International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Review Study on the Strength Characteristics of Clayey Soil with Latex Treated Coir Fibre

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Abstract: ***Natural fibres like sisal, bagasse, banana fibre, and coir from coconuts can be used to reinforce polymers. Composites made of biodegradable, natural fibres are environmentally friendly. Due to variations in water content, clayey soil is prone to significant volume changes (swelling and shrinking). The clayey soil's general characteristics include high compressibility, poor bearing capacity, and weak shearing strength. The bearing capacity and shear strength of treated soil are increased with the use of natural fibres. They are environmentally friendly and biodegradable. The natural extract rubber latex was utilized to preserve coir and boost its longevity. Due to their advantages, such as high strength with very little weight and recyclable nature, the use of latex treated coir composites has increased. This paper discusses the review of literature on the effect of the strength characteristics of clayey soil in conjunction with latex treated coir fibre.***

Keywords: coir, natural rubber latex, latex treated coir composites

1. Introduction

Natural fibres can substitute synthetic fibres in uses like erosion control, separation, filtration, and reinforcement. The main drawback of the fibres, which are typically derived from plant stems, leaves, or fruits, is that they frequently have a low resistance to moisture. Due to the need to increase the mechanical properties of composite materials and the adhesion of the fibres to the matrix, chemical treatments of natural fibres must be used to change the material's properties

Coir is an inexpensive fibre obtained from the husk of coconut. It benefits from being a lignocellulose fibre. It is both environmentally beneficial and commercially viable. However, the durability is insufficient for reinforcement. Therefore, it is necessary to increase the durability of coir geotextiles, which can be done by chemical processing and polymer coating. Coir geotextiles could be coated with natural rubber latex to extend their lifespan in a variety of civil engineering applications. In comparison to the uncoated coir geotextiles, the environmentally friendly rubber latex coated coir geotextiles have better mechanical properties and durability.

2. Literature Review

Anyaporn Boonmahitthisud and Kanoktip Boonkerd (2021) presented the paper sustainable development of natural rubber and its environmentally friendly composites. The article summarizes the different solutions to achieve the sustainable development of green natural rubber (NR) technology. In spite of the emergence of various synthetic rubbers, NR gained much attention from the rubber industry because of issues on environmentally friendly material, sustainable resource, and its properties. The use of rubber composites will also increase. Based on the positive impact on NR technology, the paper summarized that there would be a change in the future trend about rubber industry. Similarly, Joseph and Nair (2014) studied the eco - friendly bio - composites using natural rubber (NR) matrices and natural fiber reinforcements. The bio - composites were prepared using natural fibers for the reinforcement phase and natural rubber or other natural polymer for the matrix. Natural fibres are available and economical, and have excellent strength and stiffness also low in cost and density. The characteristics of bio - composites are influenced by a variety of parameters, including fibre type, preparation environment, processing method.

The paper fibers for geotextiles was reviewed by Ali Raza et al. (2020) and the chapter has listed the fibers into three sequence natural fibers, synthetic fibers, and high - performance fibers. In each order, the fibers for the geotextiles have been described completely with respect to their operations, advantages, and disadvantages. The operation of natural fibers in geotextiles is preferred in terms of profitable and technical grounds. Still, mainly sisal, jute, and coir fibers are dominating in geotextiles. Still, natural fibers offer some disadvantages like low mechanical strength, biodegradable, durability issues, poor resistance against acids and bases, moisture absorption characteristics. These downsides pushed researchers and scientists to use different synthetic materials. Polyester, polyamides, and polypropylene are considerably used in the manufacturing of geotextiles for different operations. The synthetic fibers were used in fiber woven or knitted form according to the operation area. Still, in different areas the generality of high performance fibers is gaining significance because of their extraordinary performance in geotextiles.

Characteristics of mechanical properties of coir - fibre/rubber composite by Arrohman et al. (2020) concluded that the increasing fiber content can reduce the mechanical strength of composites. The investigation of mechanical properties with different composition of coconut fibre and rubber was needed to find its optimum properties of the porous natural composite. The paper concluded that the longitudinal direction coir fibre have good mechanical strength. Similarly, in the paper the mechanical performance of coir fiber/polyester composites by Monteiro et al. (2008) analyzed the flexural mechanical behavior of untreated coir–

polyester composites covering a larger range of weight fractions. From the experimental results obtained it is concluded that the random oriented coir fiber–polyester composites are low - strength materials, but can be designed to have a set of flexural strengths that enable their use as non - structural building elements. The low modulus of elasticity of coir fibres, compared to that of bare polyester resin, is to reason for their ineffective reinforcement. Natural fiber reinforced vinyl polymer composites was studied by Hao et al. (2018) and discussed the natural fibers and natural fiber reinforced vinyl polymer composites. The natural fiber reinforced polymers (FRP) have developed due to the advantages over other FRPs. The natural fiber composites are low density, low cost and it has high mechanical properties, and biodegradability. There were common defects that occur in processing fiber reinforced vinyl polymer composites and it has effects on the final product and needed to be considered.

Anand et al. (2019) reviewed the paper transmissivity of coir latex emulsion and it deals with transmissivity test conducted in laboratory on lately developed coir latex emulsion to be used as division in flexible pavement. Transmissivity of the emulsion was measured under varying hydraulic grade and normal pressure. Transmissivity of the coir latex emulsion seemed to drop with increase in hydraulic grade as well as with increase in normal pressure. The results were compared under test conditions without using the emulsion as well as with coir geotextiles without latex treatment. Woven geotextile WC and WCL have similar transmissivity characteristics. With latex treatment, the transmissivity of nonwoven geotextile NWC showed a significant improvement in drainage properties. From the study results it can be concluded that placing a separator layer improves the drainage behaviour of the test specimen compared to the test specimen without any separator. Han et al. (2003) studied the transmissivity of smart geotextiles and geonets was found to decrease as compressive stress increases. The decrease of in plane permeability and transmissivity with compressive stress of the geotextiles showed the same behavior as exhibited by the variation in thickness. Under compressive stress, the transmissivity tends to change with intrusion. The transmissivity seems to vary with intrusion under compressive stress. Pak and Zahmatkesh (2010) studied the filtration and drainage properties of several nonwoven needle - punched geotextiles with different properties and unit mass per area under various confining stresses and hydraulic gradients, were studied using standard permittivity and transmissivity apparatus. Hydraulic heads ranging from 10 cm to 60 cm and confining loads up to 1000 kPa were applied to prepared samples, and their hydraulic behaviour was evaluated. The flow regime through geotextile fibres, as well as the anisotropic behaviour of geotextile permeability, were investigated in this research. The results showed that transmissivity decreased exponentially with increasing the normal stress until a residual value is obtained, and permittivity and transmissivity coefficients were seen to decrease with increasing the hydraulic gradient.

Muneerah and Nurafiqa (2019) studied the effects of coir fibre on consolidation behaviour of soft clay demonstrates the effects of coir fibre inclusion on the consolidation behaviour of clay samples. Natural fibres from coconut, bamboo, cane or palm were used in soil improvement to enhance the behaviour of soft deposits. Kaolin and the fibres that was extracted from the matured coconut husks and were cut into three different lengths of 10, 20 and 30 mm and diameter of 0.4 mm was used. The standard Proctor's method was conducted to investigate the consolidation behaviour of high plasticity clay soil reinforced with coir fibres. The values of coefficient of consolidation increased with the inclusion of coir fibres. The paper concluded that it was due to the longer length of coir it caused lower strength. Influence of biodegradable natural fibre drains on the radial consolidation of soft soil investigated by Indraratna et al. (2016) studied a general degradation function for drain discharge capacity over time was assumed and incorporated in a conventional analysis of consolidation assisted by Prefabricated verticals drains (PVDs). In this study, an analytical solution was proposed based on scientific findings of earlier microbiological studies to describe the consolidation behaviour of soil with respect to the degradation of natural fibre drains. The research concluded that the proposed analytical solution can capture the effect that drain degradation has on the radial consolidation of soil. The paper performance of coir fiber addition for clay as a sub - grade for pavement design by Munirwan et al. (2019). CBR (California Bearing Ratio) value was analysed and the effect of coir fiber addition for mechanical stabilization of clay soil was studied. Two lengths of coir fiber were taken for the study i. e.2 cm and 3 cm respectively. The percentage between the mixture of soil and coir fiber was determined for 4conditions, namely 0%, 0.2%, 0.4%, and 0.6%. Two types of treatment method were used: direct mixing treatment and layers treatment. From the study the use of coir fiber was able to improve soil bearing capacity. The research concluded that the clay which was stabilized with coir fiber by mixed treatment has higher CBR values compared to coir fiber with layered treatment. Clay - coir fiber with a length of 3 cm has increased CBR value compared to coir fiber with a length of 2 cm. The direct mixing treatment CBR results has a higher value than the layered treatment method.

Probing the hydrophilicity of coir fibres: analysis of the mechanical properties of single coir fibres by Sabu Thomas et al. (2017) investigated the mechanical properties of dry versus fully hydrated single micrometre - thick coir fibres. The motivation was to gain insights into the hydrophilicity of the fibres. The coir fibres were tensile tested until it ruptured using a horizontal environmental micromechanical tester mounted on an inverted microscope for simultaneous microscopy and mechanical testing. During the test, the hydrated specimens were immersed in water contained in a Petri - dish mounted on the tester for continuous hydration. Statistical results showed significant variations in the following parameters. Wet specimens have a higher mean fibre diameter than dry specimens. The dry specimens have a higher mean tensile stiffness and fracture strength than the wet specimens. However, the fibre extensibility has no evidence of differences. While the dry fibre has a higher characteristic strength than the wet fibre, the wet fibre has a smaller spread of strength variability than the dry fibre, according to a probability strength study. Geethamma and co - authors (2005) studied the dynamic mechanical

Paper ID: SR22804085234 DOI: 10.21275/SR22804085234

behavior of short coir fiber reinforced natural rubber composites, the research covers the studies on natural rubber composites containing short coir fibers as reinforcement. Coir is a lignocellulosic fibre made from the fibrous mesocarp of coconuts, which are the fruit of coconut trees (Cocos nucifera) that are widely cultivated in tropical areas. Compared to other natural fibres, coir fibre has a few advantages. Due to the higher level of lignin, it has a higher weather durability. Due to its lower cellulose concentration, coir fibres absorb water to a lesser amount than all other natural fibres. As a result, research has been conducted to uncover new areas of application for coir, such as polymer reinforcement. Due to its large and variable diameter, high microfibrillar angle, and high lignin and hemi - cellulose content, coir was found to be a poor polymer reinforcement. The research revealed that composite with poor interfacial bonding tend to dissipate more energy than those with good interfacial bonding. The damping effect of chemically treated coir fibre was also investigated.

Volume change behavior of expansive soil stabilized with coir waste by Jayasree et al. (2014) studied the use of coir waste to control the volume change behavior of marine clay keeping sustainable development in focus. Consolidation tests, swelling pressure testing, and three - dimensional (3D) shrinkage strain tests were used to investigate the influence of adding coir waste on volume change behaviour. Coir waste consisted of pith along with some short fibers that was separated to study their independent effects on volume change behavior. Volumetric swelling of optimum soil pith - fiber mix was also analysed by conducting three - dimensional free swell tests. Mixing of coir waste with expansive soil helps to reduce the volume change behavior of expansive soil. Based on the results obtained, it was recommended that coir waste can be used as a reinforcing material for mitigating the volume change of expansive soil. This is an efficient and cost - effective way to dispose of coir waste. The effective use of coir waste can improve rural economies and lead to beneficial effects in engineering construction. Abdi et al. (2008) has investigated the effect of random fiber inclusion on consolidation, hydraulic conductivity, swelling, shrinkage limit and desiccation cracking of clays has focused on the development of desiccation cracks in compacted clays. Samples of 75 percent kaolinite and 25% montmorillonite were reinforced with 1, 2, 4, and 8% fibres as dry weight of soil with 5, 10, and 15mm lengths to evaluate improvements in soil properties. The results showed that fibre reinforced materials' consolidation settlements and swelling were significantly decreased. Increased fibre content and length increased hydraulic conductivities slightly. With increasing fibre quantity and length, shrinkage limits also increased. As a result, desiccation caused far less volumetric changes in the samples, and the amount of crack formation was reduced.

Coconut fibre: a biodegradable soil erosion control by Ranjith (2012). The objective of this study was to evaluate three types of coconut fibre matting for soil and water conservation in an Ultisol of Sri Lanka. The coconut fibre matting can be used as effective mulching material to control soil erosion. The coconut fibre mattings reduced run - off and soil loss while increasing the moisture availability in the soil profile. The soil temperature and the diurnal temperature variation decreased with mulching, reducing the evaporation from soil. All these factors contributed to higher dry matter production and seed yield in mulched plots. The high C: N ratio of coconut fibre mattings compared with a common green manure indicated that these materials can last for a long time before decomposition. Moreover, coconut fibre mattings are biodegradable, less capital intensive to lay in the field, and also help in weed control. Both types of coconut fibre matting are suitable for erosion control on perennial crops, while the coconut fibre - rubber mixture is more suitable for annual crops.

Sandhyarani Biswas et al. (2011) investigated the effect of fiber length on mechanical behavior of coir fiber reinforced epoxy composites. The work described the development and characterization of a new set of natural fiber based polymer composites consisting of coconut coir as reinforcement and epoxy resin as matrix material. Experiments were carried out to analyse the effect of fiber length on mechanical behavior of these epoxy based polymer composites. The scanning electron microscope (SEM) of fractured surfaces was done to study their surface morphology. It showed the fabrication of a coir fiber reinforced epoxy composites with different fiber lengths possible by simple hand stirring technique. In the research study, untreated coconut coir fibers have been used in epoxy resin composites as reinforcement materials. It confirmed that coconut coir fiber reinforced epoxy composites have better tensile strength, tensile modulus, flexural strength, and higher impact strength of the composites are also greatly influenced by the fibre lengths. Monteiro et al. (2009) proposed, a strong alkali treatment of coir fiber improves the adhesion to the polyester matrix and thus increases the composites strength by approximately 50 % for a volume fraction of 30 % of coir fiber. Another possibility of effective reinforcement to a polymer matrix could be obtained through the selection of thinner coir fiber. Monteiro et al. (2010) further fabricated with the thinnest fibers of sisal, ramie and curaua in their work and it has improved polymer matrix composites mechanical properties. The flexural strengths of these composites were found to be more than 30% higher than the comparable values for identical composites with non - selected, average diameter fibres. Physical and Mechanical Properties of Jute, Bamboo and Coir Natural Fiber by Subhankar Biswas et al. (2013) investigated the mechanical and physical properties of jute, bamboo and coir (brown and white) single fibers. In the research, tensile test was conducted on jute, bamboo, brown coir and white coir fibers using different span lengths. Morphology study using environmental scanning electron microscope (ESEM) supports the characteristics of fibers determined through tensile test. Based on the experimental results, it concluded that the Young’s modulus increased with increased span length. Tensile strength and strain to failure decreased when the span length was increased. Bamboo fibre showed the highest Young's modulus values among jute, bamboo, and coir fibres. Jute fibre had a smooth surface, but bamboo and coir fibres had a rough surface. It was demonstrated that accurate properties of natural fibers can be determined by using newly developed analytical equations.

Wang et al. (2017) evaluated laboratory investigation on strength characteristics of expansive soil treated with jute fiber reinforcement and studied the potential of using randomly distributed jute fibers to improve the changeable shear strength of expansive soil. The effects and mechanisms of fibre content, fibre length, fibre orientation, water content, and dry density on the contribution of jute fibres in strengthening expansive soil were also investigated based on the results of direct shear and triaxial compression tests. Direct shear and triaxial compression tests were performed on unreinforced and jute fiber - reinforced expansive soil. The reinforcing effects of jute fibers on the shear strength characteristics of expansive soil are discussed and interpreted for the purpose of producing considered parameters relevant to including fiber content, fiber length, fiber orientation, water content, and dry density. Several limitations of this study and a discussion of possible future areas of study were presented. Increases in fibre content improve direct shear strength, cohesion, and strength ratio (Rf) until fibre content reaches 0.6 percent, beyond which more fibre content tends to decrease fiber - reinforcing effects due to the replacement of soil particles by too many fibres. For the various fibre compositions tested in this study, the internal friction angle remains unchanged. The fiber - reinforcing effects was more evident at lower water content and higher dry density, owing to a larger effective contact area and the fiber - soil interface's weaker water - lubricating effects. Similarly, the strength and stiffness response of coir fiber - reinforced tropical soil by Sivakumar and Vasudevan (2008) studied the experimental results on the influence of coir fibers on strength and stiffness response of a typical soil that is normally used in the construction of embankments in tropical countries, such as India. Various fibre contents, fibre lengths, fibre diameters, and confining pressures were used in a series of triaxial compression tests. A number of triaxial compression tests were conducted using different fiber contents of different fiber lengths, fiber diameters, and confining pressures. Deviator stress at different strain levels has been determined and compared with that of unreinforced soil specimen. The experimental results have statistically analyzed and expressions for obtaining strength parameters, namely cohesion, friction angle, and stiffness were proposed. These expressions were used to examine the available theoretical models for prediction of strength of fiber - reinforced soil in relation to the results of the research. The paper summarized that Stiffness of soil increases considerably due to fiber inclusion, hence immediate settlement of soil can be reduced by incorporating fibers in the soil. Energy absorption capacity of CFRS increases as fiber content increases and hence toughness of soil can have increased with fiber inclusion; and regression analysis is useful to quantify the effect of various fiber parameters on shear parameters, major principal stress at failure and initial stiffness modulus for coir fiber reinforced soil over a wide range of confining pressures. Coir fibres, polypropylene fibres, and waste tyre rubber fibres were used to study the strength behaviour of cohesive soils reinforced with fibres by Singh and Mali (2014). Tri - axial, Direct Shear box, and unconfined compression tests were performed. The addition of coir fibres to the silty soil improved stress–strain behaviour, according to tri - axial test results. When more fibres of constant length are added, the principle stress at failure increases. When the fibre was added in exceeding 1% with an aspect ratio of 150, there was only a minor increase in strength. Shear strength of soil reinforced with polypropylene fibre increased with fibre inclusion up to 0.4 percent, then decreased. The maximum increase was observed at a length of 20 mm. The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

3. Conclusion

Based on the papers reviewed, the subsequent conclusions may be drawn

- Latex treated coir fiber is a good alternative that can be used for soil stabilization.
- Coconut coir is biodegradable and has less durability but that can be improved by coating the surface of coir by latex.
- Detailed analysis of the characteristics, benefits, applications and weaknesses of coir fiber as soil reinforcement was reviewed.
- The performance of coir - latex stabilized soil and its suitability for pavements can be studied.
- Latex treated coir fiber exhibits many advantages such as good strength properties, low cost and high toughness to biodegradability.
- The cost of rubber latex and coir fiber is relatively low, combination of the these can be the economical and also environmental friendly for the stabilization of soil.

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