IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

ESTIMATION OF UNCONFINED COMPRESSIVE STRENGTH OF CLAY USING COCONUT FIBER WASTE

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Abstract: The Strength of soil is an important criterion while constructing a structure over it. Expansive soils are soils that have low strength and bearing capacity. This project focuses on stabilizing the expansive soil in Kuttanad region. The soil in Kuttanad is very weak so the structures constructed over it is very vulnerable to failure, also the bunds constructed in the agricultural fields of this regions is prone to breaching. Weakness of soil in this region is hazardous to both the agricultural and domestic life
of people residing there. In this project the stabilization is done using an easily available and cost-effective material, coconut fiber . Coconut fiber, it can find application in soil stabilization, addressing issues like erosion and improving the properties of the soil. The incorporation of coir fiber not only addresses environmental concerns but also aligns with growing emphasis on sustainable and responsible construction practices in today global contest. The soil will be treated using coconut fiber(0.25%,0.5%,0.75%,1%,1.25% & 1.5%). Optimum percentage of coconut fiber will be determined by comparing the result of UCC test. To determine the effect of curing on the material tests will be conducted on soil treated with optimum percentage of coconut fiber after curing it for 3&7 days.

***Index Terms* -** Clay, UCS, Secant modulus,Coconut fiber.

I. INTRODUCTION

The unconfined compressive strength (UCS) of clay serves as a pivotal indicator of its mechanical integrity playing a vital role in geotechnical engineering and construction projects. Clayey soils are known for their unique properties often exhibiting low strength and high strength compressibility. However the integration of natural fibers into these soils has emerged as a sustainable d innovative solution to enhance their strength and stability. One such promising reinforcement agent is coconut fiber waste derived from coconut husks which has gained attention for its eco-friendly attributes and inherent tensile strength. Coconut fiber waste a byproduct of the coconut industry offers a sustainable alternative for soil improvement. As an organic material it brings an environmentally conscious dimension to geotechnical engineering applications. When mixed with clay, these fibers create a composite material that not only mitigates the shortcomings of pure clay but also adds strength and cohesiveness. The interplay between the clay matrix and coconut fibers influences the soil's UCS paving the way way for a cost-effective and ecologically sound approach to geotechnical challenges. The strengthening of clay by coconut fiber waste holds promise for various engineering applications. Beyond enhancing the mechanical properties of the soil this approach aligns with the broader goals of sustainable construction practices by repurposing agricultural waste. The exploration of this composite material's unconfined compressive strength represents a dynamic area of research , with implications for geotechnical engineers seeking resilent and environmentally friendly solutions in project.

2. LITERATURE REVIEW

2.1 EXPERIMENTAL AND OPTIMIZATION STUDY OF UNCONFINED COMPRESSIVE STRENGTH OFAMELIORATED TROPICAL BLACK CLAY, Attah C I, Okafor O F, Ugwu O O, (2021).

The study aims to comprehensively assess the impact of various amelioration techniques on the UCS of this particular soil type. The experimental setup includes laboratory tests conducted under controlled conditions measuring the UCS of the ameliorated clay specimens. The results obtained contribute valuable insights into the feasibility and efficiency of different amelioration strategies shedding light on their potential applications in geotechnical engineering projects
dealing with tropical black clay.

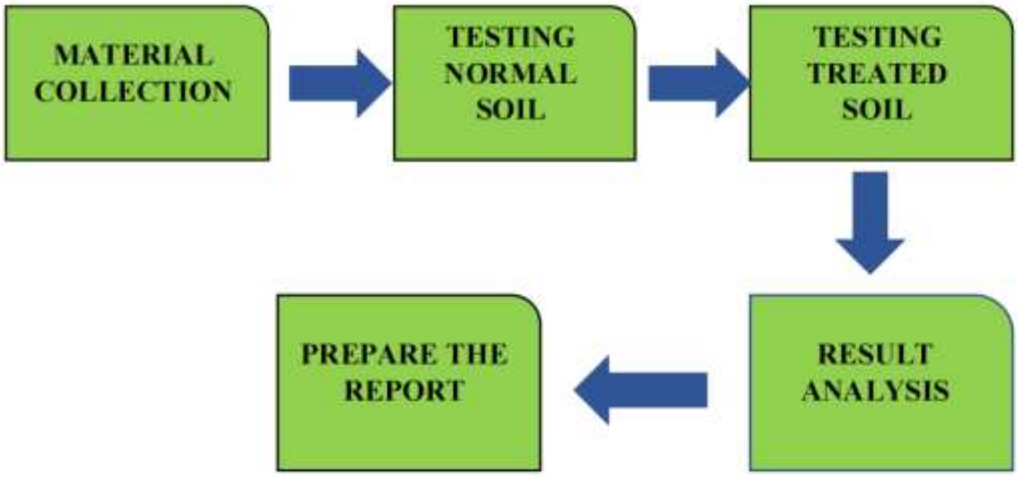
2.2 INVESTIGATION OF UNCONFINED COMPRESSIVE STRENGTH FOR BIOPOLYMER TREATED CLAY, Cheng Z, Geng X, (2023).

The research delves into the investigation of UCS concerning clay treated with biopolymers. Biopolymers derived from natural sources have gained prominence for their eco-friendly and sustainable attributes. The study focuses on elucidating the
impact of biopolymer treatment on the mechanical properties of clay soils specifically the enhancement of UCS. The experimental approach involves subjecting clay specimens treated with various biopolymers to comprehensive laboratory testing to evaluate their compressive strength under different conditions.The specimens treated with various biopolymers to comprehensive laboratory testing to evaluate their compressive strength under different conditions. The investigation spans
a range of biopolymer types and concentrations aiming to discern the most effective formulations for optimizing UCS. The findings of this investigation not only contribute to the growing body of knowledge on bio polymer clay interactions but also hold
practical implications for geotechnical engineers and environmental scientists.

2.3 UNCONFINED COMPRESSIVE STRENGTH OF CLAY REINFORCED WITH KEROSINE – TREATED COIR FIBER, V Lestelle, Diego S A, Alcantara M, (2020).

The novel aspect of this research lies in the treatment of coir fiber with kerosene aiming to enhance its compatibility with clay and consequently improve the overall strength characteristics of the composite material. The experimental methodology involves
systematically blending kerosene treated coir fibers with clay and subjecting the resulting mixtures to rigorous laboratory testing to quantify the impact on UCS. The results of this research contributes not only to the understanding of soil reinforcement
with coir fibers but also present a unique perspective on the role of kerosene treatment in optimizing the effectiveness of this natural reinforcing material.

I . RESEARCH METHODOLOGY



The purpose of this study is to put forward a stabilization method for soil in kuttanad region. Here stabilization will be done by treating the soil with coconut fiber. Coconut fiber, it can find application in soil stabilization, addressing issues like erosion and
improving the properties of the soil. First the basic properties of the soil collected will be determined using some tests. Thus, the characteristics of the soil in that region can be determined. Then UCC test will be used to determine the effect of coconut fiber on
the strength of soil. Effect of curing on the material will also be studied.
The tests that will be conducted are:
* Specific Gravity test – IS 2720(Part III)-1980
* Atterberg Limit test – IS 2720 (Part V)-1985
* Standard proctor test – IS 2720 (Part VII)- 1974
* Unconfined Compressive Strength test – IS 2720 (Part II)-1973
* California Bearing Ratio test – IS:2720 (Part XVI):1987**3.1Population and Sample**

KSE-100 index is an index of 100 companies selected from 580 companies on the basis of sector leading and market capitalization. It represents almost 80% weight of the total market capitalization of KSE. It reflects different sector company's performance and productivity. It is the performance indicator or benchmark of all listed companies of KSE. So it can be regarded as universe of the study.Non-financial firms listed at KSE-100 Index (74 companies according to the page of KSE visited on 20.5.2015) are treated as universe of the study and the study have selected sample from these companies.

The study comprised of non-financial companies listed at KSE-100 Index and 30 actively traded companies are selected on the bases of market capitalization.And 2015 is taken as base year for KSE-100 index.

Fig 3.2.1 : Soil sample

3.2 Materials Used

3.2.1 Expansive soil

* The clayey soil was collected from Kuttanad taluk, Alappuzha district, Kerala.
* The soil founded is expansive soil, that is it will show high shrinkage and swelling.
* This soil has very low strength, and all the engineering properties required for construction is very low.
* Instability of this soil is the main reason for bund breaching in the agricultural fields of Kuttanad.

Fig 3.2.1 : Soil sample

3.2.2 Coconut Fiber

* Using coconut fiber to strength clay is a common practice in soil stabilization. The fibers add tensile strength to the clay, reducing cracking and improving its overall stability.
* The coconut fiber has the highest tensile strength among all natural fibers because it contains 54% cellulose. The fiber has a high lignin content so that the degradation process is the slowest among other natural fibers.
* The fibers in coconut coir have mechanical properties that are rigid, tough and resistant to compressive forces to withstand cracks and fractures. The strength of the fiber itself varies, depending on the size of the diameter and the degree of defects that exit in the fiber.
* If they are mixed thoroughly these fibers will work optimally throughout the soil layer.

Fig 3.2.2 : Coconut fiber

Table 3.2.2: Properties of coir fiber

PROPERTIES	VALUE
COLOR	Golden
LENGTH	4- 12 cm
DIAMETER	0.20 - 0.4 mm
DENSITY	1.15 g/cm3
MOISTURE CONTENT	8 - 15 %
pH	6 - 6.7
THERMAL CONDUCTIVITY	Low
WATER ABSORPTION CAPACITY	High
SPECIFIC GRAVITY	1.15

3.23 PREPARATION OF TESTING SOIL

Soil sample collected will be mixed with coconut fiber .Coconut fiber is extracted from the husk of the coconut which is easily and locally available, cheap, biodegradable and eco-friendly.It is collected from the coir manufacturing industry. Percentages of coconut fiber that will be added to the soil are 0.25%, 0.5%,0.75%, 1%, 1.25% & 1.5%.

3.4 EXPERIMENTAL SETUP

3.4.1Specific Gravity

To determine the specific gravity of soil fraction passing 4.75mm I.S sieve by pycnometer. Specific gravity is defined as the ratio of the weight of a given volume of the soil particles to the weight of an equal volume of distilled water at that temperature, both weights taken in air. The specific gravity of the soil particles lie within the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2. Soils having heavy substances may have values above 3. The apparatus used in the test are

- Pycnometer of about 900ml capacity with conical brass cap.
- Balance to weight the materials
- Wash bottle with distilled water
- Glass rod Testing procedure for specific gravity:

Clean and dry the pycnometer. Tightly screw its cap. Weigh the empty bottle with stopper(W1). Unscrew the cap and place about 200gm of oven dried soil in the pycnometer. Screw the cap, determine the mass (W2). Unscrew the cap and add sufficient amount of de – aried water to the pycnometer so as to cover the soil. Screw on the cap. Remove the entrapped air. Shake well the contents. Fill the pycnometer with water about three fourths full. Dry it from outside and determine the weight of the bottle and the contents(W3). Empty the pycnometer, clean it and wipe it dry. Fill the pycnometer with the water only. Screw on the cap upto the mark. Wipe it dry. Take its mass(W4). Repeat the same process for 2 to 3 times, to take the average reading of it.

3.4.2 Atterberg limit test is also conducted for Liquid Limit The liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit, the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit.

3.4.3 Standard Proctor Test Compaction is the process of increasing soil density by mechanical means. It leads to rearrangement of soil particles and reduction of voids. Highly compacted soils have few voids and therefore a higher unit weight. The degree of compaction of soil is measured in terms of dry density and this dry density is maximum at optimum moisture. By plotting a graph between dry density and water content of the different samples, the OMC and max dry density can be determined.

3.4.4 Unconfined Compression Test - It is not always possible to conduct the bearing capacity test in the field. Sometimes it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also, to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remoulded soil sample. We will investigate experimentally the strength of a given soil sample. The apparatus available for this test is,

- Compression machine
- Proving ring
- Deformation dial gauge
- Timer, Sampling tube
- Specimen extruder
- Split mould
- Specimen trimming tools.
- Vernier calipers
- Balance
- Apparatus for moisture content determination.

Testing Procedure: Prepare the test specimen, which may be either undisturbed, remoulded or compacted. Undisturbed specimens can be carved from a large soil block, or obtained through a sampling tube from which the specimen can be extruded to a split mould using a sample extruder. 2. Trim the two ends of the soil specimen, remove it from the mould, and measure the length, diameter and weight. 3. Place the specimen on the bottom plate of the compression machine and adjust the upper plate to make contact with the specimen. Initialize the vertical displacement gauge and proving ring gauge to zero. Select an axial strain rate between 0.5% to 2.0% per minute and apply compression load. Record the load and displacement readings at every 20 to 50 divisions of displacement gauge, or at every 15 seconds. Compress the specimen till the load peaks and then falls, or till the vertical deformation reaches 20% of the specimen length. Remove the specimen from the machine and take soil samples for water content determination.

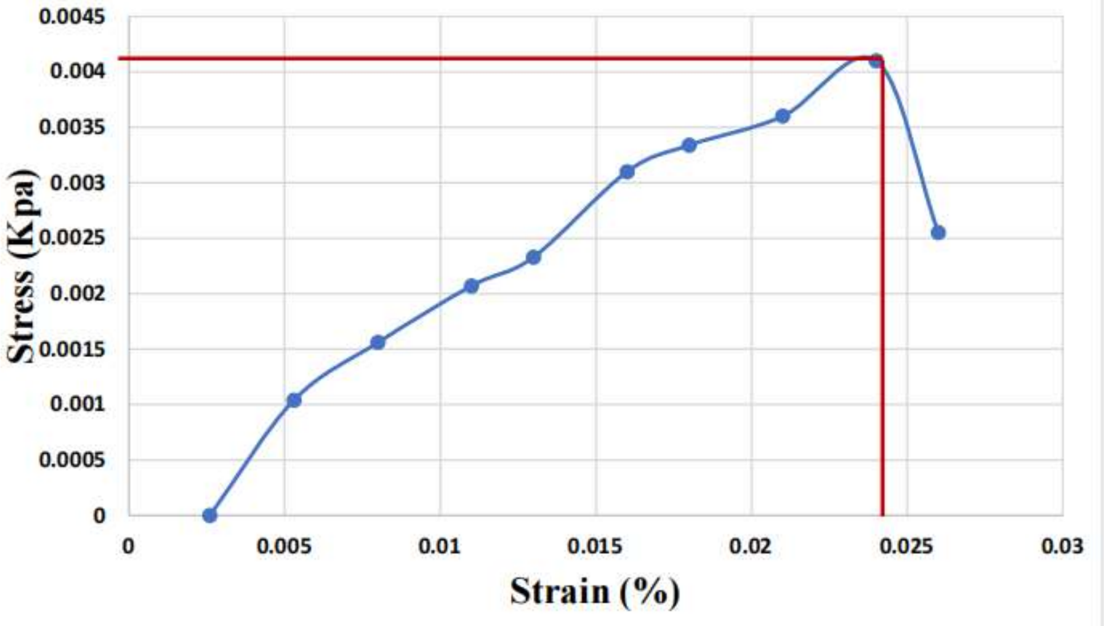
3.4.5 California Bearing Ratio Test -According to IS: 2720 (Part 16) – 1987 The ratio expressed in percentage of force per
unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1’25 mm/min to that required for. corresponding penetration in a standard material. The ratio is usually determined for penetration of 2’5 and 5 mm. Where the
ratio at 5 mm is consistently higher than that at 2’5 mm, the ratio at 5 mm is used. Therefore, the CBR value of a soil can be considered as an index which, in a way, is related to its strength. The test used to determine CBR value is known as CBR test. This method was used by the California State Highways in the United States until 1950 to evaluate subgrade soil strength for flexible pavement design. Report use advanced curves prepared from the study of performance of flexible pavement.
Apparatus involved in this test are:

- Cylindrical mold having a nominal internal diameter of 152±0.5 mm with a detachable plate and collar.
- 20 mm and 4.75mm IS sieve.
- Compaction rammer- detail of the rammer with respect to compaction.
- surcharge weight-annular weights each of 2.5kg and 147mm diameter.
- Spacer discs are 148 mm diameter and 47.7 mm height.
- A compression device for static compaction. The device shall be capable of applying a force of at least 300 KN.
- Weighing balance, filter paper etc.

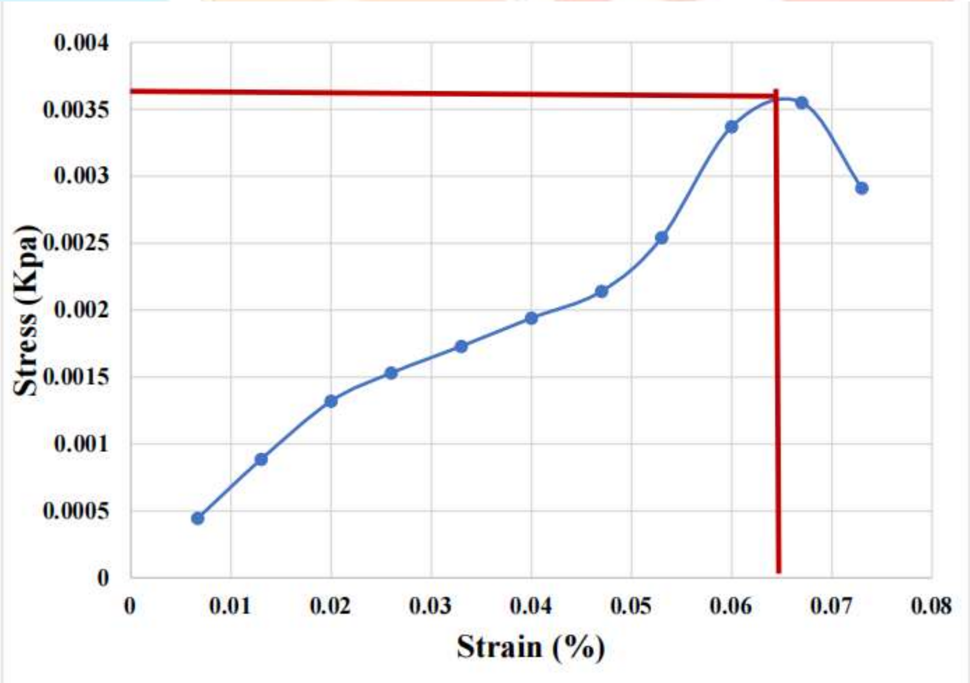
4.1 RESULT AND ANALYSIS

Least count of the dial gauge = 0.01
Proving ring constant (kN / Div) = 3.17
Initial length of the specimen (LO) = 75 mm
Initial diameter of the specimen (Do) = 30 mm

Dial gauge reading	**Proving ring reading**	**Displacement (mm)**	**Load (kN)**	**Strain, ε=AL/L0**	**Corrected area, A= A0/1-ε**	**Compressive stress□= P/A**
20	0	0. 2	0	2.6×10^{-3}	708.75	0
40	0. 2	0. 4	0. 74	5.3×10^{-3}	710.75	1.04×10^{-3}
60	0. 3	0. 6	1. 11	8×10^{-3}	712056	1.56×10^{-3}
80	0. 4	0. 8	1. 481	0.011	714.72	2.07×10^{-3}
100	0. 45	0. 1	1.67	0.013	716072	2.33×10^{-3}
120	0. 6	1. 2	2.23	0.016	718.35	3.1×10^{-3}
140	0. 65	1. 4	2.41	0.018	719.82	3.34×10^{-3}
160	0. 7	1. 6	2.6	0.024	722.02	3.6×10^{-3}
180	0. 8	1. 8	2.87	0.024	724.24	4.1×10^{-3}
200	0. 5	2	1.85	0.026	725.23	2.55×10^{-3}

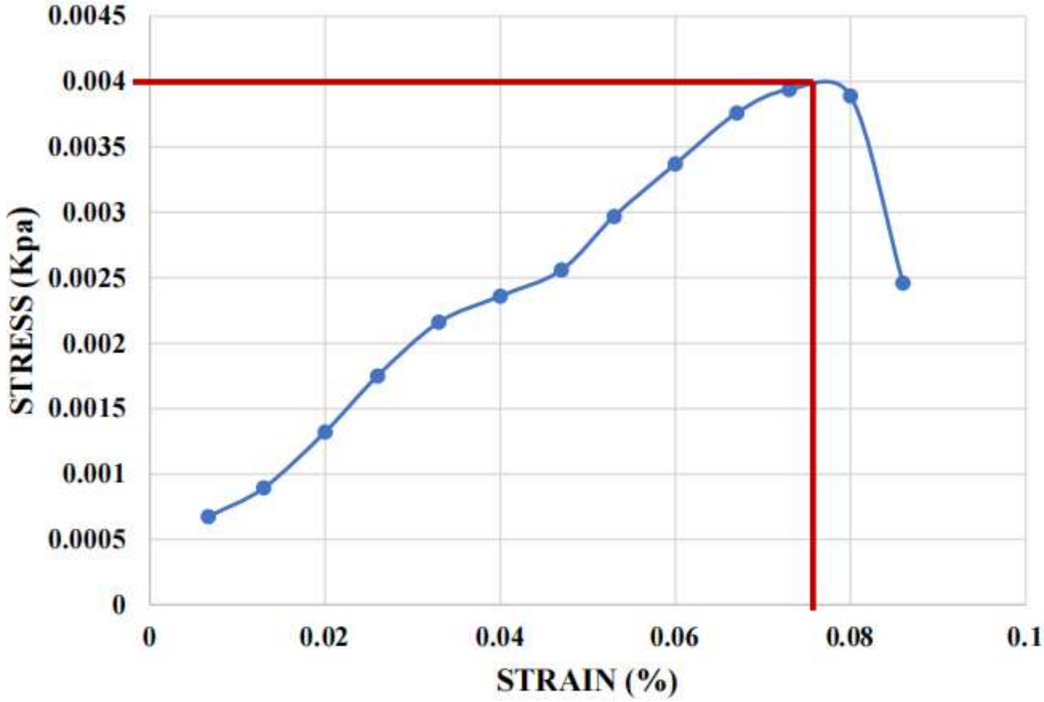


Unconfined Compressive Strength = 4.2 Kpa



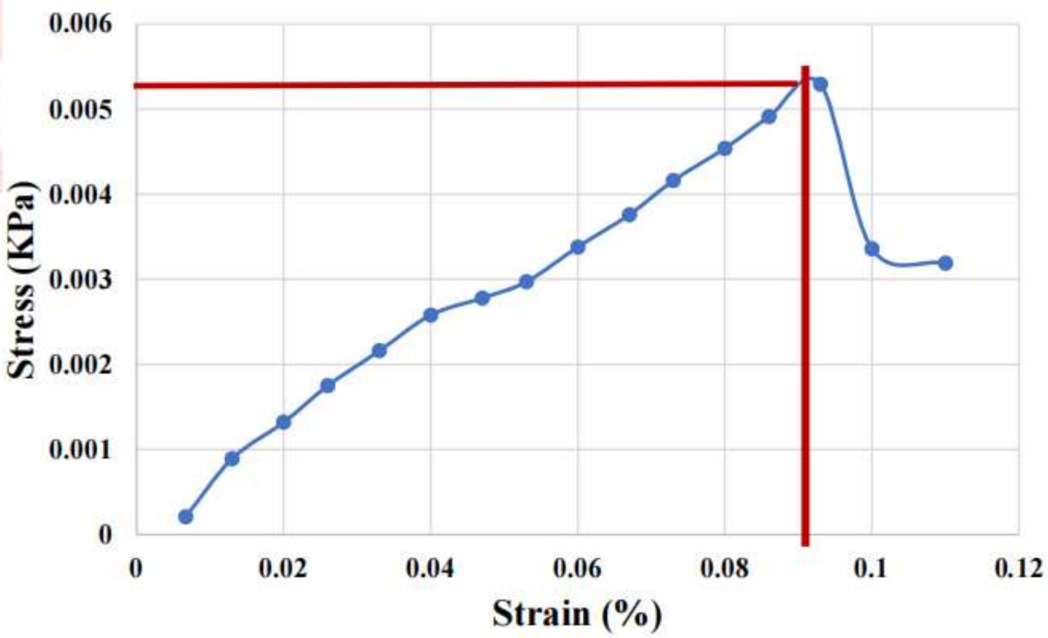
(a) UCS of 0.25%

Unconfined compressive strength = 3.6 Kpa



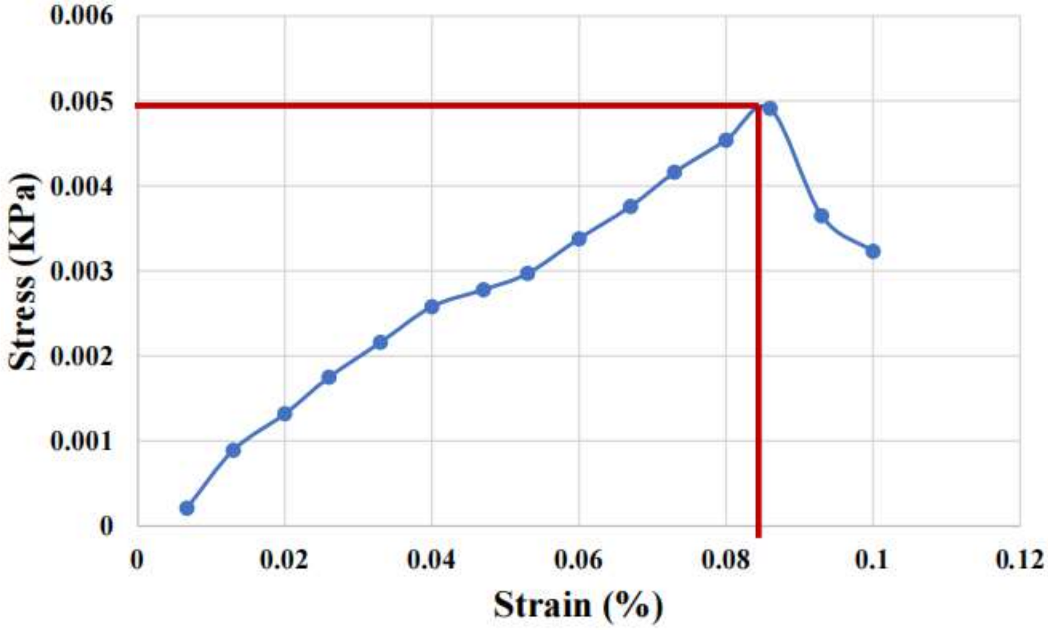
(b)UCS of 0.5%

Unconfined Compressive Stress = 4Kpa



(c)UCS OF 1%

Unconfined compressive stress = 5.4Kpa



(d) UCS of 1.25%

Unconfined Compressive Strength = 5 KPa

3.4.3.1 TESTS TO DETERMINE OPTIMUM PERCENTAGE OF COCONUT FIBER

In order to determine the optimum percentage of coconut fiber to be added to obtain maximum strength the soil is treated with different percentages of coconut fiber. Unconfined compressive strength test is done on the soils treated with different
percentages of coconut fiber. By comparing the results optimum percentage is determined.
This equation is as follows;

3.4.3.2 UCS of 0.25%

Least count of dial gauge = 0.01
Proving ring constant = 3.217
Initial length of specimen, L0 = 75 mm
Initial diameter of specimen, D0 = 30 mm
Initial area of specimen, A0 = 706.86mm^2

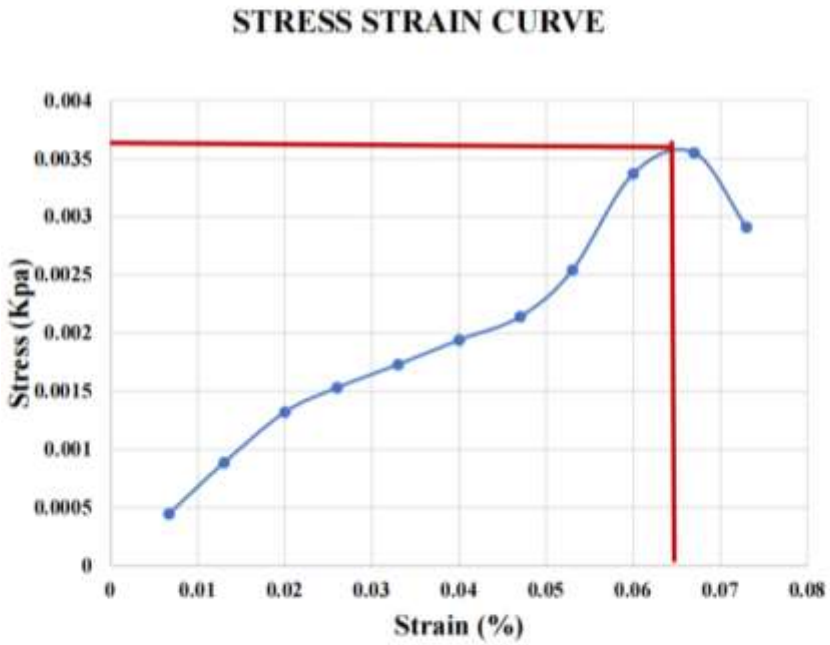


Fig 4.6.1 Stress strain curve

Unconfined compressive strength = 3.6 Kpa

II. CURING PROCEDURE

Curing for unconfined compressive strength (UCS) of clay with coconut waste typically involves maintaining a controlled environment, such as constant temperature and humidity, to allow the clay-coconut waste mixture to undergo hydration and achieve its optimal strength. This process helps the clay particles bond with the coconut waste fibers, enhancing the overall strength of the material. The duration of curing can vary depending on factors like the specific mixture proportions and environmental conditions.

Curing done for 7 days in unconfined compressive strength of clay using coconut waste

Curing for 7 days in unconfined compressive strength (UCS) testing of clay with coconut waste involves subjecting the clay-coconut waste mixture to a controlled environment for a period of seven days. During this time, the mixture undergoes hydration, allowing the clay particles to bond with the coconut waste fibers and develop strength. The curing conditions typically involve maintaining a constant temperature and humidity level to promote optimal bonding and strength development. After the 7-day curing period, the mixture is tested for its compressive strength to assess its suitability for various applications.

Curing done for 3 days in unconfined compressive strength of clay using coconut waste

Curing for three days is a common practice to enhance the strength of clay mixed with coconut waste. During this time, the mixture undergoes hydration, allowing the clay particles to bind together more effectively. This process helps improve the unconfined compressive strength, making the material more durable and suitable for various construction applications. The three-day duration ensures sufficient time for the curing process to take place, resulting in a stronger final product.

III. CONCLUSION

1. The value of the unconfined compressive strength of clay has increased along with the more coconut fiber added.
2. The maximum value of unconfined compressive strength and secant modulus obtained in clay with coconut fiber
reinforcement is 0.75% of the mixed soil weight.
3. The clay strengthened with coconut fiber becomes stiffer than the initial soft clay, thereby improving its soil stability.

In further research, it is necessary to test the durability of a mixture of soil and coconut fiber. In further research, it is necessary to test the durability of a mixture of soil and coconut fiber.

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