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A Review On Fiber Reinforced Soil

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ABSTRACT :

This study explores the use of natural and synthetic fibers—bamboo, sisal, palm, and polypropylene—to enhance the mechanical properties of soil for geotechnical applications. The research focuses on improving soil strength, stability, and ductility through fiber reinforcement, addressing challenges such as weak subgrades, settlement, erosion, and cracking. Laboratory tests including Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), compaction, and shear strength for evaluations, were conducted to assess the performance. Bamboo fibers known for their high tensile strength and flexibility, significantly enhance soil stability and load-bearing capacity with an optimum of 1.2% and varying lengths, Sisal fibers can be a sustainable natural option to demonstrate excellent performance in increasing shear strength and reducing volumetric changes in soil. Palm fibers enhance ductility and reduce brittleness, particularly at an optimal fiber content of 0.5%. Polypropylene fibers can be a synthetic alternative to exhibit superior resistance to desiccation cracking and compression with an optimum performance at 0.4–0.8% fiber content, while combining them with additives like bagasse ash further improves soil properties. The results can confirms that incorporating these fibers enhances soil performance under various loading conditions, provides sustainability, cost-effective solutions for construction and environmental applications. This approach aligns with global sustainability goals, utilizing biodegradable materials like bamboo, sisal, and palm fibers, while recycling synthetic polypropylene waste for eco-friendly infrastructure development.

Keywords: synthetic fibers, ductility, flexibility, polypropylene, sisal, biodegradable materials

INTRODUCTION :

Fiber Reinforced Soil (FRS) refers to the technique of incorporating natural or synthetic fibers into soil to enhance its mechanical properties particularly its strength, stability, and durability. The addition of fibers serves to improve the soil's performance under load and its resistance to cracking, erosion, and settlement. This method is an innovative approach to soil stabilization, commonly used in geotechnical engineering to address issues such as weak soil, erosion-prone areas, and the need for improved load-bearing capacities in construction projects.

Natural fibers come from plants and animals, while synthetic fibers are manufactured from chemical compounds. Fibers are usually of natural fibers and synthetic fibers. Both fibers are different from each other on the basis of their origin. Natural fibers are obtained naturally from plants, animals and minerals. These are pure fibers that are extracted and weaved to form cloths, bags, jackets, paper, etc.., like Coir fiber, Jute fiber, Sisal fiber, Bamboo fiber etc..,Synthetic Fibers are man-made fibers and most of them are prepared from raw material petroleum called petrochemicals like Polypropylene, Polyester, Nylon, Glass etc..,

LITERATURE REVIEW :

- The use of sisal fiber to reinforce clay soil, finding significant improvements in soil strength and deformation resistance. The optimal sisal fiber content for soil reinforcement was determined to be around 0.6% of the soil's dry weight, with higher fiber amounts showing diminishing returns in strength improvement. Improving the Compressive and Shear strengths by adding sisal fiber by up to 1.2 times compared to unreinforced soil and significantly boosts shear strength by helping the soil for better resistance to deformation under loads. Micro structural Benefits by Scanning Electron Microscopy (SEM) revealed that sisal fibers create cementation links between soil particles promoting even stress distribution and enhancing resistance to cracking. This use of sisal fiber represents an innovative, eco-friendly alternative for soil stabilization, especially beneficial in applications requiring durable and crack-resistant soil structures.The California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) both improve significantly with 0.5% sisal fiber content, especially when using fibers cut to a length of 2.5 cm.In terms of durability, Sisal fiber embedded in soil shows resilience but loses tensile strength over time when embedded in clay, with an 8.98% reduction after one month.Sisal fiber offers a sustainable way to stabilize problematic soils, enhancing strength while reducing reliance on synthetic stabilizers.
- The effects of incorporating polypropylene (PP) fibers into clayey soil to enhance its engineering properties particularly for construction applications. The studies explores an environmentally friendly approach for soil stabilization by repurposing polypropylene fibers. The study incrementally varies the fiber content (0%, 0.25%, 0.5%, and 1%) and provides detailed findings for each percentage, which allows for a clear understanding of the optimal fiber content for improved soil strength. Variations in fiber length or type could influence soil properties and

examining these variables might have broadened the study's scope and applicability. Evaluating the environmental impact of polypropylene in soil over extended periods would be valuable for testing the stabilization effects on various soil types. The study effectively addresses two major issues soil stabilization and plastic waste management by repurposing non-biodegradable polypropylene fibers. Comprehensive tests, including compaction, unconfined compressive strength (UCS), direct shear, and California Bearing Ratio (CBR), were conducted, particularly noticed improvements in soil strength at an optimal 0.4% fiber of 12mm addition**.**

- The soil needs to be improved to increases its unit weight. By using bamboo reinforcement having a length of 12 inch and 0.5 inch in diameter distributed in uniform medium dense soil at different depths below the footings follows the load carrying capacity of single layer reinforced soil is increased up to 1.77 times and 2.02 times for multiple reinforced soil system than the load carrying capacity of unreinforced condition of soil. Bearing Capacity Ratio (BCR) increases with increasing number of reinforcing layer and also improves the attreburg limits. The bearing capacity and settlement of the footing resting on soil depends on the properties of soil such as relative density, size, shape, and embedment depth of footings. The natural bamboo fibers having diameter 3mm and 6mm with length 10mm and 20mm respectively can be used by waterless weight of normal soil was used as 0.20,0.40,0.80,1.00,1.20,1.40 percentages were checked. It was observed that from the test results the unsoaked and soaked CBR value of soil increases with the increase in length and diameter of bamboo fiber.
- The study explored how palm fiber reinforcement impacts the strength properties of clay under various stress paths by 16 triaxial tests. The research analyzed variables such as palm fiber length (5 mm to 20 mm) and fiber content (0.3% to 0.9% by mass). In the Reduced Triaxial Compression (RTC) conditions, clay with 0.3% fiber content showed increased deviator stress, particularly under higher confining pressures, with variations depending on fiber length. Fibers increased cohesion and friction angle under effective stress. For instance, samples with 10 mm fibers and 0.5% content showed enhanced cohesion and shear strength compared to bare clay.The reinforcement effect was stronger at 5 mm fiber length and decreased as fiber length increased, especially for unloading conditions.The fiber content and length are key factors in achieving optimal reinforcement, with lower content and shorter fibers generally offering better results.

CONCLUSION :

The addition of fiber significantly increases the tensile strength and ductility of soil, reducing the livelihood of failure under load. In road construction the fiber is mixed with soil and it is used in subgrade level to increase the load bearing capacity of the soil.The inclusion of bamboo fibers significantly improves the shear strength and stability of soil. Laboratory tests on various percentages (1% - 5% by weight) of bamboo fiber reinforcement demonstrated better load-bearing capacity which is essential for foundational stability in construction. The load bearing capacity increases 1.77 times in single layer and 2.02 times for multilayer of soils.The study found that adding 0.4% Polypropylene fiber by weight provided the best improvement in soil strength and stability for many properties. At higher fiber contents (1.5%), there was a notable decrease in the soil's compression index (69%) and swelling index (78%), making it less prone to deformation under loads. By Adding 0.5-1.5% sisal fiber content to soil can significantly enhance its engineering properties like 10-60% increases in compressive strength,15-70% increases in tensile strength, 12- 65% increases in shear strength,and 15-70% increases in CBR.The use of palm fiber as soil reinforcement significantly enhances soil strength, increases the shear strength by up to 25-40%, compressive strength by 15-30%, and reduces soil cracking, depending on optimal fiber content (typically 0.5-2%), fiber length (10-30 mm) and appropriate fiber treatment. Fiber reinforcement is an innovative technique used to enhance the mechanical properties of soil. This aims to investigate the effectiveness of various fiber types, such as synthetic and natural fibers, in improving soil stability. By incorporating fibers into soil potentially reduce erosion, increase load-bearing capacity and enhance durability. The outcomes will contribute to the development of sustainable construction practices and provide insights into the application of fiber reinforced soil.

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