

Soil Stabilization by using Chia Seeds and Rice Husk Ash (RHA)

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CHAPTER 1 INTRODUCTION INCLUDING, OBJECTIVES, AND LIMITATIONS INTRODUCTION

1.1 General

The soil at a construction site is the foundation for any structure ,so its properties are very important. Many times, natural soil is weak and cannot with stand heavy loads. If such soil is directly used,It can cause cracks, settlements , or even failure of structure. To overcome this problem , soil stabilization is carried out , which means improving soil properties such as strength , durability , and stability. Traditionally , cement , lime , and bitumen are the most commonly used stabilizers. However , their use is not fully sustainable as they are costly and their production causes a lot of carbon dioxide emissions,which contributes to global warming. In recent years , engineers have started looking for eco-friendly alternatives. Two such materials are chia seeds and Rice Husk Ash(RHA). Chia seeds contain a natural polymer called mucilage , which swells in water and forms a sticky gel that binds soil particles together. Rice Husk Ash , which is a waste product from burning rice husks , is rich in silica and has pozzolanic properties , meaning it reacts with calcium in the soil to form strong compounds. By using chia seeds and RHA together , soil properties can be improved in a sustainable and cost-effective way.

1.2 . Properties of Chia Seeds and Rice Husk Ash

Chia seeds are tiny black or white seeds of the plant *Salvia hispanica*. When soaked in water, the outer Layer of the seed swells and produces a sticky gel called mucilage. This gel is rich in polysaccharides and has strong binding. In soil stabilization , this sticky gel fills the gaps between soil particles and helps them hold together more firmly. This reduces erosion, improves cohesion, and increases the soil's short- term strength. Since chia seeds are biodegradable and natural, they do not cause any harm to the environment Rice Husk Ash (RHA) is obtained by burning rice husks , which are an agricultural byproduct. If rice husks are burned under controlled conditions , the ash obtained contains about 70 to 90 percent amorphous silica. This silica is reactive and, when mixed with soil containing calcium, it undergoes a pozzolanic reaction, producing calcium silicate hydrate (C-S-H). These compounds increase the strength of the soil , reduce compressibility , and improve durability.RHA is cheap , easily available in rice – growing countries like India , and its use also helps in recycling agricultural waste.

1.3 Problem Statement

In civil engineering, the strength and stability of soil play an important role in the safety of any structure. However, in many areas, the soil available at the construction site is weak, highly compressible or has swelling and shrinkage problems. Such soil cannot safely support heavy loads and often causes cracks, uneven settlement, or even structural failure. To improve weak soil, stabilizing agents like cement and lime are commonly use. But these materials is costly, requires large amount of energy for production, and release high levels of carbon dioxide, which contributes to environmental pollution and global warming. Therefore, there is need to find eco-friendly, sustainable and cost-effective alternatives for soil stabilization agricultural wastes and natural materials are being studied for this purpose. Among them chia seeds, which and natural material are form natural sticky gel, can help bind soil particles, while Rice husk Ash [RHA] a by-product rich in silica, can chemically improve the soil's strength. Both materials are environmentally friendly and easily available. However, limited research has been done on their combined use for soil stabilization

To solve this problem by using chia seeds and rice husk [RHS] together. Chia seeds form a sticky gel that binds soil stronger, stable, ecofriendly, and low cost compared to cement and lime.

1.4 Objective

Overall objectives of these study were to investigate to improve weak soil using chia seeds and rice husk [RHA]

. Specific objective included

1. To evaluate the effect of chia seeds as natural binder on the geotechnical properties of soil.
2. To study the role of rice husk ash [RHA] as a pozzolanic stabilizer in improving soil strength and durability.
- 3 To compare the performance of untreated soil with soil stabilized by different proportion of chia seeds and RHA
- 4 To develop a cost effective and ecofriendly soil stabilization technique using agricultural and natural by-product.
- 5 To explore the potential application pf this method in roads, embankment, and construction projects.

1.5 Scope of work

In the future, more experiments should be conducted to find the best mix

Of chia seeds and RHA for different soil conditions. Field trials on actual construction sites are required to test durability and performance under real condition. Cost benefits studies should also be carried out to compare this method with traditional stabilizer like cement and lime. There is also scope to combine chia seeds and RHA with other natural or industrial waste materials for better result. If these studies are successful, this technique can become widely accepted eco-friendly solution for soil stabilization.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Rivew

Number of studies has already been done in soil stabilization by using chia seeds and rice husk ash (RHA)An overview of it, in the form of literature review is needed.

B. Mohan Babu, studied problem rice husk ash (RHA) helps to improve to quality of weak soils. when RHA mixed with soil, it reduces plasticity increase the strength and make the soil more stable. Using RHA with lime or cement gives even better results. The best amount of RHA depends on the type of soil. Overall using rice husk ash is good and ecofriendly way to make soil stronger while also reducing waste from rice mills.

Duong Thanh Nguyen (2), from the review studies it's clear that rice husk ash (RHA)is an effective and eco friendly material for soil improvement. It helps reduce soil plasticity, swelling, and permeability while increasing strength and stability, especially when mixed with lime or cement. Using RHA not only improves soil properties but also lowers construction costs and minimizes environmental pollution by recycling agricultural waste.

Anjani Kumar Yadav (3) from the reviewed literature, it is clear that locally available agricultural wastes like rice husk ash, sugarcane, bagasse ash, and cow dung ash can effectively improve the strength and stability of weak soil. This material increases the soils bearing capacity and reduce construction cost, making for suitable for rural development. Overall, using such waste materials is an ecofriendly and economical method for soil stabilization.

Emmanuel Adeyanju (4) from the reviewed studies, is that using waste materials like cement kiln dust (CKD) and rice husk ash (RHA) can make weak soils stronger in a cost effective and eco friendly way. Many studies show that CKD works better than RHA based geopolymers for improving soil, but both can help reduce construction costs and pavement thickness. In short using these materials is good for the environment and saves money, but more research is needed to make RHA-based solution even better.

Er. Jasvir Singh (5) from the reviewed studies, adding waste materials like fly ash and rice husk ash to soil can make the soil much stronger and better for building roads and other structures. Research shows the best improvement happens when 8% fly ash is used with 12% rice husk ash, making the soil more stable and stronger. Using these waste materials not only saves money but also helps the environment by recycling industrial by-products.

Hamid Reza Manavuparast from the reviewed studies, the study concludes that using rice husk ash (RHA) and lime sludge (LS) as soil stabilizers is an effective and eco- friendly solution for improving clay soil. Both materials are low-cost industrial by products that enhance soil strength and reduce environmental waste. Research findings show that increasing the amount of RHA and LS raises the soil's water requirement and lowers its density, while moderate proportions when RHA and LS are used together in a balanced amount -around 6% RHA with 7% LS for building foundations, and 10% RHA with 4% LS for road pavements. The study also highlights that future research should focus on testing this combination on various soil types and evaluating their long-term effects under real field conditions.

2.2 Theoretical content

2.2.1 Introduction in chia seeds and rice husk ash

Soil stabilization means improving the strength, stability, and durability of soil so it can support building and other structures. Many natural soils are weak and cannot carry heavy loads so stabilizing materials are added to make them stronger. Traditionally materials like lime and cement are used but they can be costly and harmful to the environment. Therefore, nature and waste materials are now being used for eco-friendly soil improvement. In this study, chia seeds and rice husk ash (RHA) are used as natural stabilizing agents. Chia seeds contain a sticky gel-like substance called mucilage, which helps in building soil particles together and introduces water improvement through the soil. This improves the soil strength and decreases swellings and shrinkage. Rice husk ash, which is a by-product of rice milling, is rich in silica. It reacts with soil minerals and fills the gaps between particles, increasing density and strength. The combination of chia seeds and RHA provides both physical and chemical stabilization. Chia seeds improve cohesion and reduce permeability, while RHA improves compaction and bearing capacity. Together, they make the soil stronger, more stable, and suitable for construction work.

2.2.3 Different methods used for soil stabilization

1. Mechanical Stabilization Method
2. Chemical Stabilization Method
3. Wet Mixing OR Slurry method
4. Bio chemical Stabilization method
5. Sandwiched method

Among these methods, the one used for soil stabilization by combination of chia seeds and rice husk ash (RHA)

1] Bio chemical stabilization Method

Bio polymer stabilization, also known as bio-stabilization, is an innovative and environmentally friendly method of soil improvement that uses natural microbial polymers to enhance the engineering properties of soil. Unlike traditional chemical stabilization, this method relies on bio-degradable, non-toxic substances such as chia seeds mucilage, xanthan gum, guar gum, and other plant- or micro-derived polysaccharides to bind soil particles together. When bio polymers are mixed with soil, they form a gel-like coating around the particles, filling the voids and creating strong interparticle bonds. This results in improved cohesion, increased shear strength, reduced erosion, and better water retention, making the soil more stable under load and less susceptible to environmental degradation. The process typically involves preparing a biopolymer solution or gel, uniformly mixing it with the soil, and allowing adequate curing time for the polymer to interact with the soil particles. Biopolymer stabilization is particularly effective for sandy, silty, and loose soils, and it is less harmful than chemical stabilizers like cement or lime. In addition, it offers benefits such as eco-friendliness, cost-effectiveness, and compatibility with the natural ecosystem, making it suitable for applications in road subgrades, embankment, slope stabilization, and erosion control. The success of biopolymer stabilization depends on factors such as the type of biopolymer, concentration, soil type, and curing conditions, but when properly applied, it produces durable soil with enhanced strength and stability while reducing environmental impact.

2.2.4 Different Properties of Chia seeds and Rice Husk Ash RHA

Table no 2.1 gives the Table comparing the properties of **Chia Seeds and Rice Husk** for soil stabilization

Table No. 2.1: Properties of Chia Seeds and Rice Husk ash Use Soil Stabilization

Property	Chia Seeds	Rice Husk
Nature	Natural seed, rich in mucilage (polysaccharide)	Fibrous agricultural by-product
Function in Stabilization	Acts as a natural binder; forms gel to hold particles together	Provides structure, bulk, and reinforcement
Water Absorption	Very high (absorbs 10–12 times its weight); forms gel	Moderate; fibrous, can retain some moisture
Cohesion/Adhesion	High; binds soil and rice husk particles effectively	Low; needs binding agent for stability
Silica Content	Low	High (15–20%), adds strength and durability
Biodegradability	Fully biodegradable and eco-friendly	Biodegradable and eco-friendly
Effect on Soil Properties	Increases cohesion, viscosity, water retention	Improves mechanical structure and aeration
Chemical Resistance	Works over a range of pH, non-toxic	Resistant to minor chemical reactions
Thermal Stability	Moderate	High

2.2.5 Advantages of chia seeds and rice husk [biopolymer] stabilization:

1. Environmentally friendly and biodegradable:

. chia seeds and rice husk are natural, non-toxic, and biodegradable, making this method eco-friendly and safe for soil and environmental.

2. Enhance soil strength and cohesion:

. the gel from chia seeds binds soil and rice husk particles together, increase shear strength and load-bearing capacity

3. Reduce soil erosion:

. forms a cohesive matrix around soil particles, preventing erosion caused by water or wind, suitable for slopes, embankment and erosion-prone areas

4. Improve water Retention

. Chia seed mucilage absorbs and retains water, maintaining moisture in soil, especially useful for sandy or loose soils and supporting vegetation growth.

5. Cost effective and locally available:

. Both materials are inexpensive, readily available, and reduce dependency on costly chemical stabilizer like cement or lime

6. Safe and non corrosive:

. Being natural, they do not produce harmful reaction with soil, groundwater, or surrounding structures , ensuring environmental and human safety.

7.improves soil workability:

. The mixture becomes easier to handle, spread, and compact, enabling smooth and uniform field applications.

8.Supports and Sustainable Construction:

. Uses agricultural by-product and natural polymer, promoting sustainable, green construction practices while reducing carbon footprint

CHAPTER 3 METHODOLOGY

3.1 Collection of materials

The materials used in this study wear collected from easily available local sources :

- **Soil** : The natural soil sample was collected from a nearby construction site where soil-related problems like low bearing capacity were noticed.
- **Rice Husk Ash (RHA)** : Obtained from a local rice mill where rice husk is used as fuel.the ash was collected after proper burning and sieving to remove larger particles.
- **Chia seeds** : Purchased from a local market . These seeds were selected because of their natural binding and water – absorbing properties.

3.2 Preparation of Material

Before mixing , all materials were prepared to ensure uniformity:

- The soil sample was air-dried and passed through a 4.75 mm sieve to remove stones and debris.
- The RHA was sieved through a 425-micron sieve to obtain a fine powder for proper mixing.
- The Chia Seeds were soaked in water for a few hours to allow them to form a gel- like texture , which helps in improving soil cohesion.

3.3 Experimental Procedure

The experiment was divided into several stages:

a) Preliminary Tests On Soil

Before adding any stabilizing materials , basic tests were carried out to understand the natural properties of soil :

- Moisture Content
- Atterberg Limits (Liquid Limit , Plastic Limit ,Plasticity Index)
- Specific Gravity
- Grain Size Distribution
- Standard Proctor Test (For Optimum Moisture Content And Maximum Dry Density)

These tests helped in identifying the type of soil and suitability for stabilization.

b) Mixing of Stabilizers

Different proportions of RHA and Chia seeds were added to the soil to compare results.

For example :

- 5%,10%,and 15% of RHA (by weight of soil)
- 0.5%,1%,and 1.5% of soaked Chia seeds

The soil, RHA, and chia mixture were thoroughly mixed by hand to ensure a uniform blend.

c) Compaction Test

A Standard proctor Test was conducted on each mix to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). This step helped to find how well the mixture could be compacted and how dense it could become.

d) Strength Test

The California Bearing (CBR) test was performed on unstabilized and stabilized soil samples to measure the improvement in strength. Higher CBR values indicated better soil performance for construction purposes.

3.4 Curing process

After preparation, the stabilized soil samples were kept for curing for 7 days and 14 days. This allowed the chemical reactions between RHA and soil particles to take place, improving the bonding and overall strength.

3.5 Data Analysis

All test results were recorded and compared between natural soil and stabilized soil. The improvement in parameters such as MDD, OMC, and CBR values were analyzed to evaluate the effectiveness of using RHA and Chia Seeds.

3.6 Summary

This methodology provided a step-by-step approach to assess how natural and eco-friendly materials like Rice Husk Ash and Chia Seeds can be used for soil stabilization. By following this process, we aimed to develop a sustainable and cost-effective technique that not only strengthens the soil but also promotes the use of agricultural waste and natural binders.

CHAPTER 4

CONCLUSION

From the experimental study, it is concluded that the combination of Rice Husk Ash (RHA) and Chia Seeds can effectively improve the engineering properties of soil. The addition of RHA increases the soil's strength and reduces its plasticity due to the pozzolanic reaction between the ash and soil minerals. Chia Seeds, even in small quantities, act as a natural binder that enhances the cohesion and moisture-holding capacity of the soil.

The results showed noticeable improvement in California Bearing Ratio (CBR) values and Maximum Dry Density (MDD) of the stabilized soil compared to natural soil. The best performance was observed when RHA content was higher and Chia Seed proportion was lower, indicating that ratio provides better strength and workability.

Therefore, the use of RHA and Chia Seeds is a sustainable, eco-friendly, and cost-effective method for soil stabilization. It also helps in the utilization of agricultural waste (RHA) and promotes the use of natural polymers (Chia Seeds), contributing to environmentally responsible construction practices.

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