JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# PERFORMANCE STUDY OF SOIL STABILIZATION USING NATURAL MATERIALS

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***Abstract*** -Soil stabilization is a critical technique in geotechnical engineering, aimed at enhancing the properties of soil to improve its strength, stability, and durability. This study investigates the use of natural materials—egg shell powder (ESP), rice husk ash (RHA), and tamarind kernel powder (TKP)—as sustainable alternatives to traditional soil stabilizers. These materials, derived from waste products, are environmentally friendly, locally available, and cost-effective.

Laboratory experiments were conducted to assess the impact of varying proportions of ESP, RHA, and TKP on soil stabilization. Results indicate that the addition of these natural stabilizers significantly improved soil strength, reduced plasticity, enhanced compaction, and lowered permeability. The combination of ESP, RHA, and TKP demonstrated a notable increase in UCS and a reduction in swelling behavior, making it particularly beneficial for clayey and expansive soils. Moreover, the use of waste materials provides an eco-friendly solution to the disposal of agricultural by-products. The study concludes that natural materials like ESP, RHA, and TKP offer an effective, sustainable, and cost-efficient alternative for soil stabilization, with the potential for widespread application in construction and infrastructure projects

## I. INTRODUCTION

In this study, an attempt has been made to explore the possibilities of using natural materials like Tamarind Kernel Powder (TKP), Egg Shell Powder (ESP) for the beneficial improvement of problematic clays. Increased focus on the possible environmental risk associated with the large scale use of the grouting agents has revealed that leakage of chemicals from grouting activities can cause harm to the environment.

This paper seeks to explore to improve the strength of the soil using natural materials like TKP, ESP and RHA. The use of natural materials for soil stabilization has emerged as a promising approach in geotechnical engineering. Eggshell powder, TKP, and RHA are among the natural materials that have shown potential in enhancing soil strength, reducing erosion, and promoting sustainable development. These materials are biodegradable, non-toxic, and can be sourced locally, making them an attractive alternative to synthetic soil stabilizers.

Soil stabilization is a critical process that enhances the engineering properties of soils, rendering them more suitable for construction and infrastructure development. The increasing demand for sustainable and eco-friendly solutions has led to the exploration of natural materials as potential soil stabilizers. Eggshell powder, Tamarind Kernel Powder (TKP), and Rice Husk Ash (RHA) are three natural materials that have garnered significant attention for their potential to improve soil properties. These materials are not only readily available and cost-effective but also offer a sustainable alternative to traditional soil stabilizers.

## 2.OBJECTIVES OF THE PRESENT STUDY

- To improve the Maximum dry density of the soil by 20% by adding 3.5% of the natural materials.
- To increase the compressive strength of the soil by 10%-20% by adding 3.5% of the natural materials.
- To improve the Atterberg Limit in addition of natural materials by 3.5%.

## 3.Natural Materials:

Improvement of soil by the recent methods have proved to be of great use in improving the soil and providing the scope for use of otherwise unusable land but on the other hand have had an impact on the quality of the environment. In the recent years more emphasis has gone towards protecting the environment by reducing activities of pollution and using alternative methods that minimise the impact on the environment.

**Tamarind Kernel Powder**: Tamarind Kernel Powder (TKP) has not been documented for its use in construction industry as such, but its function as an additive to improve the performance of materials like cement has been recently recognized. TKP can be used as hydrocolloids in cement and lime to improve their performance. The hydrocolloids function as water retention agents, thickener, binder, suspending agent, lubricant and friction reducing agent, air entraining agent reducing the weight without sacrificing strength and eliminating the need of other additives.

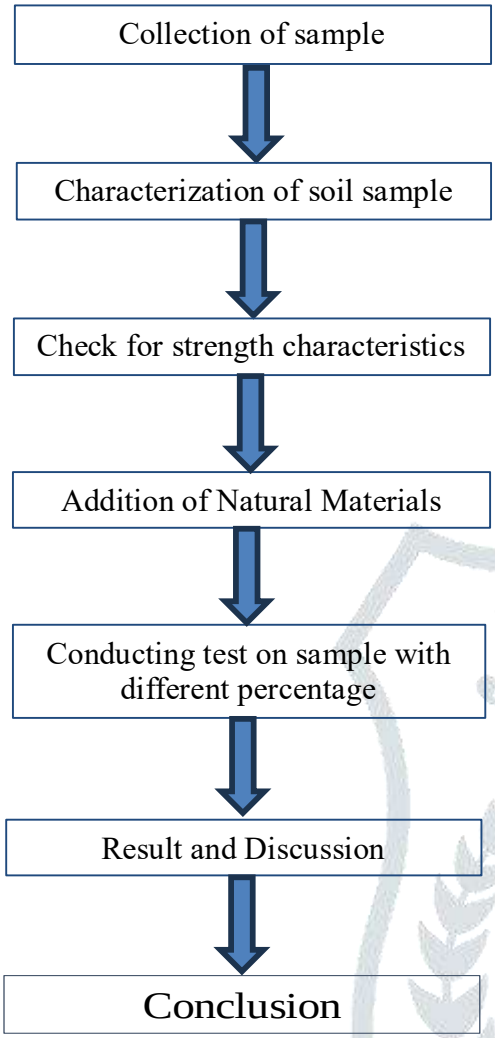
**Egg Shell powder(ESP)**: By the composition of egg shell powder could enhance the properties and can be a sustainable replacement for lime, concrete, etc. as stabilizer. Through much experimental investigation it has been showed that plastic and egg shell powder can be used as an effective stabilizer with encountering waste disposal problem as well, along with the economical solution for stabilizing weak soil.

**Rice Husk Ash (RHA)**: RHA is a promising natural stabilizer for soils, offering numerous benefits and characteristics that make it an attractive alternative to traditional stabilizers. By incorporating RHA into soil, its compressive strength and shear strength can be significantly improved, leading to enhanced durability and stability. Additionally, RHA's high silica content and pozzolanic properties enable it to react with lime, forming cementitious compounds that bind soil particles together, thereby increasing soil stability and reducing the likelihood of landslides and settlement.

Table:-1

| Fractions | Particle Size (mm) | Distribution (%) |
|---|---|---|
| Fine gravel | 20 – 4.75 | 1.4 |
| Coarse sand | 4.75 – 2 | 5.1 |
| Medium sand | 2 – 0.425 | 9.3 |
| Fine sand | 0.425 – 0.075 | 10.6 |
| Silt | 0.075 – 0.002 | 7.0 |
| Clay | <0.002 | 66.5 |

## 4. METHODOLOGY




### MIXING PROPORTIONS USED

Tests were done on the soil which as taken from the construction site with different proportions of Rice Husk Ash, Tamarind Kernal Powder and Egg shell powder. Three mixes were taken with

(I) [1.5:1:1] [Rice Husk Ash: Tamarind Kernal Powder: Egg shell powder]

(II) [1:1.5:1] [ Rice Husk Ash: Tamarind Kernal Powder: Egg shell powder]

(III) [1:1:1.5] [ Rice Husk Ash: Tamarind Kernal Powder: Egg shell powder]

# 5.RESULTS AND DISCUSSION

## 5.1 Atterberg limit tests

| % of Waste | Construction soil+different percentages of RHA,ESP &TKP | | | |
|---|---|---|---|---|
| | Liquid limit | Plastic limit | Plasticity index | Average plasticity index |
| 1 | 52.5 | 50.98 | 1.62 | 4.28 |
| | 62.5 | 55.95 | 6.95 | |
| 1.5 | 61.0 | 54.64 | 3.13 | 3.51 |
| | 66.50 | 61.15 | 3.90 | |
| 2 | 67.50 | 62.64 | 4.87 | 4.8 |
| | 65.50 | 60.78 | 4.72 | |

| % of Waste | Construction soil+different percentages of RHA,ESP &TKP | | | |
|---|---|---|---|---|
| | Liquid limit | Plastic limit | Plasticity index | Average plasticity index |
| 1 | 51.30 | 48.38 | 1.52 | 3.7 |
| | 60.42 | 53.41 | 5.89 | |
| 1.5 | 43.50 | 42.03 | 1.476 | 2.90 |
| | 48.50 | 44.17 | 4.33 | |
| 2 | 48.23 | 45.56 | 2.67 | 1.85 |
| | 46.65 | 45.62 | 1.03 | |

| % of Waste | Construction soil+different percentages of RHA,ESP &TKP | | | |
|---|---|---|---|---|
| | Liquid limit | Plastic limit | Plasticity index | Average plasticity index |
| 1 | 50.21 | 47.21 | 1.45 | 3.68 |
| | 59.18 | 52.91 | 5.92 | |
| 1.5 | 48.52 | 44.56 | 3.96 | 3.04 |
| | 47.62 | 45.5 | 2.12 | |
| 2 | 42.56 | 41.03 | 1.53 | 1.29 |
| | 44.61 | 43.56 | 1.05 | |

**Table-2:** Experimental Results for Atterberg limit with different trial mix

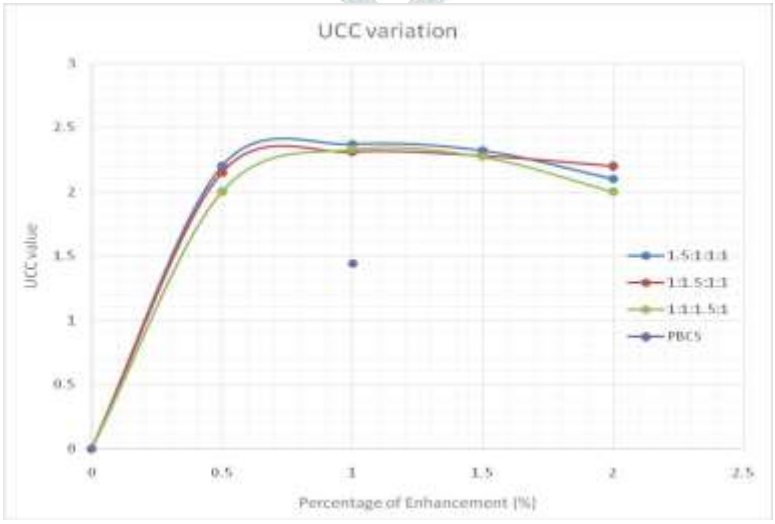
## 4.2 Unconfined Compressive Strength Test

| Percentage of Enhancement (%) | Soil + different percentages of RHA + ESP +TKP | |
|---|---|---|
| | Unconfined Compressive strength (UCS values) | Cohesion (kg/ m2 ) |
| 1 | 2.37 | 1.85 |
| 1.5 | 2.32 | 1.22 |
| 2 | 2.1 | 1.1 |

| Percentage of Enhancement (%) | Soil + different percentages of RHA + ESP +TKP | |
|---|---|---|
| | Unconfined Compressive strength (UCS values) | Cohesion (kg/ m2 ) |
| 1 | 2.31 | 1.79 |
| 1.5 | 2.28 | 1.68 |
| 2 | 2.2 | 1.42 |

| Percentage of Enhancement (%) | Soil + different percentages of RHA + ESP +TKP | |
|---|---|---|
| | Unconfined Compressive strength (UCS values) | Cohesion (kg/ m2 ) |
| 1 | 2.33 | 1.82 |
| 1.5 | 2.27 | 1.54 |
| 2 | 2.00 | 1.39 |

**Table-3:** Experimental Results for unconfined compression strength with different trial mix



# CONCLUSION

The study reveals that the inclusion of Rice Husk Ash, Egg Shell Powder and Tamarind Kernal Powder gives more consistent results as compared to the individual addition to the specimen. The research determines the following investigations carried out in the laboratory are as given below: -

- The collected soil has specific gravity is very less. This is basically due to fibrous nature of the soil. The mixing of different proportions of ashes to the soil shows that there is improvement in the specific gravity in addition of 1% ash which is considered as an indication of high strength
- The mixing of different proportions of ashes to the soil shows that there is improvement MDD in addition of 1%and then further decreases due to stiffness of the soil.
- The optimum moisture content was attained at 1% and then further there is sharp decline. This OMC is used as an index to mix the quantities together for various projects.
- The Atterberg limits of soil shows that the collected soil is highly plastic in nature as its plasticity index is more than 17. The differ in percentages of enhancement at 1% addition of ashes renders that soil shows clayey nature. This nature is fruitful to the applying soil for the pavements.
- The UCS test gives the shear strength as an index to structuring the buildings by various engineers. It is clear from the above results that the strength increases slowly.
- Increase in Optimum moisture content of soil, plays an important role in compaction as well as the durability and strength of compacted soil.
- The values obtained after the experimentation clears that these values are used as index for the designing and laying the base and sub base material for the infrastructure development and pavements structuring.

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