

SUSTAINABLE STABILISATION OF SOIL USING JUTE FIBRE IN DELHI REGION

by Ankita Yadav

Submission date: 26-May-2026 10:44AM (UTC+0530)

Submission ID: 2969635907

File name: Ankita_proj.pdf (2.44M)

Word count: 8847

Character count: 53305

M. Tech Geotechnical Engineering

Ankita Yadav

2026

SUSTAINABLE STABILISATION OF SOIL USING JUTE FIBRE IN DELHI REGION

A DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE
OF

MASTER OF TECHNOLOGY

IN

GEOTECHNICAL ENGINEERING

Submitted by:

ANKITA YADAV

(2K24/GTE/03)

Under the Supervision of

Prof. KONGAN ARYAN



Department of Civil Engineering

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Shahbad Daulatpur, Bawana Road, Delhi-110042

MAY 2026



DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Bawana Road, Delhi-110042

CANDIDATE'S DECLARATION

I, **ANKITA YADAV**, ² **Roll No: 2K24/GTE/03** student of M. Tech (Geotechnical Engineering) , hereby declare that the project Dissertation titled "SUSTAINABLE STABILIZATION OF SOIL USING JUTE FIBRE IN DELHI REGION"² which is submitted by me to the **Department of Civil Engineering, Delhi Technological University, Delhi** in the partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work was not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

ANKITA YADAV

Place: Delhi

Date:



DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Bawana Road, Delhi-110042

CERTIFICATE

I hereby certify that the Project Dissertation titled “SUSTAINABLE STABILIZATION OF SOIL USING JUTE FIBRE IN DELHI REGION”² which is submitted by **ANKITA YADAV, Roll No: 2K24/GTE/03** Department of ²Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the Degree of Master of Technology, is the record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Prof. Kongan Aryan

SUPERVISOR

Associate Professor

Department of Civil Engineering

Delhi Technological University

Place: **Delhi,**

Date:

ABSTRACT

This study investigated randomly distributed natural fibers as a reinforcement for Poorly Graded Sandy Soil. Sands are found widely and are, particularly, vulnerable to variations in moisture and low strength in engineering-related issues. Weak soil frequently requires stabilisation when the intended use requires strength and durability. These soils are porous, and exist widely in parts of Northern and southern India. In building roads, subgrade strength should be increased when encountering weak subgrades, as the strength of the subgrade soil has a major impact on the thickness and lifespan of the pavement. Increasing strength and stability of the subgrade soil can help reduce pavement thickness through reduced construction costs, with traditional building materials being preserved for the generation to follow.

Jute Fibre for the improvement of soil is an advantageous option and low-cost for environmental conservation, it can be readily derived ¹⁷ and improves engineering properties of soil. Soil subgrade enhancement is a perennial subject of concern for soil engineering. To strengthen the soil subgrades, I employed jute fibre, which is advantageous, as it is relatively cheap, readily available at a local level, biodegradable, and eco-friendly. I used

jute fiber mixed with soil at different lengths 40mm and 45mm and at different percentages 0.5% , 1% , 1.5% , and 2.0% , and the diameter of jute fibre is 2mm.

Compaction tests across different fibre contents established the specific characteristics of the compaction curves, as the fibre content was enhanced , so the OMC of the soil was increasing but the maximum dry density decreased . ⁷Maximum dry density reduced as the length of fiber was increased and OMC ⁷was observed to increase significantly . The engineering properties of the soil (poorly graded sand (SP)) , reinforced with jute fibre, were analysed in this study. The lab tests , Proctor and CBR were carried out using 40mm and 45mm long jute fibre that had different percentages (0.5%, 1.0%, 1.5%, 2.0%), to determine the optimal value of jute fibre.

ACKNOWLEDGEMENT

I, **ANKITA YADAV**, would like to express my gratitude to all those who have given unforgettable contributions to the successful contribution of this thesis.

I would like to place on record, my thanks to Prof. Prateek Sharma, Vice Chancellor, ¹¹ for providing all the facilities and helping in carrying out this project.

I am also grateful to **Dr. Awadesh Kumar**, Professor and Head, in Department of Civil Engineering for the encouragement and support provided during the project work.

I would like to express my ¹² sincere thanks to the coordinator **Dr. A. K. Sahu**, Professor for his valuable suggestions for improvement during project reviews.

I hereby acknowledge with deep sense of gratitude the valuable guidance, encouragement and suggestions given by my project guide ³ **Prof. Kongan Aryan**, Professor who has been a constant source of inspiration throughout this project.

I would also like to take this opportunity to thank all the faculty members and non-teaching staff members in the Department of Civil Engineering for their direct and indirect help rendered during the course of the project work.

I would like to give a huge token of gratitude to my parents and all ²⁷ family members for their unwavering support and understanding throughout this journey. Their encouragement, motivation, and belief in my abilities have been a constant source of strength.

ANKITA YADAV
(2K24/GTE/03)

CONTENTS

CANDIDATE'S DECLARATION	II
CERTIFICATE.....	III
ABSTRACT.....	IV
ACKNOWLEDGEMENT.....	VI
CONTENTS.....	VII
LIST OF TABLES	X
LIST OF FIGURES	XI
LIST OF ABBREVIATIONS	XII
CHAPTER 1	13
INTRODUCTION.....	13
1.1 GENERAL	13
1.2 TYPES OF NATURAL FIBERS.....	13
1.3 JUTE FIBER	14
1.3.1 PROPERTIES OF JUTE.....	15
1.3.2 APPLICATIONS OF JUTE.....	16
1.3.4 USES OF JUTE	16
1.4 FIBER REINFORCED SOIL	17
1.5 MOTIVATION OF STUDY	18
1.6 OBJECTIVES	18
CHAPTER 2	19
LITERATURE REVIEW	19

2.2 GAPS IN LITERATURE	23
CHAPTER 3	25
MATERIAL AND METHODOLOGY	25
3.1 METHODOLOGY	25
CHAPTER 4	26
EXPERIMENTAL PROGRAMME	26
4.1 GENERAL	26
4.2 MATERIAL PROPERTIES	26
4.2.1 SOIL SAMPLE	26
4.2.2 Grain Size Analysis:	27
4.2.3 Atterberg Limits	30
4.2.4 Moisture Content Test	32
4.2.5 Specific gravity	32
4.2.6 Standard Proctor Test	34
4.2.7 DIRECT SHEAR TEST	36
4.2.8 CALIFORNIA BEARING TEST	38
4.3 Jute Fibers	40
CHAPTER 5	41
SAMPLE PREPARATION	41
5.1 GENERAL	41
5.2 COMPACTION TEST	42
5.3 CALIFORNIA BEARING RATIO TEST	43
CHAPTER 6	44
EXPERIMENTAL OBSERVATIONS, RESULTS AND DISCUSSIONS	44
6.1 GENERAL	44
6.2 EFFECT OF JUTE FIBRE ON COMPACTION CURVES	44
6.2.1 FOR FIBRE LENGTH	44
6.2.1 FOR FIBRE LENGTH (45mm)	46

6.3 EFFECT OF JUTE FIBRE ON CALIFORNIA BEARING RATIO TEST	49
CHAPTER 7	52
SUMMARY AND CONCLUSIONS	52
7.1 SUMMARY	52
7.2 CONCLUSIONS.....	53
<u>REFERENCES</u>	<u>55</u>

LIST OF TABLES

<i>Table 1. Properties of Natural Fibres.....</i>	<i>14</i>
<i>Table 2 Sieve analysis of soil.....</i>	<i>29</i>
<i>Table 3: Specific Gravity.....</i>	<i>33</i>
<i>Table 4 : Proctor Test.....</i>	<i>35</i>
<i>Table 5 : Direct Shear Test.....</i>	<i>36</i>
<i>Table 6 : California Bearing Test.....</i>	<i>38</i>
<i>Table 7 : Summary of index properties test.....</i>	<i>39</i>
<i>Table 8 : Summary of fibre properties</i>	<i>40</i>
<i>Table 9 : Soil Sample with 0.5% of Jute Fiber</i>	<i>44</i>
<i>Table 10 : Soil Sample with 1.0% of Jute Fiber</i>	<i>45</i>
<i>Table 11: Soil Sample with 1.5% of Jute Fiber</i>	<i>45</i>
<i>Table 12: Soil Sample with 0.5% of Jute Fiber</i>	<i>46</i>
<i>Table 13: Soil Sample with 1.0% of Jute Fiber</i>	<i>46</i>
<i>Table 14: Soil Sample with 1.5% of Jute Fiber</i>	<i>46</i>
<i>Table 15 : Laboratory Results of Standard Proctor Test.....</i>	<i>48</i>
<i>Table 16 : Effect of jute percentage on CBR value</i>	<i>51</i>

LIST OF FIGURES

Figure 1 : Jute fibers.....	15
Figure 2 :Flowchart of Methodology.....	25
Figure 3: Soil collected site location.....	26
Figure 4: Soil Sample	27
Figure 5: Sieve Analysis	28
Figure 6 : Grading characteristics of study soil.....	29
Figure 7: Liquid Limit Apparatus	30
Figure 8 : Flow Curve.....	31
Figure 9: Plastic Limit.....	31
Figure 10 :Pycnometer	33
Figure 11: Compaction curve of unreinforced soil	35
Figure 12: Displacement vs Shear Stress.....	37
Figure 13: Normal Stress vs Shear Stress.....	37
Figure 14 : Penetration vs Load.....	39
Figure 15: 45mm Jute fibre.....	41
Figure 16 :Jute Fibre mixed in Soil Sample.....	42
Figure 17 : CBR.....	43
Figure 18: Compaction Curves for 40mm Jute Fibre Length	45
Figure 19 : Compaction Curves for 45mm Jute Fibre Length	47
Figure 20 :Effect of Fibre Content on MDD.....	47
Figure 21:Effect of Fibre Content on OMC.....	48
Figure 22 : Load Penetration Curve for 40mm fibre length.....	49
Figure 23: Load Penetration Curve for 45mm fibre length.....	50
Figure 24 : Effect of fibre content on CBR value.....	50

LIST OF ABBREVIATIONS

- C_u = Coefficient of uniformity
- C_c = Coefficient of curvature
- D_{10} = Effective particle size (m)
- D_{30} = Diameter through which 30 % of the total soil particles is passing
- D_{60} = Diameter through which 60 % of the total soil particles is passing
- OMC = Optimum moisture content
- G = Specific gravity of soil
- MDD = Maximum dry density
- C = Cohesion
- Φ = Angle of internal friction
- τ = Shear strength
- σ = Normal stress
- γ_b = Bulk Density
- γ_d = Dry Density
- I_p = Plasticity Index
- W_p = Plastic limit
- W_L = Liquid Limit

CHAPTER 1

INTRODUCTION

1.1 GENERAL

During recent times , natural resources are being used up , landfills are filling up , planed is becoming more polluted by the day and ¹non- renewable resources will not last forever. Hence , there is a need to depend on more environmentally friendly materials . That is the reason why there have been many experimental investigations carried out across the globe which has led to creation of great deal of interest ¹potential applications of natural fibers for soil reinforcement in recent years. The term “eco-composite” depicts the importance of role of natural fibers in the modern industry. It mainly tells as to what part of the plant fiber came from , what is the age of the plant and the how the fiber was isolated . These are some of the factors which affect the performance of natural fibers when we use them for soil reinforcement .

¹1.2 TYPES OF NATURAL FIBERS

It is essential to mention that for a long time , Natural fibers have been used in many developing countries due to their availability and low cost in cement composites . The properties and composition of certain natural ³fibers are shown in Table 1.

Table 1. Properties of Natural Fibres

Type of fiber	Cellulose (wt%)	Lignin (wt%)	Hemicellulose (wt%)	Density (g/cm ³)	Tensile Strength (MPa)	Moisture absorption (%)
Flax	71-78	2.2	18.6-20.6	1.4-1.5	345-1500	7
Hemp	57-77	3.7-13	14-22.4	1.48	550-900	8-9
Jute	45-71.5	12-26	13.6-21	1.3-1.46	393-800	307
Kenaf	31-37	15-19	21.5-23	1.2	295-930	12
Sisal	47-78	7-11	10-24	1.33-1.5	400-700	56-230
Cotton	85-90	0.7-1.6	5.7	1.21	287-597	890-1165
Coir	36-43	41-45	0.15-0.25	1.2	175-220	130-180

1.3 JUTE FIBER

Jute is the among the world's most natural important natural fibers . It come second to cotton in production . Jute is abundantly grown in Bangladesh, China, India and Thailand. It is extracted from the fibrous bark of jute plants , these plants grow as tall as 2.5m along with the the base stem diameter of 25 mm. Different varieties of jute fibers have varying properties . Jute is considered to be environmental-friendly fiber that is used in production of porous textiles which are further used for filtration, drainage, and soil stabilization.

Jute is a bast fiber obtained from two species namely White Jute (Cochoruscapsularis) and Tossa Jute (Corchorusolitorius). Every part of jute from root to stem is put to use in different forms such as packaging material, furnishing fabrics, vegetables, cooking fuel etc.

Due to jute being a coarse textile fibre it is mainly used as a raw material for the production of packaging material. Jute fibre is fairly lustrous when Properly retted and washed . The color of the fibre varies from creamy white to brown. Jute and its products are bio degradable, photodegradable, thermal degradable, nontoxic, hydrophilic, droppable and less extensible with high moisture and UV absorbing capacity. Due to the presence of cellulose and lignin respectively , jute shows similarity with cotton and wood simultaneously . Attributable to its properties , large number of traditional and diversified jute products are produced .



Figure 1 : Jute fibers

1.3.1 PROPERTIES OF JUTE

- High strength and modulus-Low extensibility
- Moisture absorbing ability
- High abrasion resistance
- Good thermal stability
- Insulation against sound
- Anti-static property
- Surface morphology

1.3.2 APPLICATIONS OF JUTE

- Typically jute has been used for the production of packaging material such as hessian, sacking, ropes, twines, carpet backing cloth etc .

- Yams/Twines/Cordages

- A variety of yarns / twines / cordages (3lbs-500lbs) are manufactured in various counts / diameters . For tying, knotting, and binding etc Jute yarns of various dimensions are plied together to make twines as per requirement and use.

1.3.3 PHYSICAL PROPERTIES OF JUTE

- Ultimate length: 1.5 – 4 mm
- Ultimate diameter: 0.015 – 0.020 mm
- No. of ultimate in X-section: 6 – 10
- Fibers length: 5 – 12 ft
- Color: White, Off White, Yellow, Brown, Grey, Golden
- Strength (Tenacity): 3 – 4 gm/den
- Elongation: 1.7% at the break
- Specific Gravity: 1.5
- Moisture Regain(mr%):13.75%
- Dimensional stability : good
- Abrasion resistance : average
- Effect of light and heat: average

1.3.4 USES OF JUTE

Next to cotton , jute is the second most important vegetable fibre . Not only for cultivation but also for various uses :

Jute is most commonly used for creating cloth to wrap bales of raw cotton and for making sacks and coarse cloths .

Fibers are also woven into curtains , chair coverings , carpets , area rugs , hessian cloth , and backing for linoleum .

While jute is being replaced by synthetic materials by many of these uses, some uses take advantage of the biodegradable nature of jute where synthetics would not be suitable. Jute butts, the coarse ends of the plants, are used to make inexpensive cloth.

1.4 ¹FIBER REINFORCED SOIL

The fibre-reinforced soil is defined as a soil mass that contains randomly distributed, discrete elements, i.e. fibers, which provide an improvement in the mechanical behaviour of the soil composite. ¹Fibers of relatively high tensile strength are embedded in a matrix of soil which makes the fibre-reinforced soil behave as a composite material.

¹Shear stresses in the soil mobilize tensile resistance in the fibers, which in turn imparts greater strength to the soil. To mimic the behaviour of plant roots and to stabilize the soil mass by adding strength to the near-surface soils in which the effective stress is low, random discrete flexible fibres are used. Further ¹laboratory and some in situ pilot test results have led to encouraging conclusions proving the potential use of fibers for the reinforcement of soil mass providing an artificial replication of the effects of vegetation. To mimic the behaviour of plant roots and to stabilize the soil mass by adding strength to the near-surface soils in which the effective stress is low, random discrete flexible fibres are used.

1.5 MOTIVATION OF STUDY

The lifespan of pavement is closely connected to the subgrade soil beneath. Subgrade failure may result in surface fracture formation. Therefore, a new reinforcing material will become necessary to stabilize the subgrade. Jute fibre is an ideal choice for soil reinforcement due to its natural, biodegradable and environmentally friendly nature—therefore avoiding dependence on synthetic stabilizers. It is inexpensive, easily available, and renewable, making it suitable for sustainable construction practices. Although naturally produced jute has excellent tensile strength and flexibility in soil which is beneficial in enhancing soil stability, interlocking, and deformation resistance. However, its natural biodegradation is a major limitation that restricts its utility in civil engineering in the long run. Thus, to overcome this drawback and to maximize the functionality of jute for extended geotechnical applications, specific diameter, length and concentration of jute are used. On the other hand, the development of natural fibre composites is moving toward the development of ecologically friendly matrix materials which deliver superior performance at a lower cost than conventional synthetic matrices. Finally, the use of jute fibre as a soil reinforcement has been shown to be very promising in recent researches.

1.6 OBJECTIVES

The objectives of this study involve,

- To evaluate the enhancement in strength characteristics of sand reinforced with 40mm and 45mm lengths of jute fibre at varying fibre concentrations.
- To investigate and compare the effect of jute fibre length on Optimum Moisture Content and Maximum Dry Density when soil is reinforced with fibre.
- To assess the compaction characteristics of sand reinforced with jute fibre.
- To methodically analyse examine the overall structural behaviour of the soil-fibre composite with varying fractions and lengths of jute fibres.
- To determine the optimal Fibre parameters (ideal fibre content) that contributes to maximum increase in strength of the reinforced soil.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Mr.D.Rambabu et al, (2024) have done an ¹ investigation study on improvement in CBR value of soil reinforced with jute fibre: it found that adding jute fiber to soil increases California Bearing Ratio (CBR) compared to unreinforced soil. As the quantity of jute fiber increases, CBR values continue to increase significantly, with significant improvements observed up to around 5% fiber content. Longer and thicker jute fibers also increase CBRs and thus the reinforced soil is stronger and stiffer than plain soil as the results indicate.

Shwetha Prasanna et. al (2020) in their investigation called “Use of Jute Fiber in Soil Stabilisation : the work concludes that mixing jute fibre particles (0.5–2%) in the soil enhances its engineering characteristics such as strength quality. According to laboratory study, reinforcement of the soil exhibits much improvement over the stability of the soil, since the CBR and shear properties are better for the improved soil than for the un-reinforced soil. The fact that jute fiber can convert otherwise weak soils beneficial for construction purposes such as road subgrades and site development. Jute fiber works as an eco-friendly soil stabilizer.

Naveed Anjum Dar and Dr. Gunjan Bhalla, (2020) in ²¹ “Stabilization of Soil using Jute Fibre and Stone Dust : The results demonstrated that the California Bearing Ratio (CBR) of the soil increases substantially with the addition of jute fiber and this effect is further

pronounced as the fiber length and content increased. CBR showed the greatest improvement > 200 % vs. plain soil at 1 % jute fiber with 90 mm length . Stone dust also increased CBR but not as much as jute fiber . Under weak soil , fiber-reinforced soil is efficient for ground improvement .

Amitesh Kumat et. al, (2020) in their study titled “Stabilization of Mountainous Subgrade Using Jute Fibre and Cement : in the experiment found that jute fiber and cement applied to reinforce clayey subgrade is more effective than just treating untreated soil in establishing a ³⁸ California Bearing Ratio (CBR) of the material . The maximum CBR values ⁵ for jute fiber were achieved at about 0.4% fiber content , while the best CBR for cement was around 5–7% depending on conditions . However , when adding jute fiber together with cement , CBR was markedly boosted considerably , especially when subjected to soaked conditions . In general , blending jute fiber with cement can also provide improved strength and load-bearing capacity of weak clayey soils .

Majid Rehman Rather and Er Vijay Kumar , (2019) in their study titled “ Soil Stabilization using Jute fiber : have noted that the reduction of the dry density of the jute fiber-based mixture as the percentage of jute fiber increased in combination with the moisture content , thus the results indicate limitations to the use within the highest moisture . Jute fiber reinforcement is therefore only applicable for soils that are considerably lower in moisture . The results indicate that jute will need to be carefully employed according to the moisture level of the soil for stabilization to work well .

Jothy V K Hema (2019) in their study titled “ Improvement of ¹⁹ Shear Strength of the Soil by using Jute Fabric : The study shows that jute fabric used for soil improves shear strength much greater than that of raw soil. The most significant increases in shear strength occurred at an optimum jute fabric content of roughly 6%. Above this value , however , the shear strength started to decrease . The data suggests that the effective rates of jute fabric use for soil reinforcement are only up to an optimal percentage .

K. Ravi Kanth and K. Deepti (2019) in their study titled “¹⁷An Experimental Study on Stabilisation of a Loose Soil by Using Jute Fiber : The study found that the addition of jute fiber up to 0.75% has increased critical engineering properties from loose soil such as maximum dry density and California Bearing Ratio (CBR), when compared to untreated soil. Improvements are shown to decline above 0.75% fiber. The optimum moisture content tended to decrease with higher jute levels, and the unconfined compressive strength in treated soils was greater than in the standard soil . The fact is that these results suggest that jute fiber , used in the proper proportions , significantly improves soil strength .

K. Arun Kumar et. al, (2019) in their study titled “Investigation of Soil Stabilization using Jute Fiber and Glass Powder : The addition of jute fibre and glass powder to clay soil had positive engineering effects ⁹compared to untreated soil . As seen , the application of 2% jute fibre helped to promote unconfined compression ⁹strength and increased ⁹stability of the soil for building applications. Additives also helped to stabilise and enhance ⁹dry density and optimum moisture content , indicating higher load-bearing performance . These findings imply that environmentally friendly soil stabilization can facilitate stronger and longer-lasting infrastructure.

Zafar Iqbal Ahanger and Abhishek Bawa , (2018) in their study titled “Utilisation ⁶of Jute Fibre as Soil Reinforcement : the study states that the addition of jute fibre significantly enhances ⁵the California Bearing Ratio (CBR) of soil , consequently increasing its strength for subgrade purposes . ³⁴The CBR value increases with increasing fibre content , with the optimum improvement observed at 0.75% jute fibre. Moreover , the optimum moisture content (OMC) of the soil rises as the fibre content increases .

Prithibi Das et. al,(2018) in their study titled “³²Study of the Behaviour of cohesive soil under the effect of jute fibres as soil reinforcement : the results showed that more jute geotextile layers in cohesive ⁸soil increases soil strength (unconfined compressive strength and safe bearing capacity) significantly compared with the unreinforced soil . The strength improvement becomes greater as more jute reinforcement layers are added . Combination of jute fibers with the soil enhances their strength but to a lower degree than the layered

configurations . They indicate that jute geotextiles can efficiently serve as reinforcing additives to reinforce soft soils and improve the loadbearing performance.

³³ **Parvesh Kumar and Fayaz Ahmad Mir ,(2018)** in their study titled “Improvement of Geotechnical Properties of Soil Reinforced with Jute fibre: when jute fibers are added to soil , a clear rise in ⁵ California Bearing Ratio (CBR) value as ²⁸ the percentage of fibers increases ¹⁵ is observed , indicating stronger soil properties compared to untreated samples . The highest CBR improvement ²⁸ was noted at the fiber content of 1% , which was the maximum tested . Findings proved that natural jute fiber is a suitable , low-cost, and environmentally friendly way to enhance basic geotechnical properties of soil , especially for subgrade applications.

¹⁹ **Yagya Sharma et. al, (2017)** in their study titled “Improvement of Soil Properties by using Jute Fiber as Soil Stabiliser : the literature demonstrates that ¹⁵ the addition of jute fiber to soil tends to enhance its engineering properties as compared to the untreated soil . As a result of experimental information collected along with testing, the increase of jute content up to a certain percentage makes the soil more resistant to unconfined compressive strength measures, providing good strength for construction work. But beyond the ideal rate , it was possible the addition wouldn’t lead to continued strength improvements . Jute fiber is also an effective and eco-friendly soil stabilizer in various geotechnical applications .

Uzma Ashraf and Faiza Manzoor ,(2016) in their study titled “³⁰Application of Jute Fibers to Improve Sub Grade Characteristics of Silty – Clay Soil : ³⁰as compared to untreated soil , supplementing the natural soil with jute fibers enhances the California Bearing Ratio (CBR) and the unconfined compressive strength of natural soil , as reported in the study . The increase in soil strength was greater with longer jute fiber lengths and higher fiber contents. Maximum dry density tended to increase and optimum moisture content also changed with fiber addition . In general , jute fiber was an efficient sustainable reinforcement material for enhancing rudimentary geotechnical characteristics of soil .

K.Rajasekar et. al,(2014) in their study titled “ Experimental Testing of Natural Composite Material (Jute Fiber) : the study shows that jute fiber reinforced polymer

composites have been fabricated using a layer-by-layer process . The properties of the composite were evaluated and compared with experimental and simulation results based on mechanical testing and computer analysis . These results confirm that jute fiber can be used to improve composite material performance . In general, it demonstrates that jute fiber can be used for natural composites .

²¹
H. P. Singh and M. Bagra ,(2013) in their study titled “ Improvement in CBR value of soil reinforced by jute fiber : the study confirms that the addition of jute fiber into soil increases the California Bearing Ratio (CBR) , which indicates better soil strength . The improvement is larger ⁵with an increase in length and diameter of the fibers . But when fiber levels are greater than 1% , uniform soil is challenging to maintain . A higher CBR enhancement , more than twice that of untreated soil , was observed at 1% fiber with longer and thicker fibers .

2.2 GAPS IN LITERATURE

Although jute fibre has shown increasing interest as a sustainable soil stabilization material , most previous studies have focused mostly on cohesive and fine- grained soils (clay, silt , and black cotton soil) . Very limited research has been conducted on stabilization of poorly graded sand (SP), whose low cohesion and poor interlocking characteristics may lead to different reinforcement behavior compared to cohesive soils . Hence , the applicability of existing findings to SP soil remains uncertain.

Moreover, there is a lack of available published experimental data on the CBR performance of jute fibre reinforced poorly graded sand . Thus far, studies reported on ⁵soaked and unsoaked CBR values, penetration resistance, and ⁵load-bearing behaviour of the SP soil reinforced in the presence or absence of jute fibre only partially cover the field . Most existing research emphasizes shear strength or UCS behavior rather than pavement-related

performance through CBR testing. Another research gap is the insufficient clarity on optimum fibre content and effective fibre dimensions for poorly graded sand stabilization.

The results of previous studies have varied due to soil type , fibre length , aspect ratio , and testing procedure, which prevents obtaining standardized reinforcement parameters for SP soil. In addition , data on compaction properties ²⁹ such as Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of jute fibre reinforced poorly graded sand is not readily accessible. SP soil content, because it contains low fines and poor water retaining capability, the compaction behaviour also needs to be studied further with fibre addition . In addition , available CBR testing of jute reinforced SP soil remains scarce in number, and comparative studies of natural fibre reinforcement in enhancing subgrade performance are limited. Thus , future experimental studies should aim to gain a better understanding of compaction and load bearing behavior of jute fibre reinforced poorly graded sand .

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 METHODOLOGY

The proposed methodology for this research are as follows:

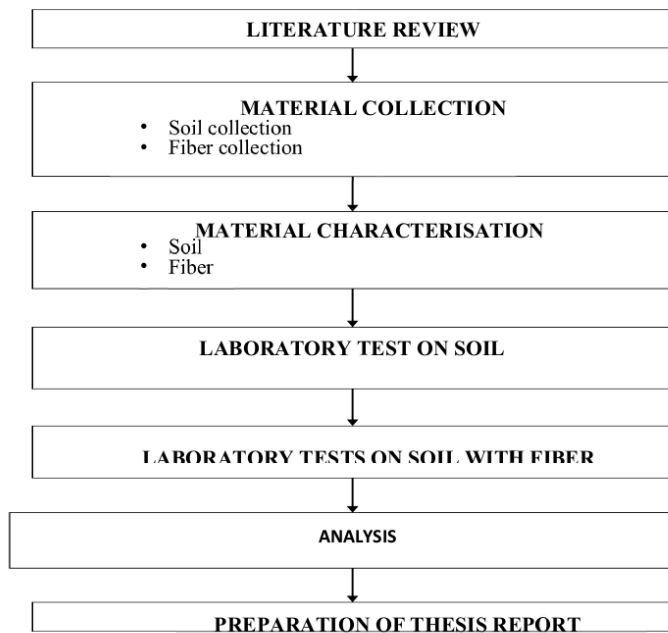


Figure 2 :Flowchart of Methodology

CHAPTER 4

EXPERIMENTAL PROGRAMME

4.1 GENERAL

The description of materials collected with their properties is presented in this chapter . The materials obtained for the current work are soil and jute fibers . Also compared are the different percentages and different fibre lengths of the jute fibre and their impacts on soil properties. To observe the jute fibres response under changing conditions under closely controlled environmental conditions , soil burial studies were carried out for the long-term durability of the fibres . The design of this experiment was to replicate extreme conditions as well as worst-case field scenarios .

4.2 MATERIAL PROPERTIES

4.2.1 SOIL SAMPLE

The samples of the sand was collected from Mcd primary school, Paschim Vihar, where it lies behind Sahibi River, at geographical coordinates 28.665N, 77.122E as shown in fig. 4.1.

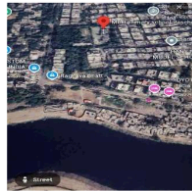


Figure 3: Soil collected site location

Some of the tests conducted are as follows:

- Classification Tests
- Grain Size Analysis
- Atterberg Limits: Liquid limit and plastic limit
- Physical properties
- Moisture Content Test
- Specific Gravity Test
- Compaction Test
- Standard Proctor Test
- ⁵Shear Strength Tests
- Direct Shear Test



Figure 4: Soil Sample

4.2.2 Grain Size Analysis:

²³Grain size analysis is a technique used to determine the size distribution of particles in soil, sediments, or aggregates. This assists in determining the textural class of the material that may affect ²⁹properties such as permeability, strength, and stability.

Grain size analysis focuses on soil being sand, silt, clay, or gravel. It can be used to interpret depositional environments, measure permeability and drainage properties, and establish the suitability of foundations and other structures.

⁷ Sieve Analysis is done for the distribution of particles . Sieve Analysis means passing soil through a stack of sieves with progressively smaller mesh sizes , and after that, the retained material is weighed to get the percentage of each size fraction .



Figure 5: Sieve Analysis

Parameters calculated are as:

- D_{10} (Effective size): Particle size at 10% finer, indicates drainage capacity.
- D_{30} : Particle size at 30% finer.
- D_{60} : Particle size at 60% finer, used to calculate uniformity coefficient (C_u) and Coefficient of curvature (C_c),

Table 2² Sieve analysis of soil

Sieve size(mm)	Weight Retained (g)	Cummulative Weight Retained(g)	Cumulative % Weight Retained	Passing percentage %
4.75	110.00	110.00	16.84	83.16
2.36	70.00	180.00	27.56	72.44
1.18	140.00	320.00	49.00	51.00
0.6	68.00	388.00	59.41	40.59
0.3	82.00	470.00	71.98	28.02
0.15	84.00	554.00	84.84	15.16
0.075	94.00	648.00	99.23	0.77
PAN	5.00	653.00		

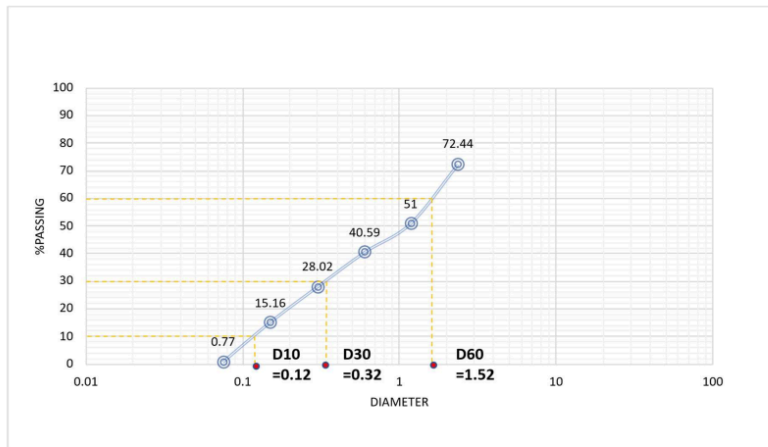


Figure 6 : Grading characteristics of study soil

From graph, we found

$D_{60} = 1.52\text{mm}$, $D_{30} = 0.32\text{mm}$, $D_{10} = 0.12\text{mm}$

- Uniformity coefficient $C_u = D_{60} / D_{10} = 12.7$
- Coefficient of curvature $C_c = (D_{30})^2 / (D_{60} \cdot D_{10}) = 0.56$

$C_u > 6$ and C_c does not lie between 1 and 3, so this soil is **SP** (poorly graded sand) .

4.2.3 Atterberg Limits

4.2.3.1 Liquid Limit (W_L)

With fine-grained soils , the liquid limit is a major property that reflects ³⁷the moisture content at which a soil changes from the plastic state to the liquid state . It represents the boundary where soil can flow under its own weight . As this property is important in clayey soils , its main purpose is to determine the consistency and behavior of clayey soils and helps to predict soil strength, compressibility, and settlement . Casagrande apparatus is used to obtain the liquid limit .



Figure 7: Liquid Limit Apparatus

By Interpolation,

For 25 number of blows,

Water content = 18.28 %

$\therefore$ **Liquid Limit=18.28 %**

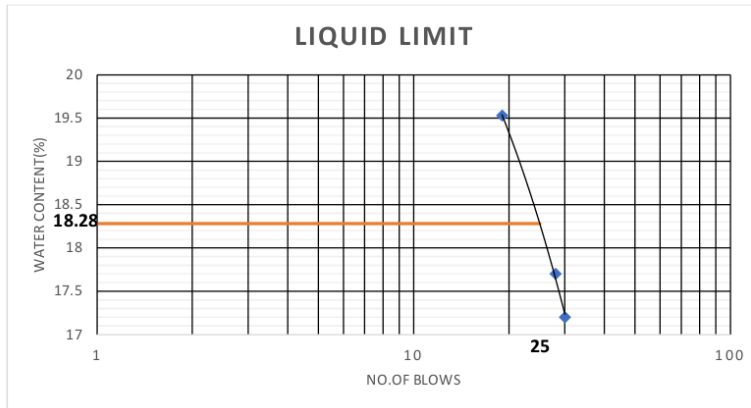


Figure 8 : Flow Curve

4.2.3.2 Plastic limit (W_P)

The plastic limit is the water content at which a soil changes from a plastic state to a semisolid state. It is the property of the soil which is defined as the minimum water content at which a soil will just begin to crumble when it is rolled into a thread of approximately to 3mm diameter.



Figure 9: Plastic Limit

4.2.3.3 Plasticity Index (I_p):

³¹ The plasticity index (PI) is the range of water content over which a soil behaves plastically. It is calculated as:

$$PI = LL - PL$$

$$I = W_L - W_P$$

$$= (18.283 - 15.99)$$

$$I_p = 2.293$$

4.2.4 Moisture Content Test

Moisture content is ¹⁶ the amount of water present in a soil or material, expressed as a percentage of the dry weight. It is, therefore, one of the most significant factors of soil mechanics, agriculture and material science, for its significance in soil strength, compaction and behavior of soil. Oven dry method (105°C – 110°C), calcium carbide method, Torsion balance and electronic moisture meters are common methods of moisture content measurement. Moisture Content of this soil from moisture meter is found to be 8.77%.

4.2.5 Specific gravity

Soil particles ²⁴ specific gravity is the ratio of the weight of soil solids to the weight of an equal volume of water. Soil classification and evaluation of various soil properties such as void ratio and porosity are done based on specific gravity. It is useful in determining ¹⁵ the unit weight of the soil under different conditions and also quantifying particle size from wet analysis. Specific gravity of soil sample is determined by Pycnometer.



Figure 10 :Pycnometer

Calculations

¹⁴ The specific gravity (G) is calculated using the formula:

$$Gs = (W_2 - W_1) / [(W_4 - W_1) - (W_3 - W_2)]$$

Where:

W_1 = Weight of empty pycnometer.

W_2 = Weight of pycnometer with soil

W_3 = Weight of pycnometer with soil and water

W_4 = Weight of pycnometer with water only

Table 3: Specific Gravity

Weight (g)	Sample 1	Sample 2	Sample 3
W_1	690	690	690
W_2	990	990	992
W_3	1730	1726	1734
W_4	1572	1572	1572
G	2.1126	2.1126	2.3714

Average value of specific gravity is **2.19** at room temperature.

4.2.6 Standard Proctor Test

Compaction is the physical act of artificially shifting and packing the soil particles into a closer contact state using mechanical means to reduce the porosity (i.e., voids ratio) of soil and thus promote the soil mass dry density due to the removal of the air in voids through a process, first and foremost, dynamic, and rapid. The compaction density of the compacted soil mainly is influenced by its water content, compactive effort, soil type, and admixtures.

Laboratory compaction tests are carried out to find out the appropriate quantity of water at which the weight of the soil grains in a unit volume of the compacted soil is maximum; this is named the Optimum Moisture Content (OMC) and maximum dry density (MDD), respectively.

Observations

- Diameter of mould = 10.2 cm
- Height of mould = 11.8 cm
- Volume of mould = 964.21 cm³
- Empty weight of mould (W₁) = 4184 g
- Weight of rammer = 2.6 kg
- Empty weight of mould (W₁) = 4184 g
- Dry Density $\gamma_d = \gamma_b / (1 + W)$

Table 4 : Proctor Test

S.No.	Weight of mould (Kg), W_1	Weight of compacted soil + mould (Kg), W_2	Volume of mould (cm^3)	Water added (%), W	Bulk density (g/cc), γ_b	Dry density (g/cc), γ_d	Dry density (kN/m^3), γ_d
1	4.184	5.382	964.21	6	1.596	1.505	14.758
2	4.184	5.530	964.21	8	1.744	1.614	15.827
3	4.184	5.594	964.21	10	1.826	1.660	16.279
4	4.184	5.560	964.21	12	1.864	1.664	16.318
5	4.184	5.450	964.21	14	1.834	1.609	15.778

The compaction curve for unreinforced sand showed optimum moisture content (OMC) and maximum dry density (MDD) as **11.18%** and **16.357 kN/m^3** respectively. The results of compaction curve for unreinforced sand as shown in Fig 4.8 .

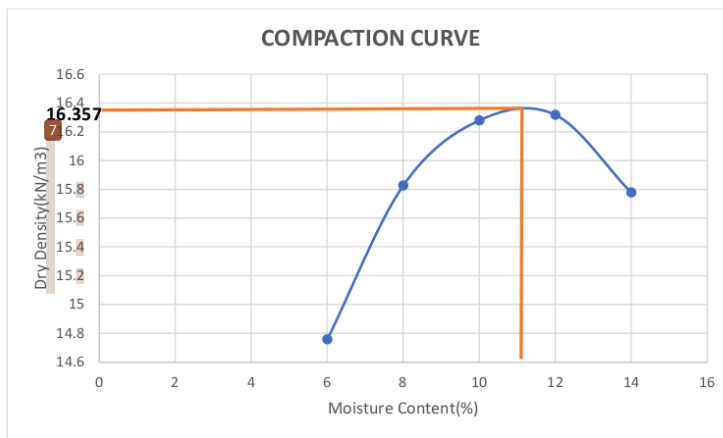


Figure 11: Compaction curve of unreinforced soil

4.2.7 DIRECT SHEAR TEST

In geotechnical engineering , the direct shear test is used for the determination of stability of slopes , retaining walls , or foundations . It helps in determining the resistance of soil to shearing forces , assessing the likelihood of slope failure, ensuring adequate shear strength for bearing capacity , and is used for lateral earth pressure measurement . Thus, the Direct Shear Test is a laboratory method of determining the shear strength parameters of the soil such as cohesion (c) and angle of internal friction (ϕ).

Calculations

The shear strength (τ) of soil is calculated using Coulomb's Law:

$$\tau = c + \sigma \tan \phi$$

Where,

τ = Shear strength

c = Cohesion (intercept on the y-axis)

σ = Normal stress

ϕ = Angle of internal friction (slope of the line)

Table 5 : Direct Shear Test

S.No.	Normal Stress(kPa)	Max. Shear Stress(kPa)
1	50	37.4602
2	100	72.1002
3	150	106.7402

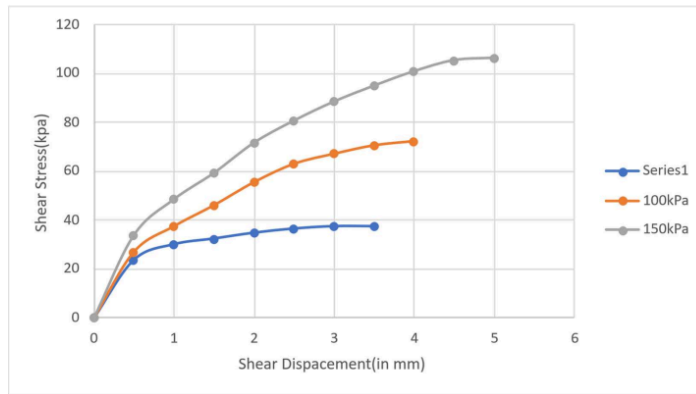


Figure 12: Displacement vs Shear Stress

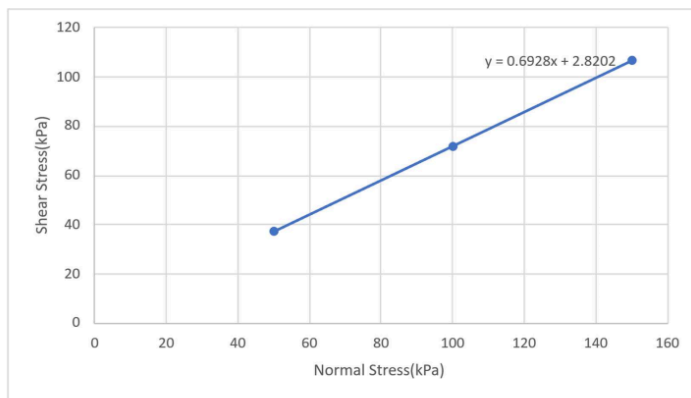


Figure 13: Normal Stress vs Shear Stress

From the above graph,

cohesion (c) = 2.8202 KN/m²

Angle of internal friction (ϕ) = 34.7°

4.2.8 CALIFORNIA BEARING TEST

³⁹ The California Bearing Ratio (CBR) test is a penetration assessment used to evaluate the mechanical strength of subgrade soils and base course materials in road construction. It measures the resistance of a soil sample to penetration by a standard plunger under strictly regulated conditions. The results are expressed as a percentage, denoting the soil's penetration resistance relative to a benchmark of standard highquality crushed stone.

Consequently, higher CBR values signify superior soil strength and enhanced load-bearing capacity. This empirical evaluation is extensively employed in flexible pavement design to determine the necessary thickness of individual structural layers. Furthermore, depending on specific project prerequisites, the procedure can be executed effectively in either controlled laboratory environments or in-situ field conditions.

¹⁰ Table 6 : California Bearing Test

Penetration (mm)	Load (Kg)
0	0
0.5	37.66
1	65.36
1.5	85.22
2	95.35
2.5	103.59
3	109.65
3.5	117.54
4	125.3
4.5	130.63
5	135.643228
5.5	145.29

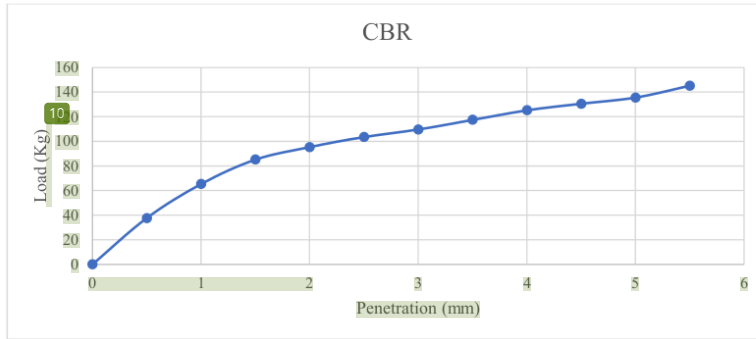


Figure 14 : Penetration vs Load

From the above table, we obtain CBR at 2.5mm = 7.56%

And CBR at 5mm = 6.6%

Therefore, value of CBR at 2.5mm that is 103.59Kg is taken for consideration.

Table 7 : Summary of index properties test

Laboratory test	Value
Specific gravity	2.109
Natural water content	8.44%
Grading	
Sand	99.23%
Silt and clay	0.765%
Consistency limits	
Liquid limit	18.283
Plastic limit	15.99%
Plasticity index	2.293%
IS Classification	SP
Compaction test	
Optimum moisture content	11.18%
Maximum dry density	16.357 kN/m ³

Shear strength	106.74 Kpa
CBR	7.56%

4.3 Jute Fibers

The processed jute fibres were obtained from a commercial firm. The jute fibres were de-stranded and cut into lengths of 40mm and 45mm . Diameter of the fibres was determined using vernier callipers upon averaging three sets of readings along the fibre length. The Summary of fibre properties of the jute fibres have been tabulated in below table.

Table 8 : Summary of fibre properties

Physical property	Value
Colour	Light brown
Diameter	2mm
Specific gravity	2.70
Fiber length Content Selected for the Study	40mm , 45mm
Fiber Content Selected for the Study	0.5%, 1.0% and 1.5% and 2.0 %

CHAPTER 5

SAMPLE PREPARATION

5.1 GENERAL

The air-dried sand samples were uniformly hand mixed with Fibres of 40mm and 45mm length with varying 0.5% , 1.0% and 1.5% by dry weight of soil .Table 6 presents the analytical results derived from multiple experiments designed to evaluate the structural characteristics of the sand matrix when reinforced with randomly and layered dispersed untreated jute fibre .To comprehensively assess these composites, the following primary laboratory evaluations were executed utilizing both fibre variants: (1 Standard Proctor compaction tests and (2) California Bearing Tests .



Figure 15: 45mm Jute fibre



Figure 16 :Jute Fibre mixed in Soil Sample

20

5.2 COMPACTION TEST

A routine Proctor compaction test was conducted to assess compactive effort of soil samples and moisture content. This laboratory process finds the Optimum Moisture Content (OMC) for a material where a soil reaches Maximum Dry Density (MDD). Compaction test is performed on both unreinforced sand and soil reinforced with untreated jute fibres in varied concentration levels in current study. Initially, air-dried sand at 3000 g was measured, and jute fibres at 40mm and 45mm lengths were prepared. The soil was then filled with jute fibres obtained evenly in the dry soil via 3 different percentages: 0.5%, 1.0%, and 1.5% by dry weight. The soil-fibre matrix was homogenistically mixed by manually blending it with an initial 6% moisture content. The compaction was subsequently repeated at 2% increments of moisture content.

This systematic assessment was performed for each concentration (0.5%, 1.0%, and 1.5%) of the jute fibres of various lengths to determine their respective OMC and MDD values

5.3 CALIFORNIA BEARING RATIO TEST

Laboratory 4-day²⁸ unsoaked California Bearing Ratio (CBR) tests were conducted on lateritic soil samples made up of randomly dispersed jute fibres of 40mm and 45mm in length. For each specimen, 5000 g⁵ of dry soil was prepared and mixed with the jute fibres at a concentration of 0.5% by dry weight³³ of the soil. In order to obtain the maximum dry density, the measured soil and fibres were consistently blended at the predetermined optimum moisture content. This uniform mixture was then compacted into five equal layers within a standard CBR mould according to IS 2720 (Part 16) – 1987.



Figure 17 : CBR

Methodologically, this procedure was performed on the jute fibres for the remaining concentrations of 1.0% and 1.5%. Penetration load values were recorded at depths of 2.5 mm and 5.0 mm during the testing phase. According to common engineering practice¹⁶, where the CBR percentage calculated at 2.5 mm penetration exceeded the value at 5.0 mm, the former was taken as the design value. If the penetration at 5.0 mm resulted in a higher CBR percentage the test was repeated to ensure the same.

CHAPTER 6

EXPERIMENTAL OBSERVATIONS, RESULTS AND DISCUSSIONS

6.1 GENERAL

This chapter discusses the results obtained from all ⁷the laboratory tests conducted to assess the water absorption capacity, strength improvement of sand reinforced with jute fibers .

6.2 EFFECT OF JUTE FIBRE ON COMPACTION CURVES

6.2.1 FOR FIBRE LENGTH

Table 9 : Soil Sample with 0.5% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
12	13.864
13	14.662
14	15.026
15	14.988
16	14.434

Table 10 : Soil Sample with 1.0% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
14	13.462
15	13.724
16	14.626
17	14.592
18	14.378

Table 11: Soil Sample with 1.5% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
15	14.014
16	14.120
17	14.498
18	14.282
19	13.646

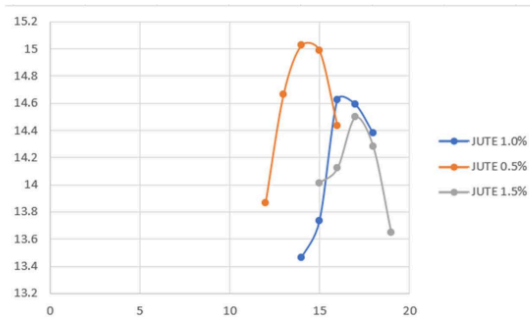


Figure 18: Compaction Curves for 40mm Jute Fibre Length

6.2.1 FOR FIBRE LENGTH (45mm)

Table 12: Soil Sample with 0.5% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
13	13.766
14	14.426
15	14.434
16	14.428
17	14.232

Table 13: Soil Sample with 1.0% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
16	12.542
17	12.824
18	12.826
19	12.802
20	12.710

Table 14: Soil Sample with 1.5% of Jute Fiber

WATER CONTENT (%)	DRY DENSITY
15	13.924
16	14.062
17	14.136
18	13.528
19	13.194

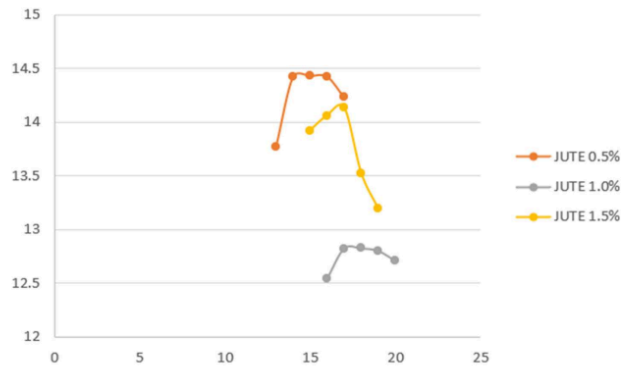


Figure 19 : Compaction Curves for 45mm Jute Fibre Length

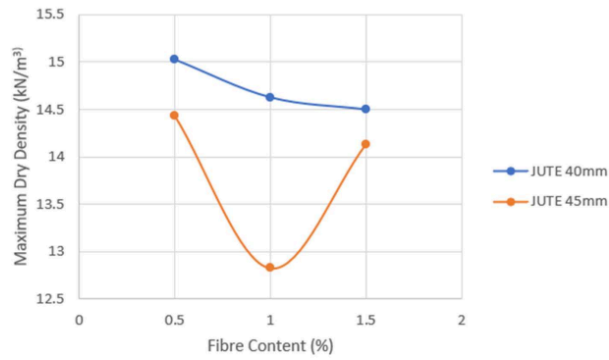


Figure 20 :²⁰Effect of Fibre Content on MDD

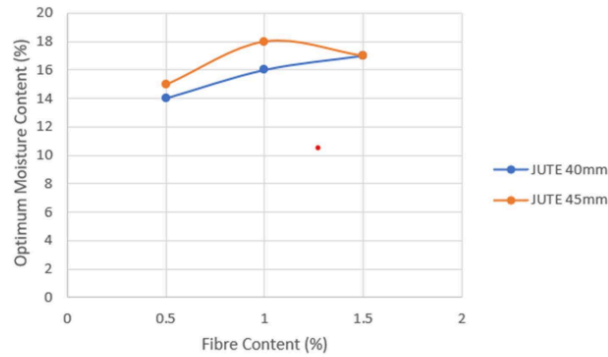


Figure 21:Effect of Fibre Content on OMC

The Compaction curves shows the effect of 40mm and 45mm jute fibre at various Fibre contents , as illustrated in Fig 17 and Fig 18 . Table 12 shows **Optimum Moisture Content and Maximum Dry Density** at different contents . Based on the Compaction Curves, OMC increases while MDD decreases when Fibre content increased for jute fibres from 0.5 % to 1.5% . Figure 20 illustrates an upward trend in OMC . Figure 18 presents a downward trend in MDD with respect to the fibre content . The OMC stabilizes or increases slightly after some fibre length .

Table 15 : Laboratory Results of Standard Proctor Test

Fibre content (%)	Jute Fibre length			
	40mm		45mm	
	MDD (kN/m ³)	OMC (%)	MDD (kN/m ³)	OMC (%)
0.5	15.026	14	14.434	15
1.0	14.626	16	12.826	18
1.5	14.498	17	14.136	17

Fig. 17 and Fig 18 showed that the compaction curves for both 40 mm and 45 mm jute fibres exhibit a reduction in MDD as Fibre concentration increases. This decrease in MDD is attributable to the fact that when Fibre content increases, lighter Fibre material replaces heavier soil material

With higher contents, the Fibre material creates a flocculated structure, which raises the void ratio and decreases the MDD. Fig. 19 depicts the linear decrease in MDD for jute fibre. Previous research has found a reduction in MDD and an increase in OMC due to the Fibre inclusion (Lawer, 2021) and (Lekha, 2015).

6.3 EFFECT OF JUTE FIBRE ON CALIFORNIA BEARING RATIO TEST

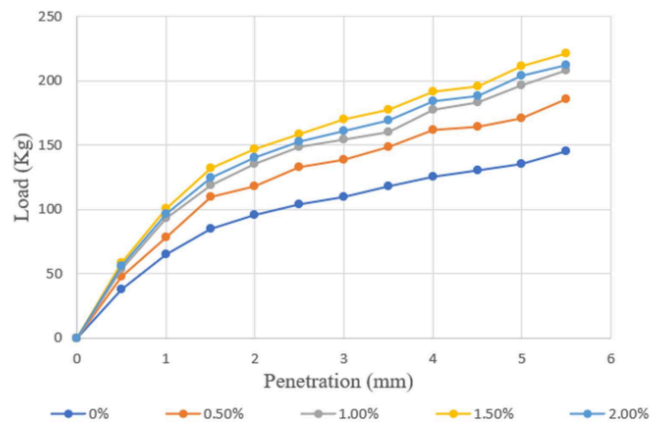


Figure 22 : Load Penetration Curve for 40mm fibre length

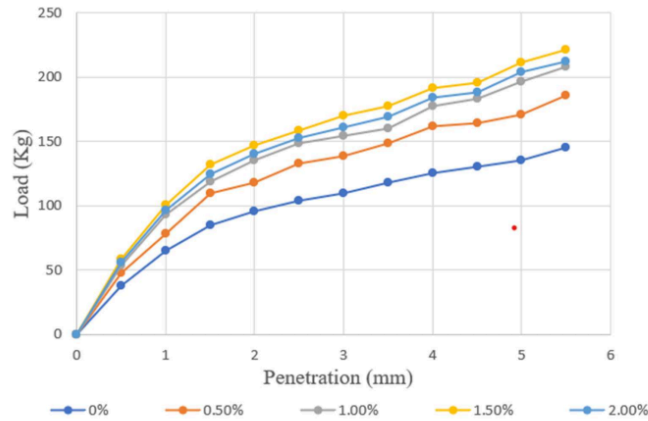


Figure 23: Load Penetration Curve for 45mm fibre length

Fig. 22 and 23 are typical load - penetration curves for unsoaked CBR containing jute fibres of 40 mm and 45 mm diameter , respectively . Fig. 24 depicts that CBR strength rises with fibre content up to optimum content and then decreases because of the formation of flocs by fibres in soil mass in jute fibres . The increased CBR strength in jute fibres is a direct result of the mechanical interlocking between jute fibres and the soil interface . The jute resists particle movement and distributes load more effectively during penetration . This increases shear strength and bearing resistance of the soil .

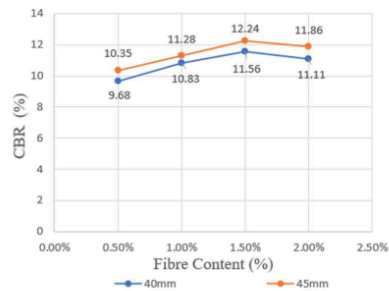


Figure 24 : Effect of fibre content on CBR value

Table 16 : Effect of jute percentage on CBR value

JUTE PERCENTAGE (%)	CBR VALUE	
	40mm	45mm
0.5	9.68	10.35
1.0	10.83	11.28
1.5	11.56	12.24
2.0	11.11	11.86

Fig 24 shows the optimum CBR value was found at a fibre content of 1.5 % for the 40mm and 45mm fibre length . After the optimum jute content , CBR decreases because excess fibers create more voids and reduce proper compaction of soil . Too much jute also causes fiber clustering and weak contact between soil particles . This lowers dry density and weakens load transfer in the soil mass . As a result , penetration resistance decreases , reducing the CBR value .

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

The present investigation focused on applying randomly distributed jute fibres as reinforcement for poorly graded sandy soil (SP) to enhance its engineering properties and load-bearing capacity. Since poorly graded sands are found to be weak and are subject to moisture distribution and variation, soil integrity is significantly affected and thus soil stabilization is required for pavement and subgrade purposes. Jute fibre was chosen as the reinforcement material due to its relatively low cost, locality, biodegradability and eco-friendliness.

Standard Proctor Compaction and California Bearing Ratio (CBR) tests with jute fibres of 40 mm and 45 mm length with different fibre contents of 0.5%, 1.0%, 1.5%, and 2.0% were conducted in laboratory tests. Results indicate that the Optimum Moisture Content (OMC) increased with increasing fibre content and fibre length, while the Maximum Dry Density (MDD) decreased when soil particles were replaced with a lighter fibre material.

With the use of jute fibre, the CBR values also improved significantly, confirming improvements in soil strength and stability. The optimum performance was observed at

1.5% fibre content , with 45 mm fibre showing better improvement than 40 mm fibre . The report confirmed that jute fibre reinforcement of poorly graded sandy soil enhances the strength , stability , and deformation resistance through better interlocking and tensile reinforcement . Therefore, jute fibre can be considered an environmentally sustainable and economical substitute for soil stabilization and subgrade improvement works.

7.2 CONCLUSIONS

The following results were concluded based on the experimental studies:

Compaction of fibre : fibres enabled OMC to rise for both the two fibre lengths . Studies showed that addition of Fibre causes an increase in OMC .

- Density trends : MDD for 40mm and 45mm specimens tended to decline steadily with increasing fiber content as the soil solids were replaced with lighter (fiber) content .
- Once you increase jute percentage and increase the water content the dry density decreases which suggests we cannot utilize these jute fibres where the moisture content of soils is significant.
- OMC rises as the thickness of jute fibre increases ; the value of OMC can then either stabilize or slightly increase after a certain fibre length.
- Thicker jute fibre is associated with an immediate reduction in the maximum dry density.
- Optimal Reinforcement Ratio (CBR) : peak values of CBR for 40mm and 45mm jute fibre reinforcement soil were obtained at an optimal jute fiber concentration of 1.5% .
- The CBR of 45mm fibre was greater than the CBR of 40mm fibres . Hence , CBR value improves with increasing fibre length . Untreated fibres at 1.5% fiber resulted in a 1.20 fold increase in CBR for 40mm fibre length compared to a 1.26-fold increase in CBR with 45mm fibre length .

In conclusion, addition of the jute fiber , promotes strengthening and soil load-bearing capacity by increasing the CBR value and increasing soil stability . It also increases its resistance to deformational stresses by improved interlockage and tensile strengthening in soil bulk. Jute being a natural material is biodegradable and economical . In this respect, it is very convenient for soil stabilization. As a result, this produces a better composite material resulting greatly to a better structural stability as well as stronger load - bearing capability of sandy subgrades .

REFERENCES

- Applications of Jute in the improvement of Subgrade. Parveen Aggarwal, BajinderSharma,Proc. Of int. Conf.2010
- ²¹ A Critical Review on applications of Natural Jute Fibre Study case. Dr T.Kiran Kumar ,B. Jagan,IJCIET,vol 7,issue3,June 2016.
- Improvement of Sub-Grade Soil using natural Jute Fibre sheets Hussein Shaia,HaiderH.Aodah and Basim H. ALHameidewi,Journal university of kerbala vol.14 No.3,01/Nov/2017
- ²⁵ The Utilization of Natural Jute fibre for the stabilization of sub-grade soil .AitharjuPrithvirani, S Madan Mohan, Dr S SreenathaReddy,MallikarjunPatil,IJITR ,Vol No.4, issue No. 5, August –September
- ¹ Improvement in CBR of expansive soil with jute fibre Reinforced.,Amit Kumar Singh, R.K.Yadav, IRJET, vol:03 Issue:11,NOV-²⁵2016
- The Utilization of Natural Jute fibre for the stabilization of sub-grade soil .AitharjuPrithvirani, S Madan Mohan, Dr S SreenathaReddy,MallikarjunPatil,IJITR ,Vol No.4, issue No. 5, August –September 2016
- Natural fibres as soil stabilization for construction. SUBRAMIN,R.K.SRIDHAR AND S.PRIYANKA,IJAIEM,vol:6,Issue :5,MAY ⁸2017
- Stabilization of soil by use of jute fibre. AAMIR FAROOQ AND DR RAJESH GOYAL,IRJET,vol:04,Issue:08,AUG-2017
- ⁴ Improvement of soil properties by using jute fibre., YAGYA SHARMA,DR D.G.M.PUROHIT AND DR.SUNIL SHARMA,AJER,vol:6,Issue:10,OCT-2017
- Utilization of jute fibres as soil stabilizers. ZAFAR IQBAL AHANGER AND ABHISHEK BAWA,IJCIET ,vol:9,Issue:8,AUG-2018
- Stabilization of soil using jute].V.ARVIND ,K. KAVEN, V.S PRIYANKA,SUPRIYASUNIL,IJERT,vol:7,Issu e:06, 2019

- Soil stabilization by Jute as Soil Stabilizer [15.,G M JAGANNATHA, AHMAD MUSTAFA HARIHAR, AKASH M RAIKAR,AJIT P ARER AND AMOGH D BADIGER, IJSRD, vol:7,Issue:03,2019
- ⁶ Md. Akhtar Hossain(2015), “Application of Jute Fiber for the Improvement of Subgrade Characteristics” , American Journal of Civil Engineering.
- ⁶ Amit Kumar(2016), “Improvement in CBR of Expansive Soil with Jute Fiber Reinforcement” , International Research Journal of Engineering and Technology (IRJET)
- ⁶ Yagya sharma(2017), “ Improvement of Soil Properties by Using Jute Fibre as Soil Stabilizer”, American Journal of Engineering Research (AJER).
- ⁸ Bera, A. K.; Chandra, S. N; Ghosh, A. and Ghosh, A. (2009) “Unconfined compressive strength of fly ash reinforced with jute geotextiles”, Geotextiles and Geomembranes, 27, 391–398.
- ⁴ Transportation Engineering,Vol. 134,15-23. [8] Research journal on engineering sciences(2014):”Development of Jute Geotextiles in Combating Geotechnical Problems”, Ghosh Swapan Kumar, Department of Jute and Fibre Technology, University of Calcutta, Kolkata, West Bengal, INDIA.
- ⁴ P. Aggarwal, and B. Sharma, “Application of Jute Fiber in the Improvement of Subgrade Characteristics”. International Journal on Transportation and Urban Development, 2011; 1(1), 56-58.

SUSTAINABLE STABILISATION OF SOIL USING JUTE FIBRE IN DELHI REGION

ORIGINALITY REPORT

7%

SIMILARITY INDEX

4%

INTERNET SOURCES

2%

PUBLICATIONS

3%

STUDENT PAPERS

PRIMARY SOURCES

1	publications.anveshanaindia.com Internet Source	3%
2	dspace.dtu.ac.in:8080 Internet Source	1%
3	www.slideshare.net Internet Source	1%
4	www.ajer.org Internet Source	<1%
5	"Proceedings of the Indian Geotechnical Conference 2019", Springer Science and Business Media LLC, 2021 Publication	<1%
6	www.iaeme.com Internet Source	<1%
7	"Problematic Soils and Geoenvironmental Concerns", Springer Science and Business Media LLC, 2021 Publication	<1%
8	1library.net Internet Source	<1%
9	"Proceedings of the Indian Geotechnical Conference (IGC 2024), Volume 2", Springer Science and Business Media LLC, 2025 Publication	<1%
10	www.ir.juit.ac.in:8080 Internet Source	<1%

11	ndl.ethernet.edu.et Internet Source	<1 %
12	www.scribd.com Internet Source	<1 %
13	www.bestjute.com Internet Source	<1 %
14	www.ijert.org Internet Source	<1 %
15	docs.neu.edu.tr Internet Source	<1 %
16	www.vegvesen.no Internet Source	<1 %
17	isindexing.com Internet Source	<1 %
18	smfe-iiith.vlabs.ac.in Internet Source	<1 %
19	www.ijrte.org Internet Source	<1 %
20	espace.curtin.edu.au Internet Source	<1 %
21	ijsdr.org Internet Source	<1 %
22	pdfcoffee.com Internet Source	<1 %
23	"Novel Infrastructure Techniques", Springer Science and Business Media LLC, 2026 Publication	<1 %
24	civilengineerdk.com Internet Source	<1 %
25	ijsrem.com Internet Source	<1 %

26	porsubstokin.web.app Internet Source	<1 %
27	Ni Yan, Canxu Zeng, Na Zhang, Song Han, Yali Li, Makoto Yokohari, Zhengxu Zhou. "Beyond the Idyll: Unveiling the realities of risk perception and neighborhood influence on rural in-migrants in the COVID-19 Era in Dali, China", Journal of Urban Management, 2024 Publication	<1 %
28	www.duet.ac.bd Internet Source	<1 %
29	"Proceedings of the Indian Geotechnical Conference (IGC 2024), Volume 4", Springer Science and Business Media LLC, 2025 Publication	<1 %
30	Aaqib Rasool Magray, Preetpal Singh. "Improvement in the properties of soil by utilization of jute fiber with black carbon as a soil reinforcement", Materials Today: Proceedings, 2023 Publication	<1 %
31	etd.auburn.edu Internet Source	<1 %
32	businessdocbox.com Internet Source	<1 %
33	Parvesh Kumar, Fayaz Ahmad Mir. "Chapter 34 Effect of Jute Fiber on Engineering Properties of Soil", Springer Science and Business Media LLC, 2023 Publication	<1 %
34	Sanjay Kumar Shukla. "Fundamentals of Fibre-Reinforced Soil Engineering", Springer Science and Business Media LLC, 2017 Publication	<1 %

35 Thongprapha, T., K. Fuenkajorn, and J.J.K. Daemen. "Study of surface subsidence above an underground opening using a trap door apparatus", Tunnelling and Underground Space Technology, 2015. <1 %

Publication

36 escholarship.mcgill.ca <1 %

Internet Source

37 hungkcct.wordpress.com <1 %

Internet Source

38 "Geotechnics for Transportation Infrastructure", Springer Science and Business Media LLC, 2019 <1 %

Publication

39 Olaolu George Fadugba, Adeyemi Amos Ojo, BAMITALE DORCAS OLUYEMI-AYIBIOWU, OLADAPO JAYEJEJE OMOMOMI, Michael Bodunrin. "Assessment of the Microstructure and Geotechnical Characteristics of Lime-Improved Lateritic Soil with the Addition of Pulverised Snail Shell and Sawdust Ash for Sustainable Highway Infrastructure", Research Square Platform LLC, 2024 <1 %

Publication

40 ethesis.nitrkl.ac.in <1 %

Internet Source

Exclude quotes Off

Exclude matches < 14 words

Exclude bibliography Off