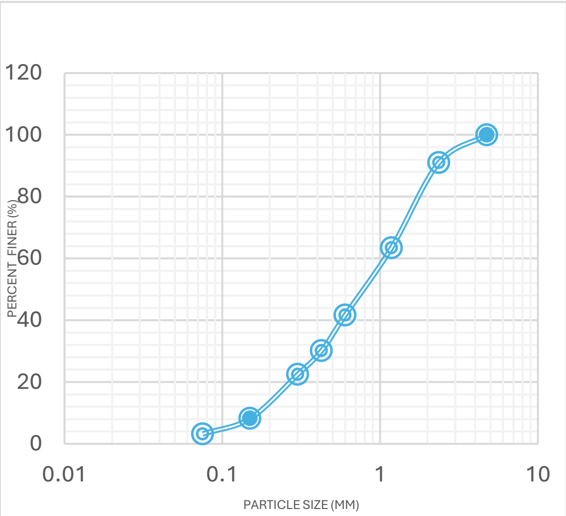

Chart-6.1: Particle Size Distribution curve

The result of dry sieve analysis shows that the course grained particles present in the sample are Poor Graded in nature.

7.PRELIMINARY TEST

7.1 Preliminary Tests for lime

7.1.1 Influence of lime on pH value of soil

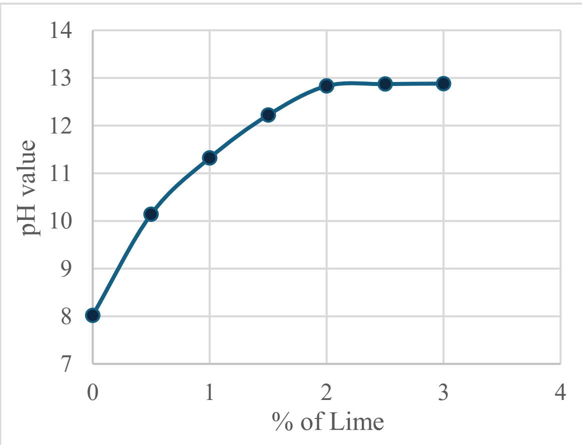

Chart-7.1.1.1: pH Value Curve

According to above graph the initial consumption of lime is founded as 2%

7.2 Preliminary Tests for lime

S.NO	DESCRIPTION	VALUE
1.	Specific Gravity	2.8
2.	Liquid Limit	55.56%
3.	Plastic Limit	17.54%
4.	Plasticity Index	38.02%
5.	Free Swell Index	46.1%
6.	IS Classification C_u C_c Percentage of fines	SP 5.71 1.0 35%
7.	Optimum Moisture Content	7.8%
8.	Maximum Dry Density	1.82 g/cc
9.	Permeability	1.38×10^{-3} cm/sec

Table-7.2.1: Preliminary Test Results for virgin soil

8. SECONDARY TESTS

The secondary test is to be conducted for adding lime and Jute fibre to the clay soil with and without curing.

8.1 Effect of lime on the liquid limit values of soil:

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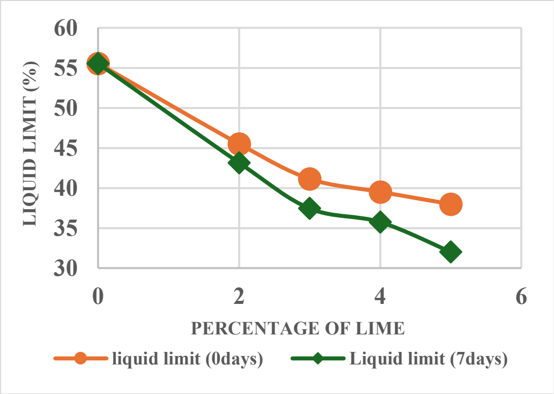

Chart 8.1.1.1: Liquid limit value for soil with lime

8.1.2 Effect of lime on the plastic limit values of soil:

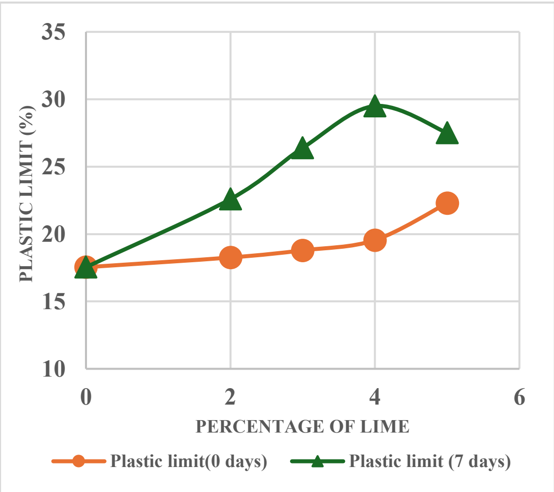

Chart 8.1.2.1: Plastic limit for soil with lime

8.1.3 Effect of lime on the plasticity index values of soil:

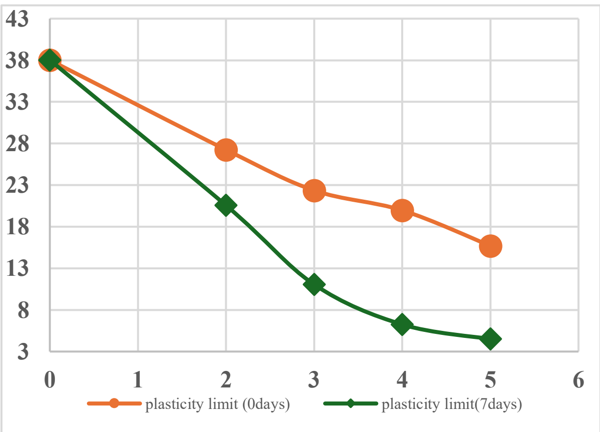

Chart 8.1.3.1: Plasticity index for soil with lime

8.4.1 Effect of lime on the shrinkage limit values of soil:

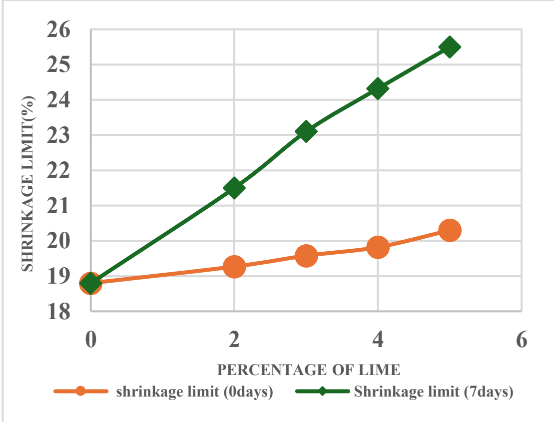

Chart 8.1.4.1: Shrinkage limit value for soil with lime

8.1.5 Influence of lime on the compaction characteristics of soil

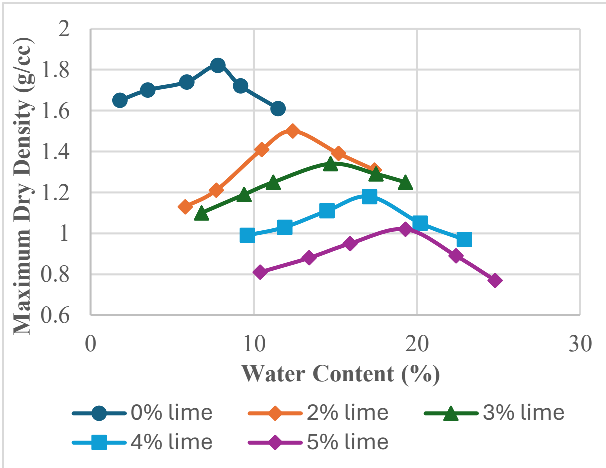

Chart 8.1.5.1: Compaction curve for soil with lime

% of lime	OMC (%)	$\gamma_{d,max}$ (g/cc)
0	7.8	1.82
2	12.4	1.4
3	13.7	1.34
4	17	1.18
5	19.3	1.02

Table-8.1.5.1 Variation of $\gamma_{d,max}$ and OMC ofSoil with % of Lime

8.1.6 Unconfined compressive strength of uncured lime stabilized soil

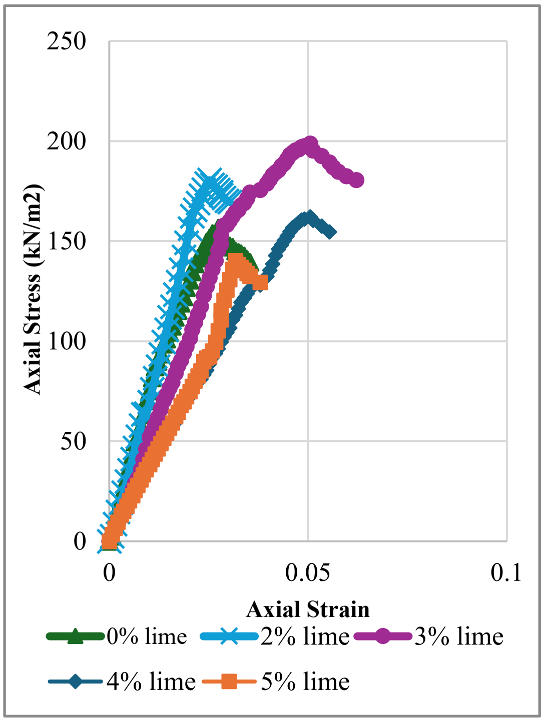

Chart 8.1.6.1 UCS of lime stabilized soil without curing

8.1.7 Unconfined compressive strength of cured lime stabilized soil

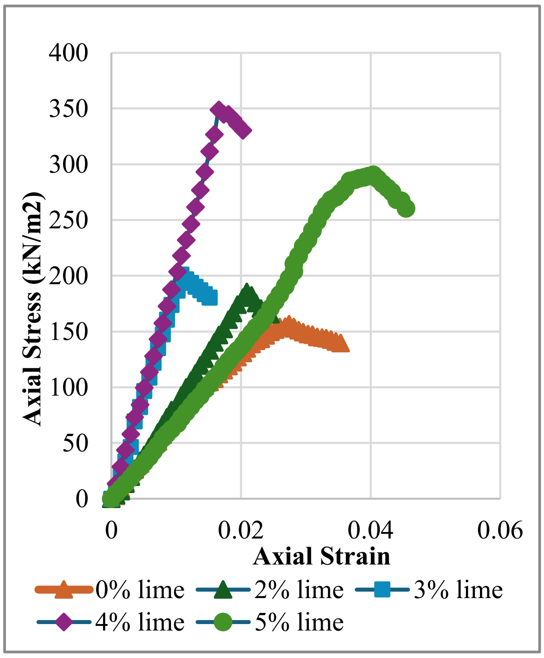

Chart 8.1.7.1 UCS of lime stabilized soil with curing

8.1.8 Effect of curing period on unconfined compressive strength of lime stabilized soil

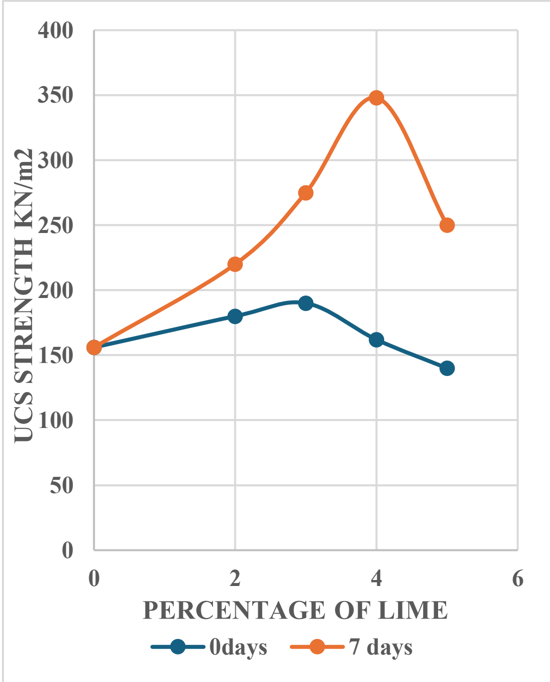

Chart 8.1.8.1 Effect of Curing on UCS

8.1.9 Unconfined compressive strength of fibre reinforced lime stabilized soil

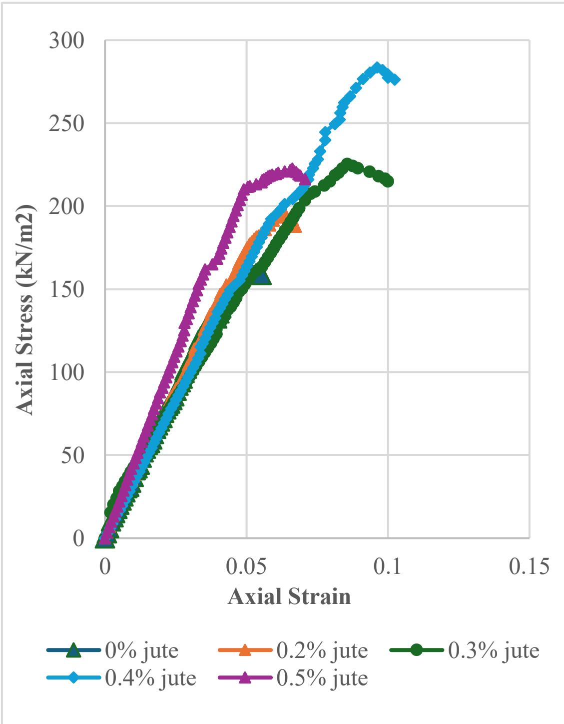

Chart 8.1.9.1 Influence of fibre reinforcement of UCS of lime stabilized soil

8.1.10 Unconfined Compressive Strength

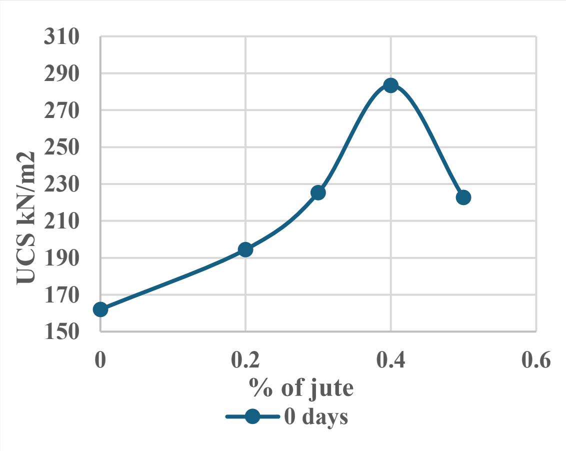

Chart 8.1.10 Unconfined compressive strength of fibre reinforced

9. CONCLUSION

To study the effect of Jute fibre on the lime stabilized soil, index tests, compaction tests and unconfined compressive strength tests were carried out. For a comparative study, tests was conducted on uncured and 7 day's cured soil. Based on the analysis of the results, the following conclusions maybe drawn,

- Addition of Jute fibre on lime stabilized soil alters the index and engineering properties of soil.
- In both, uncured and cured conditions, the addition of Jute fibre to lime stabilized soil greatly increased the unconfined compressive strength of the soil.
- Consistency limits of the soil was improved since liquid limit decreased and plastic limit vale increased for the optimum mix of lime. The compaction characteristics was also alters with the decrease in maximum dry density from 1.82g/cc to 1.02g/cc.
- The maximum unconfined compressive strength was attained for Soil + 4% Lime + 0.4% Jute Fibre, as 283.5kN/m2 for uncured condition.
- Cured samples result in improved strength as the curing period ensures proper completion of pozzolanic reaction between soil and lime.

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