Experimental and economical analysis on clayey soil using terrazyme and lime for highway construction.

[1]Rufaida M, [2]Thirugnanasambantham N

M Tech Student, Assistant Professor
Department of civil Engineering
Sree Venkateshwara Hi-Tech Engineering College
Gobi, Erode, Tamil Nadu, India.

***Abstract*- Sub-grade soil plays a pivotal role in pavement performance and its stabilization is crucial. This study investigates the effectiveness of lime and bio-enzyme (Terrazyme) treatments for sub-grade soil stabilization. Laboratory CBR tests were conducted on treated soil on different time intervals, and pavement design and economic analysis were performed using the CBR method**

***Key Words*- Soil stabilization, pavement construction, lime, bio-enzyme, Terrazyme, CBR testes, economic analysis.**

I. INTRODUCTION

The economic prosperity and social development of a nation are intricately linked with the quality and expansiveness of its road infrastructure. As countries experience rapid urbanization and an increasing number of vehicles on their roads, the demand for resilient and cost-effective road construction has never been more pressing. In the pursuit of sustainable and efficient solutions, the traditional methods of soil stabilization with materials such as cement and lime have given way to innovative approaches.

One such innovative approach is the application of bio-enzymes, exemplified by Terrazyme, to improve the engineering properties of subgrade soils. These bio-enzymes exhibit the remarkable ability to enhance the wetting and bonding capacity of soil particles, resulting in soil materials that are better suited for the rigors of road construction. This bio-enzyme technology represents a significant paradigm shift in the field of soil stabilization, offering both environmental sustainability and economic viability.

This journal article delves into the critical role of soil stabilization in the context of modern road infrastructure development. It explores the challenges posed by the burgeoning vehicular traffic and the need for superior subgrade materials from a sustainable design perspective. Through laboratory experiments, microscopic analysis, and field tests, we investigate the efficacy of Terrazyme and traditional stabilizing agents, such as lime, in enhancing the strength and shear characteristics of soft clays.

The backdrop for this research is the Indian road network, which has undergone significant expansion and modernization efforts in recent years. We discuss the pressing need for cost-effective roads, the depletion of commonly used materials, and the imperative to identify new materials and techniques to address the road structure's demands.

II. OBJECTIVE OF THE THESIS

- Evaluate Engineering Properties of Soft Clay Soil: This objective involves conducting tests to understand the natural properties of the soft clay soil, which is essential for any subsequent soil stabilization efforts.
- Study Variation in Unconfined Compressive Strength: You aim to investigate how the unconfined compressive strength of the soil changes when treated with lime, bio-enzyme, and a combination of both. This is crucial for assessing the effectiveness of these stabilizers.
- Determine Optimum Dosages of Lime and Bio-Enzyme: Identifying the ideal quantities of lime and bio-enzyme required to enhance soil strength is a critical step in your research. This information can guide future soil stabilization efforts.
- Study Efficiency of Lime-Enzyme Mixture: You intend to evaluate how efficient a lime-enzyme mixture is in stabilizing the soil. This is important as it may offer a more effective and cost-efficient solution compared to using lime and bio-enzyme separately
- Compare Improvement in Soil Strength: You aim to compare the improvement in soil strength achieved by lime-enzyme stabilization with that of soil stabilized using lime alone and soil stabilized using bio-enzyme alone. This comparison will help in assessing the relative effectiveness of these methods.
- Understand Changes in Soil Fabric: This objective involves studying how the soil's fabric changes when stabilized with lime, bio-enzyme, or a combination of both. Understanding these changes can provide insights into the mechanisms of stabilization.
- Study Increase in CBR Value and Economic Benefits: You plan to investigate the increase in the California Bearing Ratio (CBR) value, which is crucial for highway construction. Additionally, assessing the economic benefits of using the proposed stabilization methods can be valuable for practical applications.

III. PROPERTIES OF SOIL

The properties of untreated soil are given in Table3 .1

Table 3.1 Physical properties of soil

Property	Value

Liquid Limit (%)	80
Plastic Limit (%)	42
Shrinkage Limit (%)	24
Maximum Dry Density (kN/m^3)	17.06
Optimum Moisture Content (%)	34
Unconfined Compressive Strength (kPa)	75.74
Specific gravity	2.74
Initial water content (%)	102
Free Swell Index (%)	15

IV. EXPERIMENTS AND TEST RESULTS

Various studies were carried out on the determination of effect of terrazyme and lime on natural soft clay obtained from Calicut, Kerala. The materials used in the present study is a natural clay soil obtained from Chathamangalam, Calicut. Lime was purchased from local market in Mukkam at Calicut and enzyme Terrazyme acquired from Avijeet agencies, Chennai

Table 4.1. Atterberg limits

Plastic limit (%)	80
Liquid limit (%)	42
Shrinkage limit (%)	24
Plasticity Index (%)	38
Shrinkage ratio	1.95
Volumetric Shrinkage	0.79
Shrinkage Index (%)	21

Table 4.2 UCC of soil treated with lime

Percentage of lime (%)	**UCC (kPa)**
1	146.07
2	185.32
3	241.39
4	221.13
5	190.24

Table 4.3 CBR of soil treated with lime

Day	**CBR Value**
0	4.72
7	6.8
14	7.87
28	10.74

Table 4.4. UCC of soil treated with terrazyme

Terrazyme(ml/m^3)	UCC (kpa)
60 ml/m^3	142.72
70 ml/m^3	178.83
80 ml/m^3	194.96
90 ml/m^3	181.61

Table 4.5. CBR of soil treated with terrazyme

Day	CBR Value
0	4.8
7	5.5
14	7.8
28	8.7

Table 4.6. UCC of soil treated with lime and terrazyme

LIME	TerraZyme (ml/m^3)	UCC (kPa)
3%	60 ml/m^3	231.89
3%	70 ml/m^3	247.10
3%	80 ml/m^3	195.47
3%	90 ml/m^3	168.28

Table 4.7. CBR of soil treated with lime and terrazyme

Day	CBR Value
0	5.1
7	7.5
14	11.1
28	14.4

V. DESIGN AND COST ANALYSIS OF PAVEMENTS

In this study, we analyzed pavement design options for a four-lane road, considering traffic volume, CBR values, and cost implications. Our findings show that enzymatic lime stabilization offers cost savings of up to 10% compared to traditional methods. Higher CBR values result in thinner pavements and reduced construction costs. Enzymatic lime stabilization, when combined with terrazyme, demonstrates excellent binding properties. However, maintenance costs were not factored in this analysis, which should be considered for a comprehensive assessment.

Table 5.1 Thickness and cost of pavement

Type of Soil	Thickness of Pavement (mm)	Approximate Cost of Pavement (Rs)
Untreated Soil	576	8640000
Soil Treated with lime	460	7380000
Soil Treated with lime and Terrazyme	430	6675000

VI. CONCLUSION

An experimental study is being conducted to study the effect of terrazyme and lime on the stabilization of natural soils. The Engineering properties of soil have been studied. It is found that the stabilizers complement each other by providing better and quicker stabilization and stronger permanent soil matrix is formation. A higher degree of stabilization has occurred with shorter curing period.

The major conclusions from the thesis are

- Soil mixed with combination of lime and terrazyme gives the best result.

- The CBR value on 28th day mixed with combination of lime and terrazyme is 14.4.
- The optimum dosage of lime is 3 % and terrazyme is 80ml/m^3.
- The optimum dosage of combination of lime and terrazyme is 3% of lime and 70ml/m^3 of terrazyme
- Thickness of pavement as per IRC 37 2012
  - Untreated soil = 600mm
  - Soil treated with lime =460mm
  - Soil treated with lime and terrazyme =430mm

Economic advantages of enzymatic lime stabilized soil over others include:

- Using local and ecofriendly material for stabilization much as possible.
- Avoiding transportation cost
- Reduction in construction time
- Reduction in construction materials
- Using enzymatic lime stabilization for the construction of pavements, a cost saving up to 10% may be obtained as compared to lime stabilized methods

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