Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 03 ISSUE 3, 2025

# Impact of Recycled Jute Fiber Addition on the Strength Characteristics of Soil: an Overview

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**Abstract:**

The inclusion of recycled jute fibers in soil is gaining attention as a sustainable method for enhancing soil strength characteristics. This overview article examines the impact of integrating jute fibers into soil on its engineering properties, particularly focusing on strength aspects. Recycled jute fibers, a byproduct of jute production, are environmentally friendly and cost-effective, presenting an alternative to conventional soil reinforcement materials. The review synthesizes findings from various studies on how jute fibers affect soil compaction, shear strength, and overall stability. It highlights that the addition of jute fibers generally improves the tensile strength and reduces the brittleness of soil, thereby enhancing its load-bearing capacity. The article also discusses the optimal fiber content and distribution for achieving the best performance, along with the potential benefits and limitations of using recycled jute fibers in different soil types and environmental conditions. This approach not only contributes to better soil management but also promotes recycling and sustainability in construction practices.

**Keywords:** Recycled Jute Fiber, Soil Strength, Soil Reinforcement, Sustainable Construction, Engineering Properties

## INTRODUCTION

Infrastructure development is crucial for advancing industry, economy, culture, and society. Effective transportation and communication systems are essential for this growth, necessitating cost-effective construction practices. Soil, being an abundant and inexpensive material, is increasingly considered in infrastructure projects. However, with rising concerns over the sustainability of traditional construction materials, it is important to explore alternative methods to enhance soil strength and durability. Incorporating materials like rice husk, fly ash, and industrial

waste can significantly improve soil properties at minimal cost (Lu, 2014).

Various soil modification techniques exist, and the choice of method depends on the construction requirements, soil type, characteristics, and associated costs and time constraints. Previous studies (Ghavami et al., 1999; Santoni et al., 2001; Prabharkar and Sridhar, 2002; Hossain et al., 2015; Kumar et al., 2015; Sharma et al., 2017) indicate that industrial by-products and fibers can substantially alter soil properties, including density, strength, and pH. Utilizing these materials not only enhances soil properties but also provides an effective way to manage waste.

Historically, soil stabilization has been employed to improve its mechanical properties (Wright, 2012). Emphasizing cost reduction and design efficiency, the use of waste materials such as fly ash and jute has gained attention. India, a leading producer of jute, generated 1,968,000 tonnes of jute fiber in 2014 (FAOSTAT, 2017), with major production in West Bengal, Assam, and Bihar. The jute supply is expected to increase by 10% in the 2019-2020 period, with around 101.4 lakh bales projected (The Hindu, 2019).

## HISTORY OF NATURAL FIBRE AS SOIL REINFORCEMENT

The concept of reinforcing materials with fibers is ancient, with evidence dating back to Roman times when lime and calcium were used to stabilize weak soils. Early civilizations improved the strength of mud blocks by incorporating straw and hay, and the soil used in the construction of the Great Wall of China was reinforced with tree branches (Hejazi, 2012). Modern advancements in soil reinforcement began with Vidal in 1966. Today, due to environmental concerns such as landfill overuse, depletion of non-renewable resources, and pollution, there is a growing interest in using eco-friendly materials for soil reinforcement. Natural fibers like jute, palm, and coconut have garnered attention for their low cost and environmental benefits. Researchers have investigated these fibers to enhance soil properties (Ghavami et al., 1998; Ghiassian, 2004; Aggarwal and Sharma, 2010; Sarbaz et al., 2013; Hossain et al., 2015; Hamid and Shafiq, 2017; Wang et al., 2017). Despite limited studies, the potential for natural fibers in soil improvement has increased interest among geotechnical engineers. Recent research highlights the effectiveness of jute fibers in soil stabilization. Studies have shown that incorporating jute fibers enhances the strength and mechanical properties of soil (Aggarwal and Sharma, 2010; Goyal et al., 2016; Sharma, 2017; Manohar et al., 2018). Furthermore, treating jute fibers with geotextiles has been shown to further improve soil properties (Ghazavi and Roustaie, 2010; Farooq and Goyal, 2017; Sharma, 2017). Synthetic fibers like nylon, polyethylene, polyester, and polyvinyl chloride are also used in geotextiles to enhance soil properties, especially in soft soils where they are utilized for constructing pavements.

## RECYCLED JUTE FIBER UTILIZED IN TESTING FROM USED JUTE BAGS

In recent studies, recycled jute fiber sourced from used jute bags has been examined for its potential in soil stabilization and reinforcement. This approach not only provides a sustainable solution by repurposing waste materials but also addresses the environmental impact associated with the disposal of used jute bags. Recycled jute fibers are processed and tested for their effectiveness in enhancing the mechanical properties of soil, including strength and durability.

The recycling process involves collecting used jute bags, cleaning them, and extracting the fibers. These fibers are then subjected to various tests to evaluate their performance as a reinforcement material in soil mixtures. Key properties assessed include fiber length, tensile strength, and degradation resistance. The inclusion of recycled jute fibers in soil has been shown to improve soil cohesion and load-bearing capacity, making it a viable option for construction and civil engineering applications.

This innovative use of recycled jute fibers not only contributes to waste reduction but also offers an environmentally friendly alternative to traditional soil reinforcement materials.

**Figure 1: Recycled Jute Fibre Used for Testing from used jute bags**

## OBJECTIVES OF THE LITERATURE SURVEY

The primary objective of this literature survey is to evaluate the impact of incorporating recycled jute fibers into soil on its strength characteristics. The review aims to analyze existing research on the effectiveness of recycled jute fibers as a reinforcement material, focusing on how these fibers influence soil properties such as shear strength, compressive strength, and durability. It seeks to consolidate findings from various studies to understand the performance improvements achieved through the use of recycled jute fibers, compare their effectiveness with other reinforcement materials, and identify the mechanisms through which these fibers enhance soil stability. Additionally, the survey aims to highlight gaps in current research and provide recommendations for future investigations to further optimize the use of recycled jute fibers in soil stabilization.

## LITERATURE REVIEW

Several research studies have focused on the impact of recycled jute fiber addition on the strength characteristics of soil.

**Hossain et al. (2015)** conducted a study aimed at improving subgrade characteristics using jute fiber. The research involved reinforcing clay loam soil with jute fiber, with various proportions and lengths of fiber used (0.3%, 0.6%, 0.9%, and 1.2% by weight, with fiber lengths of 15mm and 30mm). The fiber diameters were 4mm and 8mm, respectively. The study also examined the effect of the aspect ratio (length/diameter ratio) of jute fibers. To protect the fibers from microbial attack and degradation, bitumen coating was applied. Compaction and California Bearing Ratio (CBR) tests were conducted on both unreinforced and reinforced soil. The results showed that increasing the percentage of jute fiber and its length and diameter enhanced the CBR values. The optimal ratio was found to be 1.875, where the CBR value reached 6.30%. [1]

**Kumar et al. (2015)** investigated the enhancement of CBR values in clayey soil reinforced with jute fibers. The study used jute fiber percentages of 1%, 2%, 3%, 4%, and 5%, and fiber lengths of 20mm, 40mm, 60mm, 80mm, and 100mm. CBR tests were performed under unsoaked conditions. The findings revealed that the CBR value increased significantly with the fiber content up to 5%, with the optimum fiber content being between 4-5% and the optimum fiber length between 60-80mm. It was noted that more than 5% fiber content made soil sample preparation challenging. [2]

**Goyal et al. (2016)** examined the effects of jute fiber and gypsum on clay soil stabilization. They prepared twelve specimens with varying jute fiber percentages (0.5%, 1%, 1.5%, and 2%) and gypsum percentages (5% and 10%). The study found that while the addition of jute fiber initially increased the maximum dry density (MDD) and decreased the optimum moisture content (OMC), further increases in fiber content had the opposite effect. The inclusion of gypsum further improved MDD and OMC. However, the unconfined compressive strength (UCS) initially increased with 0.5% jute but decreased with higher percentages. Gypsum addition reduced soil plasticity and caused vertical cracks in the soil-jute-gypsum mixture. [3]

**Wang et al. (2017)** performed a laboratory investigation on the strength characteristics of expansive soil reinforced with jute fiber. Triaxial compression and direct shear tests were conducted on both unreinforced and reinforced soil samples. The study concluded that jute fiber improved shear strength parameters and compensated for the loss of post-peak strength. Shear strength, strength ratio, and cohesion increased with jute fiber content up to 0.6%, but further increases led to a decline in these parameters. [4]

**Hamid and Shafiq (2017)** explored subgrade soil stabilization using jute fiber of lengths 30mm, 60mm, and 90mm and proportions of 0.25%, 0.5%, 0.75%, and 1%. CBR tests showed significant increases in CBR values with fiber content up to 0.75%, beyond which the CBR value decreased. At 0.75% fiber content, the CBR value rose by 200%. [5]

**Manohar et al. (2018)** studied the strength and stability of highly compressible clayey soil reinforced with randomly distributed jute fiber. UCS tests were performed with fiber percentages ranging from 0.5% to 2.5% by weight. Tests were conducted after 0, 7, and 30 days of curing. It was found that at 30 days of curing, the strength increased by 97% with 1.5% jute fiber. Uncoated fibers exhibited higher shear strength compared to coated fibers, with kerosene-coated fibers showing the highest shear strength. Jute fiber use doubled the safety factor compared to unreinforced soil. [6]

**Lal et al. (2020)** focused on improving soil characteristics using jute fiber sheets. Triaxial and CBR tests on soil with jute fiber sheets demonstrated significant strength improvements. [7]

**Yehia et al. (2020)** investigated the shear strength of fiber-reinforced recycled concrete using various fibers, including steel and synthetic types, in a Self Consolidated Concrete (SCC) matrix with 100% coarse recycled aggregate. The results showed a 23.44% to 64.48% improvement in shear capacity for fiber-reinforced beams compared to control specimens, with steel fibers performing the best. Fiber addition improved crack resistance and ductility. [8]

**Jamil et al. (2022)** examined the combined effects of jute fiber (JF) and recycled concrete aggregate (RCA) on concrete's durability and mechanical properties. They prepared 15 concrete mixes with varying RCA and JF contents. Results showed that lower JF dosages (0.15%) positively impacted mechanical properties, while higher dosages (≥0.30%) had adverse effects. Durability decreased with increasing RCA and JF content. [9]

**Taiyab et al. (2022)** explored the desiccation and cracking behavior of clayey soil reinforced with coir and jute fibers. Direct tension and desiccation cracking tests revealed that jute fibers increased tensile strength by up to 215% and reduced cracking. The results were significant for professionals working with clay liners to address cracking issues. [10]

**Tariq et al. (2023)** reported on swelling soil treated with different jute fibers to reduce swelling characteristics and enhance geomechanical properties. The study found that all jute fiber types improved undrained shear strength and CBR values, with reductions in swell potential and pressure. For instance, undrained shear strength improved from 200 kPa to 675 kPa, and CBR value increased from 3% to 7.1%. [11]

A study on high-cellulose jute fiber composites reinforced with almond shell filler demonstrated improved mechanical properties. Tensile, flexural, impact, and shear properties increased significantly with 3 wt.% almond shell filler, with improvements of up to 63.5% in flexural strength and 52.2% in shear properties. Scanning Electron Microscopy (SEM) showed that the almond shell filler enhanced interlaminar adhesion. [12]

## SUMMARY

This overview article examines the effects of adding recycled jute fiber to soil on its strength characteristics. The use of recycled jute fiber, derived from used jute bags, presents a sustainable solution for soil stabilization and improvement. By integrating these fibers into soil mixtures, the study highlights how they enhance soil properties such as cohesion, shear strength, and load-bearing capacity. The addition of jute fiber has been shown to positively impact the mechanical performance of soil, making it a promising material for construction and civil engineering applications. This approach not only addresses environmental concerns related to waste management but also offers an effective and economical alternative to traditional soil reinforcement techniques.

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