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SOIL STABILIZATION OF DREDGED SOIL USING COCKLE SHELL POWDER

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Abstract : Dredging operations generate large volumes of dredged soil, which is typically weak and poses significant disposal and environmental challenges. However, sustainable additives like cockle shell powder (CSP), derived from waste shells, offer a viable solution to enhance the engineering properties of such soil. This study investigates the effectiveness of CSP in improving the strength and stability of dredged soil collected from Ponnani Harbor and Ayikkara Harbor. Various proportions of CSP (2.5%, 5%, 7.5%, and 10%) were mixed with the soil, and mechanical tests, including the direct shear test, were conducted to assess improvements. The results suggest that CSP can significantly enhance the mechanical properties of dredged soil, supporting its reuse in geotechnical applications such as road construction and embankments, thereby promoting sustainable infrastructure development.

IndexTerms **- Cockle shell powder, Dredged soil**

1 . INTRODUCTION

Large quantities of dredged soil are generated during dredging activities, often creating disposal and environmental concerns. In its natural state, this soil is typically weak and unsuitable for construction. This study investigates the stabilization of dredged soil using cockle shell powder (CSP), a calcium-rich marine waste material that offers a sustainable solution for enhancing soil strength and durability.

Dredged materials were collected from Ponnani Harbor and Ayikkara Harbor(Kerala, India). Various mix proportions of cockle shell powder (2.5%, 5%, 7.5%, and 10% by mass) were added to the soil. The effect of this additive was evaluated through direct shear tests, which showed significant improvement in strength, making the soil more stable and suitable for construction use.

1.1 IMPORTANCE OF SOIL STABILIZATION.

Soil stabilization is crucial in civil engineering and construction as it significantly enhances the physical and mechanical properties of soil, including its strength, durability, and load-bearing capacity. This improvement allows structures such as roads, bridges, and buildings to be built on previously unsuitable soils, reducing the need for costly material imports and excavation. Additionally, stabilization promotes environmental sustainability by minimizing waste and the ecological impact of construction activities, particularly when utilizing waste materials like cockle shell powder and GGBS. It also mitigates issues related to soil settlement and erosion, contributing to safer and more stable foundations. Furthermore, stabilized soils can withstand various climatic conditions, extending the lifespan of infrastructure while reducing maintenance needs. Overall, soil stabilization not only improves construction efficiency and safety but also aligns with sustainable practices, making it a vital aspect of modern civil engineering.

1.2 OVERVIEW OF DREDGED MATERIALS

Dredged soil, also known as dredged sediment, is the material removed from water bodies such as rivers, lakes, and harbours during dredging operations aimed at deepening navigation channels or maintaining waterways. This soil can vary significantly in composition, texture, and quality, depending on its source and the surrounding environment. Typically, it contains a mix of fine and coarse particles, organic matter, and potentially harmful pollutants, which may result in high moisture content and low shear strength, rendering it unsuitable for direct construction use. While dredged soil can be repurposed for applications like landscaping or embankments, its variable quality poses challenges, including risks of settlement and environmental contamination. Effective stabilization techniques are crucial to improve its properties, making it more viable for construction projects. By incorporating additives such as cockle shell powder, the physical and mechanical characteristics of dredged soil can be enhanced,

turning it into a valuable resource for sustainable construction and environmental management. Understanding the nature and potential uses of dredged soil is essential for leveraging its benefits while addressing associated challenges

1.3 OBJECTIVE OF THE PROJECT

The objectives of this study are to determine the basic characteristics of dredged materials and to evaluate the strength of dredged soil collected from Ayikkara harbour (Kannur, Kerala, India) and Ponnani harbour (Malappuram, Kerala, India). It also aims to identify the optimal mixing ratio of cockle shell powder (CSP) with the dredged soil to achieve effective stabilization. Additionally, the study seeks to measure and analyse the changes in engineering and index properties resulting from the stabilization process using CSP.

1.4 SCOPE OF PROJECT

The main aim of this study is to explore the current practices and potential of using Cockle Shell Powder (CSP) for sustainable soil stabilization. It includes a literature review focused on natural and industrial by-products as alternatives for improving soil properties such as strength and moisture resistance. Representative samples of dredged soil and CSP will be systematically collected and tested to assess their individual characteristics, including particle size, compaction behaviour, moisture content, and strength. Based on these results, various mix ratios of CSP will be blended with dredged soil and tested for improvements in compaction, shear strength, and overall stability. The goal is to identify the most effective and eco-friendly mix for enhancing soil performance. The study also aims to support the development of guidelines for practical application in civil engineering.

2. METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. This includes literature survey, material collection, study on properties of materials, preparation of sample and testing of sample. The details are as follows;

2.1 LITERATURE SURVEY

The investigation on soil stabilization of dredged soils utilizing cockle shell powder addresses the inherent challenges associated with dredged sediments, which frequently exhibit poor engineering properties and elevated organic content. Traditional stabilization techniques, such as the use of cement and lime, often entail significant costs and environmental impacts. In contrast, recent studies have investigated the application of natural additives like cockle shell powder—derived from marine waste—due to its high calcium content, which enhances its efficacy as a stabilizing agent. Research findings suggest that cockle shell powder possesses properties that result in marked improvements in the strength and durability of stabilized soils. Moreover, this method aligns with sustainable practices by fostering waste reduction and supporting circular economy principles. While current studies demonstrate promising outcomes regarding the stabilization capabilities of cockle shell powder, further research is warranted to evaluate long-term performance, determine optimal mixing ratios, and explore practical field applications. Overall, the potential of cockle shell powder as a sustainable solution for dredged soil stabilization is increasingly supported by empirical evidence, underscoring the importance of continued investigation in this domain [1]. The study by Rahman et al. investigates the stabilization of weak marine soil using cockle shell powder and GGBS, offering a sustainable alternative to traditional methods like lime or cement. Marine soil's high moisture and low strength make it unsuitable for construction. Cockle shell powder, a calcium-rich seafood industry waste, and GGBS are tested for their impact on unconfined compressive strength (UCS). The research aims to improve soil strength and promote environmental sustainability by repurposing waste materials [2]. The study by Bortali et al. evaluates harbor dredged sediments to determine their potential for sustainable reuse in construction. These sediments often contain fine/coarse particles, organic matter, and pollutants. The research involves testing physical and chemical properties like grain size, moisture, and contaminants. The goal is to find safe, effective ways to use dredged sediments in construction, promoting sustainability and reducing waste [3]. The study by Pranshoo Solanki et al. reviews strategies for managing and reusing dredged materials. Dredging generates large sediment volumes that can cause environmental issues if poorly handled. The review highlights beneficial uses like land reclamation, construction, and habitat restoration. It stresses the importance of sustainable practices that balance economic and environmental concerns, and calls for innovative approaches to maximize the value of dredged materials while minimizing ecological impact [4]. The study by R. Petti et al. examines the use of shell powder to stabilize dredged sediments, which often lack strength and stability. It reviews characterization tests to assess the mechanical properties of sediments mixed with shell powder. The findings show that shell powder can improve physical properties, making the sediments more suitable for construction and environmental use. The review supports shell powder as a sustainable solution for effective sediment management.

2.2 MATERIAL COLLECTION

For the study on soil stabilization using cockle shell powder, a systematic approach to material collection is followed. Initially, suitable sites for collecting dredged soil are identified, focusing on water bodies with ongoing or frequent dredging activities to ensure the samples are representative. The collected soil is stored in airtight containers to prevent contamination and moisture loss. At the same time, cockle shells are obtained from local seafood markets or coastal regions, ensuring adherence to environmental guidelines. These shells are thoroughly cleaned to remove any organic matter, then rinsed and dried in a well-ventilated area. After drying, they are ground into a fine powder using a mechanical grinder. The resulting powder is analyzed for particle size and chemical composition to ensure its suitability for soil stabilization. Additional materials, such as clean water for mixing and curing, are also gathered as required.

2.3 STUDY ON PROPERTIES OF MATERIAL

The study of the stability of Cockle Shell Powder (CSP) stabilized dredged soil aims to determine the effect of the addition of this natural by-product on the physical, chemical, and mechanical properties of the soil. CSP, which contains calcium carbonate,

is believed to have positive effects on the stabilization of the soil in terms of its strength, compactness, and resistance. The dredged soil, which is low in strength and rich in water content, would be greatly improved by the addition of CSP, which could upgrade its properties to pave the way for its utilization in construction, road construction, or land reclamation processes. The study is eager to determine the behaviour of dredged soil with different ratios of CSP under different conditions. For this purpose, a series of laboratory tests will be undertaken, providing a comprehensive investigation of the behaviour of the soil prior to and subsequent to stabilization with CSP.

Different laboratory tests will be conducted to determine the effect of CSP on the engineering characteristics of the soil. The tests will give comprehensive information regarding the behaviour of the stabilized soil under various conditions, which will enable a deeper understanding of the performance of CSP as a stabilizer.

2.4 PREPARATION OF SAMPLE

The preparation of samples for stabilizing dredged soil using Cockle Shell Powder (CSP) involves several key steps. Representative dredged soil samples are collected from target locations, air-dried to remove excess moisture, and sieved to eliminate coarse particles and debris. CSP is cleaned, dried, and ground into fine powder, then mixed with the soil in varying proportions as per the experimental design to ensure even distribution. Each mix is thoroughly combined to ensure uniformity before being used for laboratory tests. These tests aim to identify the optimal mix ratios and evaluate the effectiveness of CSP in enhancing the engineering properties of dredged soil.

2.5 TESTING OF SAMPLE

The stabilization of dredged soil using Cockle Shell Powder (CSP) involves a series of laboratory tests to assess improvements in engineering and index properties. Sieve Analysis and Hydrometer Tests are conducted to determine the particle size distribution, focusing on fine fractions like clay and silt, which influence compaction and strength. The Direct Shear Test evaluates shear strength, cohesion, and internal friction angle, while the Compaction Test identifies the optimum moisture content and maximum dry density after stabilization. The pH Test measures the acidity or alkalinity of untreated soil, with CSP expected to raise the pH due to its alkaline nature. Organic Content and Salinity Tests assess how stabilization affects organic matter and salt levels, which impact strength and permeability. Finally, the Permeability Test examines the soil's water flow characteristics, helping determine its suitability for construction applications.

3. RESULTS AND DISCUSSION

3.1 Effect of CSP on compaction characteristics

Table 3.1.1: Effect of CSP on MDD and OMC of Ponnani soil

Characteristics	% CSP				
	0	2.5	5	7.5	10
MDD (g/cc)	1.50	1.76	1.77	1.78	1.79
OMC (%)	16	12.19	11.36	11.62	16

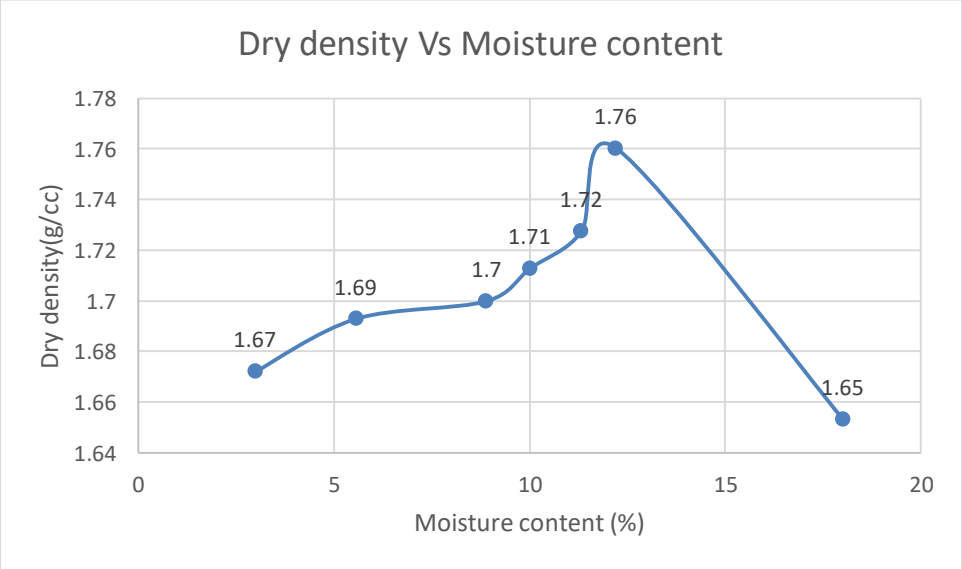

Fig 3.1.1: Compaction graph of 2.5% CSP on Ponnani soil

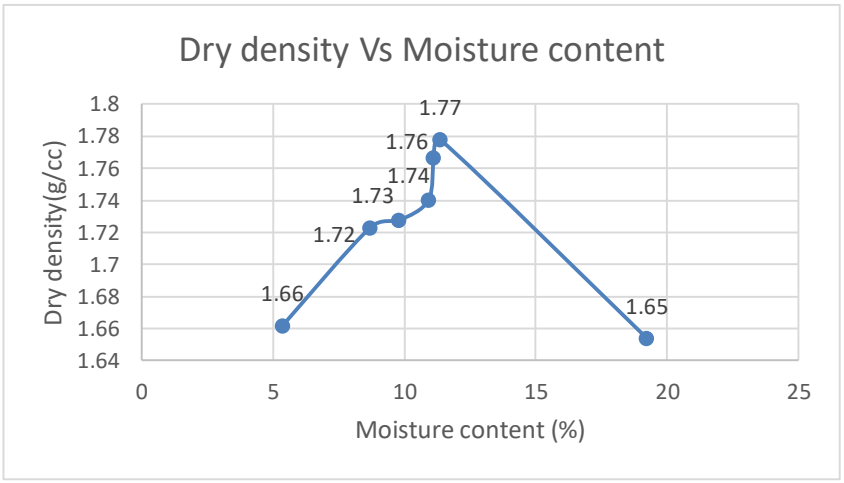

Fig 3.1.2: Compaction graph of 5% CSP on Ponnani soil.

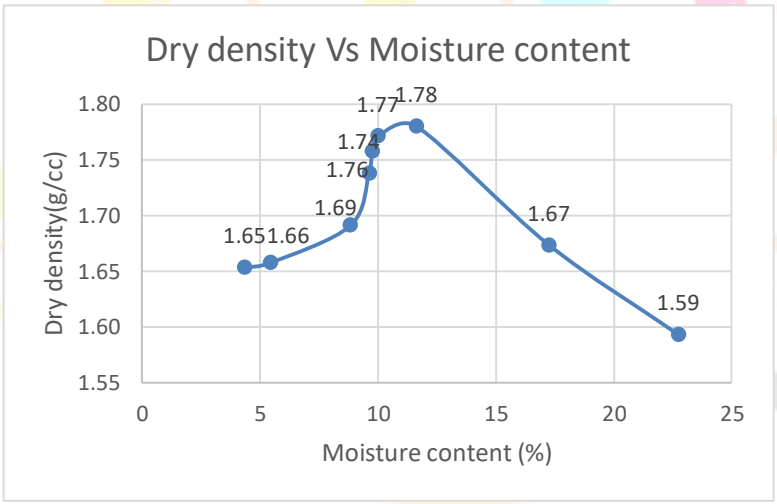

Fig 3.1.3: Compaction graph of optimal mix 7.5% CSP on Ponnani soil.

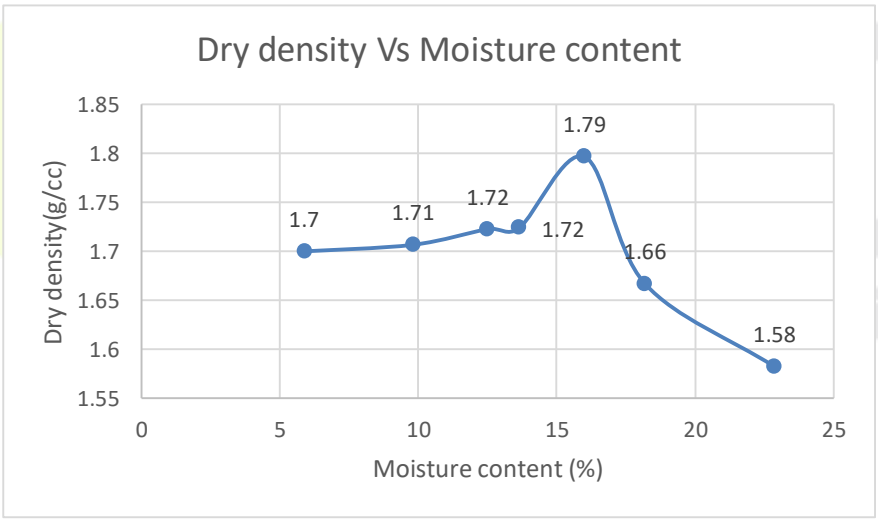

Fig 3.1.4: Compaction graph of 10% CSP on Ponnani soil.

Table 3.1.2: Effect of CSP on MDD and OMC of Ayikkara soil

Characteristics	% CSP				
	0	2.5	5	7.5	10
MDD (g/cc)	1.78	1.56	1.57	1.58	1.59
OMC (%)	15.5	14.89	12.5	16.6	17.07

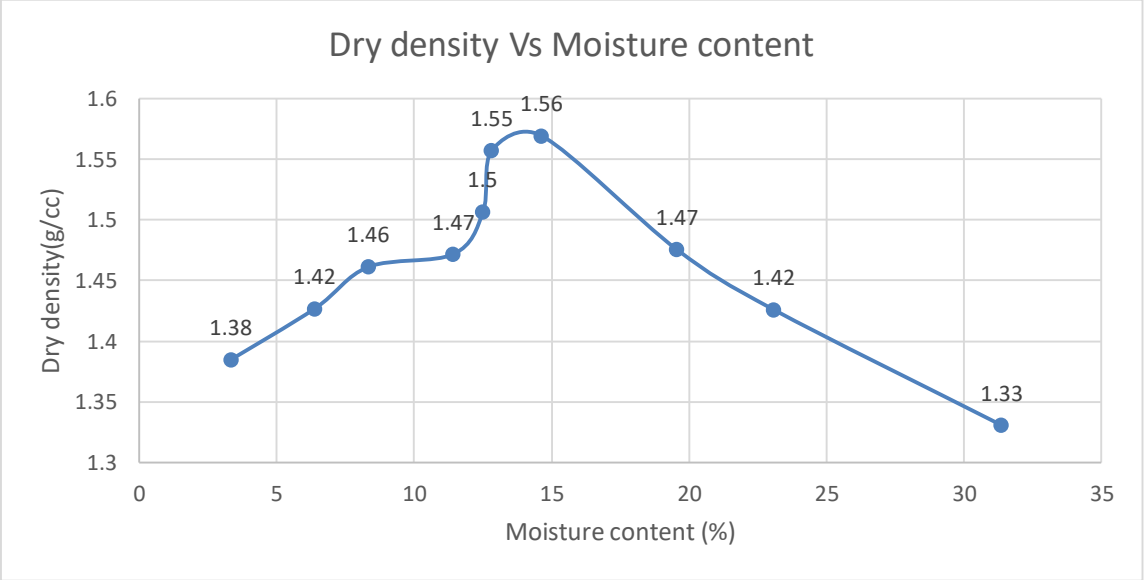

Fig 3.1.5: Compaction graph of 2.5% CSP on Ayikkara soil.

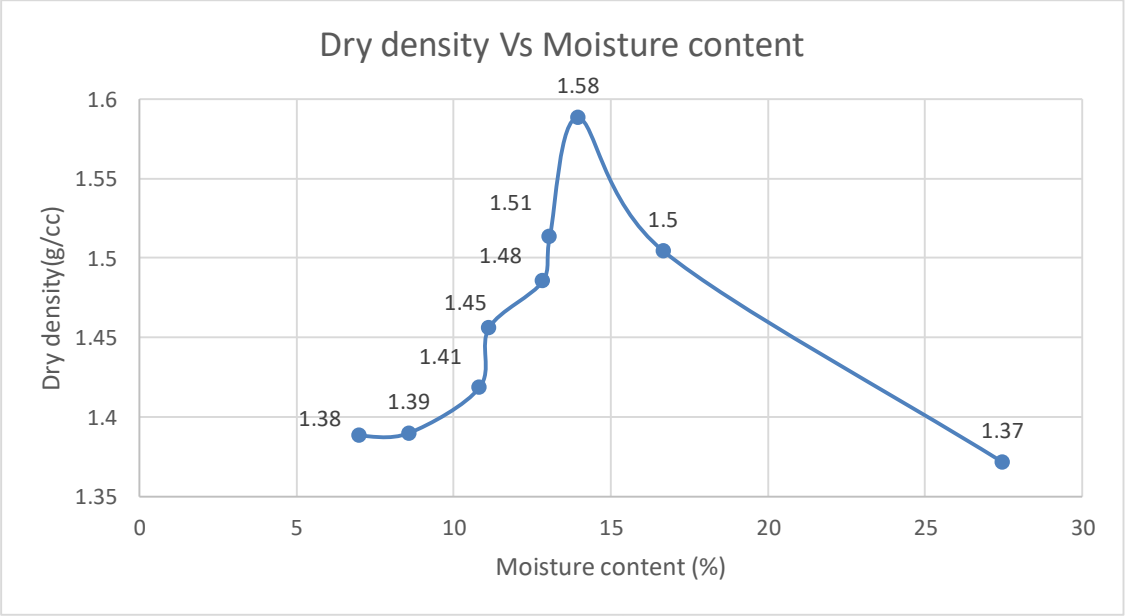

Fig 3.1.6: Compaction graph of 5% CSP on Ayikkara soil.

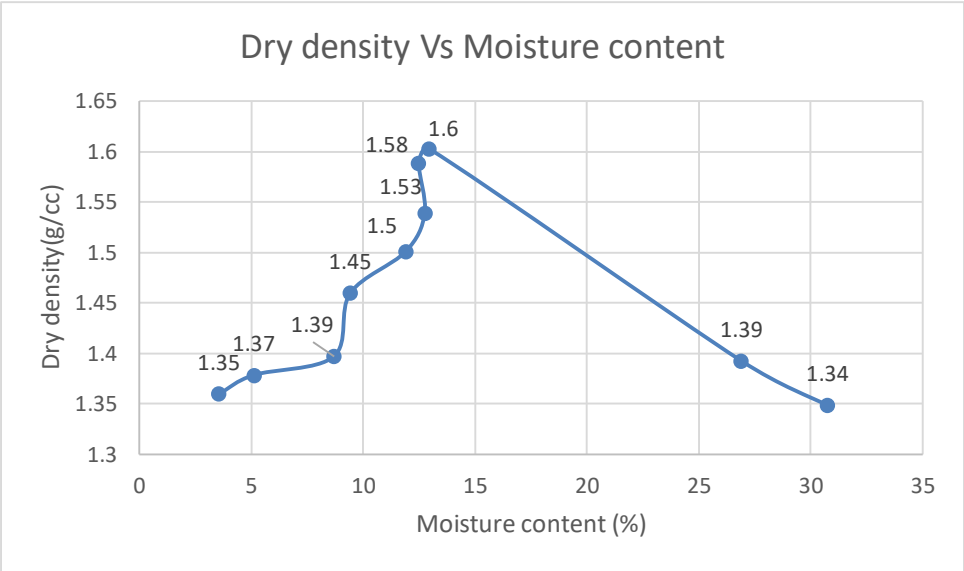

Fig 3.1.7: Compaction graph of 7.5% CSP on Ayikkara soil.

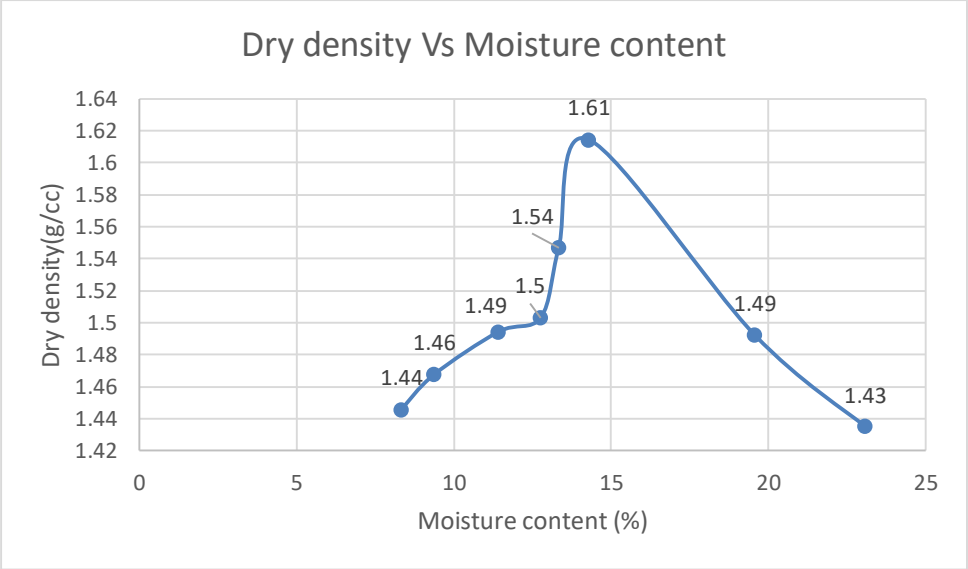

Fig 3.1.8: Compaction graph of 7.5% CSP on Ayikkara soil.

3.2 Effect of CSP on Shear strength parameters

Table 3.2.1: Effect of CSP on shear strength parameters of Ponnani soil.

Characteristics	% CSP				
	0	2.5	5	7.5	10
Cohesion (kg/cm^2)	2.252	1.3	1.37	1.39	1.63
Angle of internal friction (ϕ)	22.873	49.96	50.40	50.43	50.47

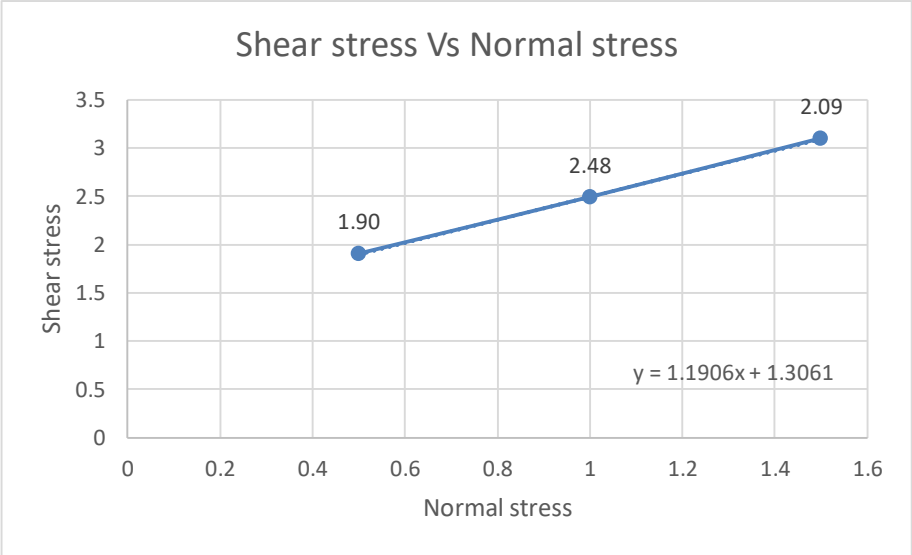

FIG 3.2.1: Shear test graph of 2.5% CSP on Ponnani soil.

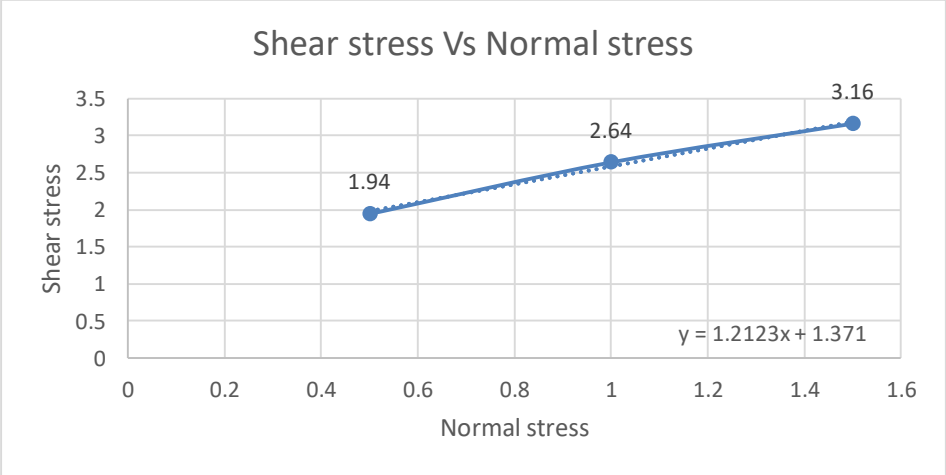

Fig 3.2.2: Shear test graph of 5% CSP on Ponnani soil.

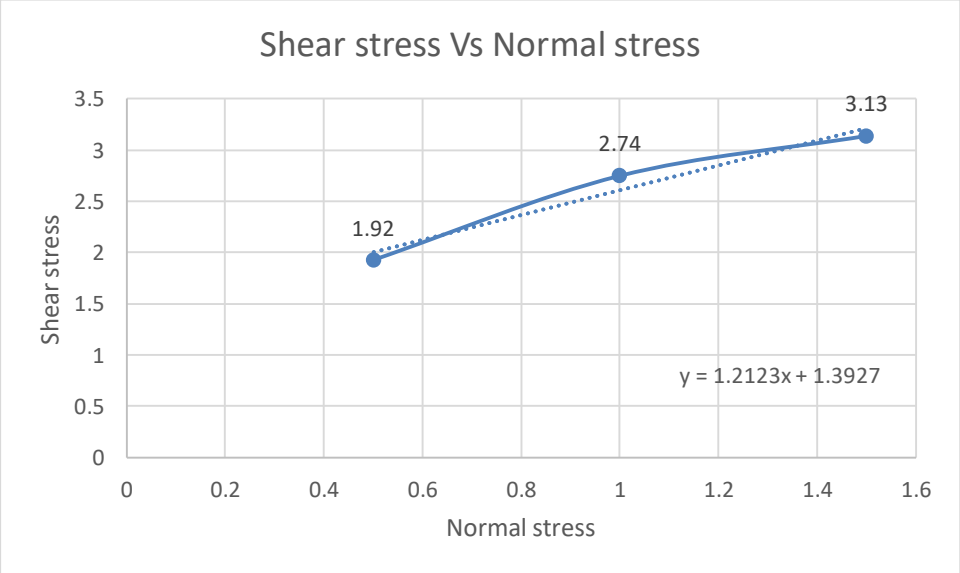

Fig 3.2.3: Shear test graph of 7.5% CSP on Ponnani soil.

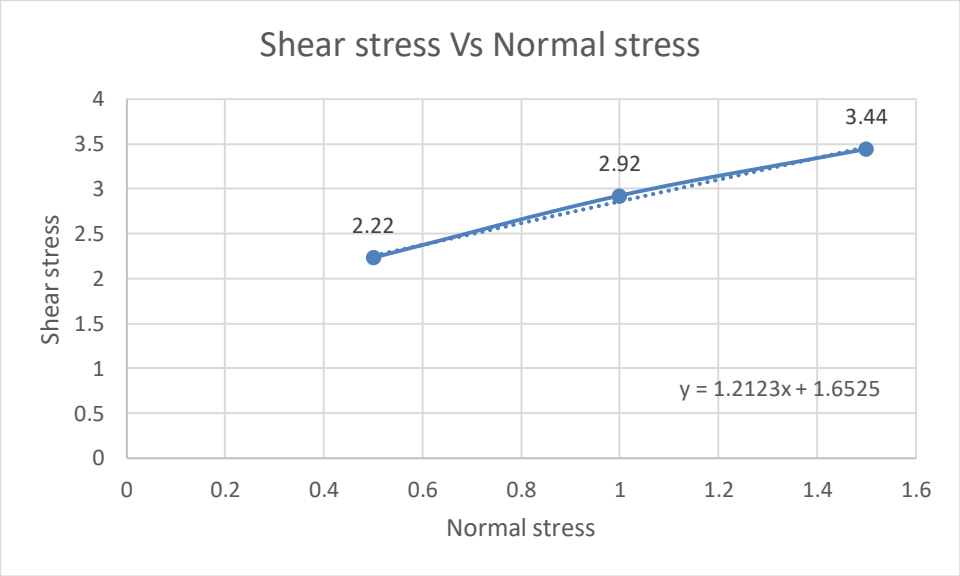

Fig 3.2.4: Shear test graph of 7.5% CSP on Ponnani soil.

Table 3.2.2: Effect of CSP on shear strength parameters of Ayikkara soil.

Characteristics	% CSP				
	0	2.5	5	7.5	10
Cohesion (kg/cm^2)	1.746	2.258	2.43	2.22	2.15
Angle of internal friction (ϕ)	34.694	35.38	36.33	37.88	40.03

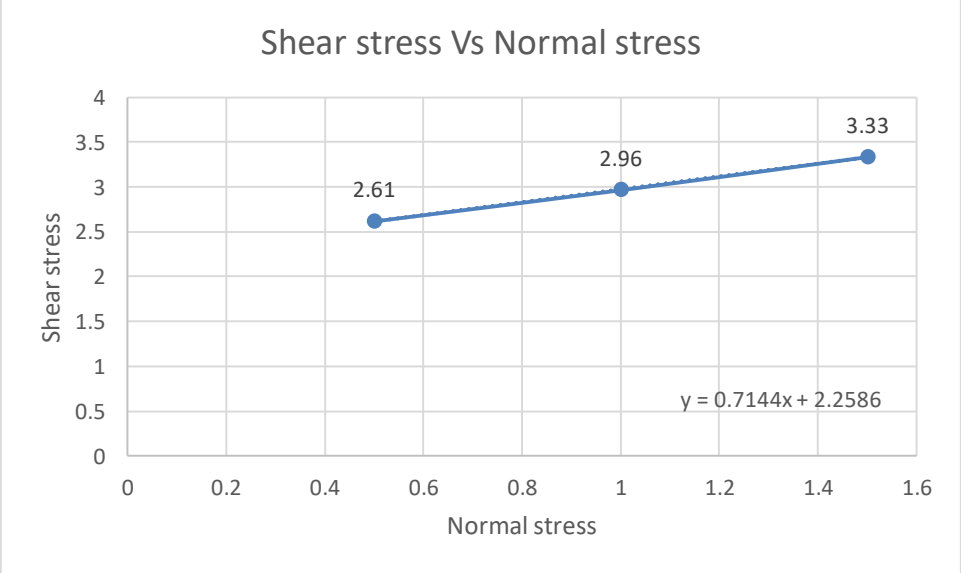

Fig 3.2.5: Shear test graph of 2.5% CSP on Ayikkara soil.

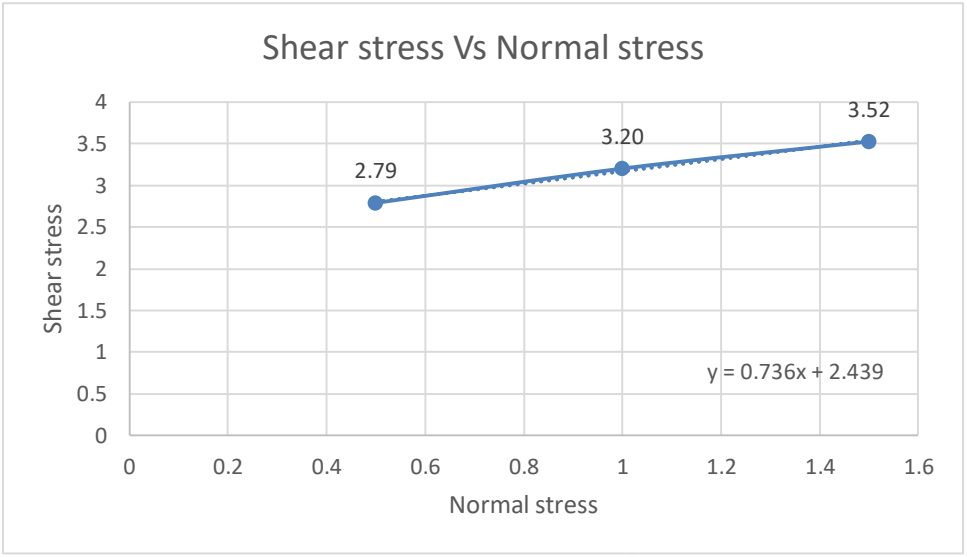

Fig 3.2.6: Shear test graph of 5% CSP on Ayikkara soil.

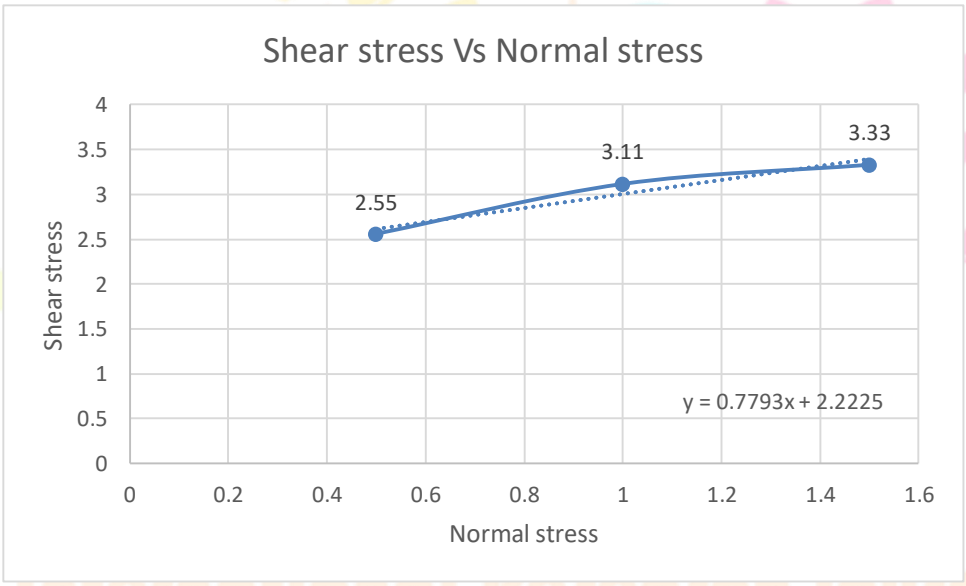

Fig 3.2.7: Shear test graph of 7.5% CSP on Ayikkara soil.

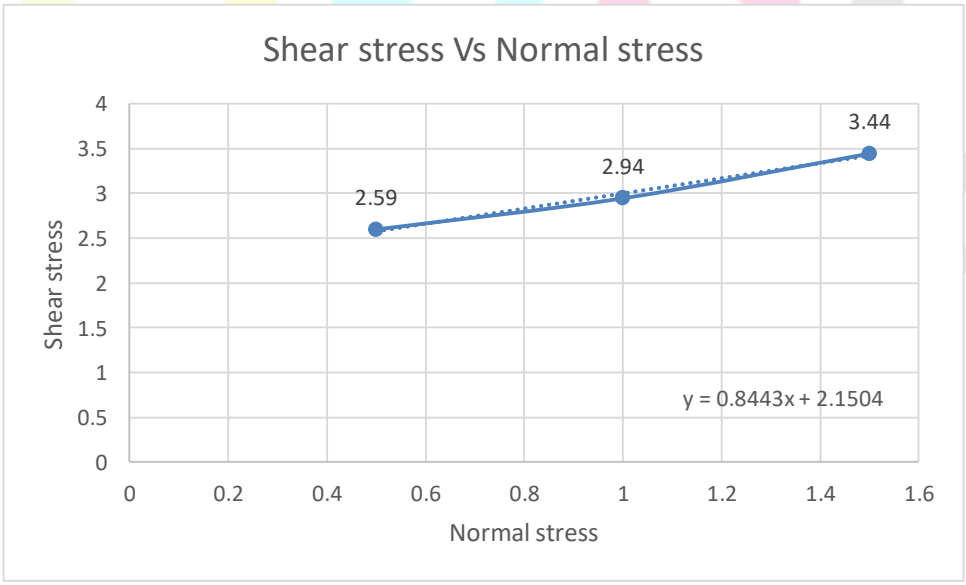

Fig 3.2.8: Shear test graph of 10% CSP on Ayikkara soil.

4. CONCLUSION

Stabilizing dredged soil using Cockle Shell Powder (CSP) is a cost-effective method that enhances soil properties while addressing environmental and waste management concerns. CSP significantly increases soil strength, making it more stable and suitable for construction, while also improving resistance to sliding, thereby reducing erosion and enhancing overall stability. A major advantage of using CSP lies in its origin as an industrial by-product from shell processing. Repurposing this material not only reduces disposal-related environmental impact but also minimizes reliance on conventional stabilizers. Compared to cement and lime, CSP offers a lower-cost, lower-carbon alternative, supporting eco-friendly construction practices. The optimal mix for effective stabilization has been identified as 7.5% CSP, balancing performance and affordability. In conclusion, this approach strengthens dredged soil while promoting sustainable development and responsible waste reuse in the construction industry.

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