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A REVIEW _SOIL IMPROVEMENT USING THE MULTI TYPE OF POLYPROPYLENE MATERIAL

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Abstract:

The increasing recognition among individuals of the detrimental impact of human-made substances on the natural world has resulted in the development of more ecologically sound substitutes for ensuring the durability of diverse polymers. Researchers have demonstrated a notable propensity towards a methodology for producing substances that possess the ability to serve as an alternative to artificial compounds. In recent years, there has been a notable surge in demand for composite materials comprising both natural and synthetic fibers for commercial purposes, which has had a significant impact on multiple industrial sectors. Natural fibers are a category of substances that are environmentally degradable and abundantly present in their native ecosystems. The aforementioned materials exhibit characteristics such as economical viability, low mass density, inherent ability to regenerate, biodegradability, and distinctive attributes.

The primary aim was to evaluate cost-effective methods for soil stabilization. The study investigates a range of materials that have the potential to enhance soil characteristics, such as polypropylene, fiber glass, and fiber plastic. The text examines the potential of said materials to augment shear strength and ameliorate soil quality through the reduction of plasticity, permeability, and compressibility, as well as the enhancement of soil strength.

Keywords: *Soil Improvement, The Polypropylene, Shear Strength, Fiber Glass, Fiber Plastic .*

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1. Introduction

The three main soil types, sand, clay, and peat, behave mechanically in very different ways. While typically being much softer than sand, clay typically has a much lower water permeability. Due to the presence of organic material fibres, peat is often very light (rarely much heavier than water), strongly anisotropic, and anisotropic in nature. Peat typically compresses easily as well. The mechanical qualities, including stiffness and strength, that an engineer needs must be determined through mechanical tests in order to produce the quantitative data. Even soils with the same particle size might differ in their mechanical characteristics(Verruijt, 2018) . Due to their availability, affordability, and durability, Numerous geotechnical engineering problems can be solved with polypropylene fibers. The soil is irregularly dotted with short, bent fibers; this reinforced soil exhibits greater ductility than unreinforced soil.It is because soil matrices with higher fiber contents have fibers that can withstand tensile loads. Since there are more fibers per volume, their improved reinforcement advantage to tensile strength is more noticeable (Jian Li, Chaosheng Tang, Deying Wang, Xiangjun Pe, 2014) . Polypropylene fiber is used in a variety of applications, including the building of embankments, subgrades, subbases, and slope stability issues (Snigdha V. K et al., 2016) .

2. Materials - Polymers

Numerous categories can be used to categorize polymers. The most evident division is between natural and synthetic polymers, which is based on the origin of the polymer. Other classifications are based on the structure of the polymer, the mechanism of polymerization, the preparative methods, or the thermal behavior. When a very high number of structural units (repeating units, or monomers), under the right circumstances, are made to link up by covalent bonds, polymers can either be naturally occurring or completely synthetic. Certain simple (small) organic compounds do not have the ability to form polymers, even when the "right" conditions exist. Let's define the term functionality in order to comprehend the types of molecules that can form polymers (Ebewele, 2000) . One-third of all carbon emissions worldwide are caused by construction. These emissions contribute to the current climate emergency and cause global warming. To effectively address the climate emergency, The adoption of sustainable and ecologically friendly products must be encouraged. An environmentally friendly material with a low carbon footprint is fiber- reinforced polymer (FRP). The refurbishment and rehabilitation of existing structures is another important use for fiber-reinforced polymer (FRP) materials in the field of civil engineering. (1) The use of FRP profiles in newly built structures. (2) The use of fiber-reinforced polymer (FRP) bars in concrete components. It discusses the fundamental characteristics of the component materials (fibres and polymer resins), the mechanical properties of FRP bars, various strengthening systems and profiles, production processes, as well as the applications of FRP composites in civil engineering. Resilience, sustainability, and recycling of FRP composites are a few more topics that are covered in this article. (Qureshi, 2022).

3. Polymer types

A. The Polymer membranes

The particles of the sand are encapsulated in addition linked together by the polymer and water mixture to create a stable construction. With increasing dry sand density, this stabilization's effectiveness decreased (Jin Liu et al., 2018) .

B. Organic Polymer

The organic polymer that was used in this experiment as a soil stabilisation primarily consists of polyurethane resin. This organic polymer's polymerization is explained in the following. Toluene, polyoxypropylene diol (PPG; Furthermore, polyoxyethylene glycol (PEG; Shanghai Ika Biotechnology Co., Ltd.; Shanghai, China), polycaprolaclone glycol (Jining Hongming Chemical Reagent Co., Ltd.; Jining, China), and polypropylene glycol were utilised. (PCL; Jining Hongming Chemical Reagent Co., Ltd.; Jining, China) were combined in the beginning in the following weight ratios: 5:5:2: once the toluene had dried in most places (Jin Liu et al., 2018) .

C. Fiber glassis

Global environmental contamination is a major concern (MUTTALEB & ALI, 2022) . There are several contemporary industrial applications for glass fiber. According to (Catarina Brazão Farinha , Jorge de Brito, 2019) It is also non-perishable and has a high level of chemical stability. These are only some of the applications that can benefit from its corrosion resistance, high temperature resistance, little moisture absorption, increased electrical insulation, and non-perishability. It also has a number of applications in the manufacturing process. nonetheless, there are still certain restrictions on its use because glass fiber is fragile, easily broken, and not wear resistant. Additionally, friction quickly produces static electricity, which restricts industrial applications. Silane coupling substances with surface sizing agents are widely used to enhance the substrate and fibre interface. This means that the strength of the glass fibre is strengthened by forming a polymer substance that composites on the glass fibre. This is done so that the product may conform to industry requirement (Arczewska, P.; Polak, M.A.; Penlidis, 2021) . During establishing glass fiber, a unique method is developed to cover the fiber's surface in a surface sizing agent. (Zhang, Y.; Pontikes, Y.; Lessard, L.; van Vuure, 2021).

Figure 1. Fiber glasses

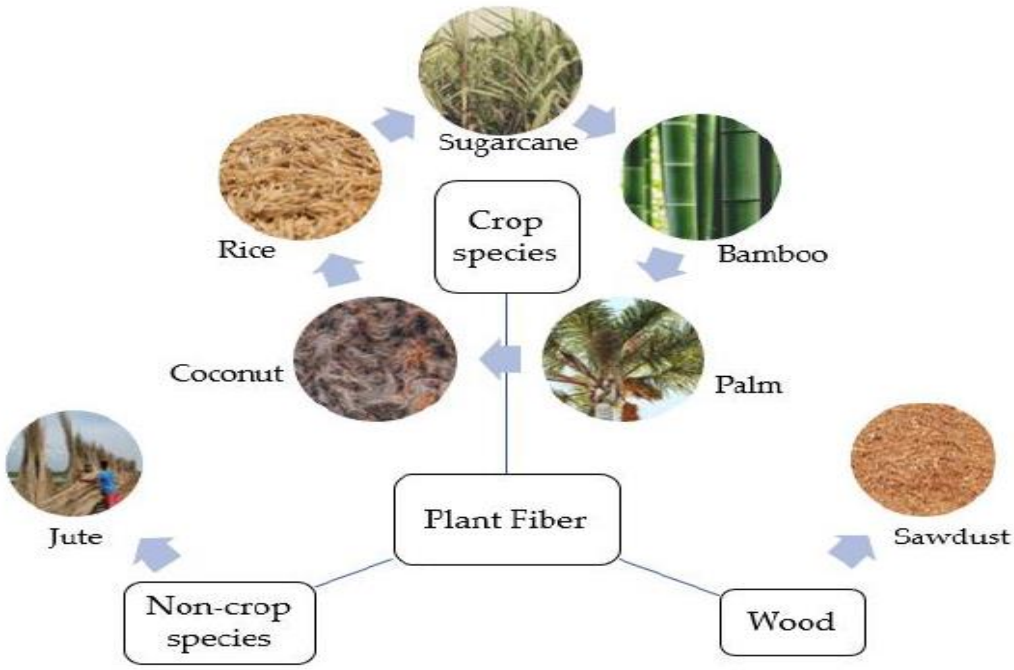
D. Natural fibers

natural surroundings, The development of such materials that can take the role of synthetic materials has attracted a lot of interest from researchers. In consequence, business interest in organic fiber-based polymers has increased recently across a number of industrial sectors. Natural fibres are easily available, environmentally friendly materials with advantages such being lightweight, inexpensive, renewable, biodegradable, and having high specific qualities. (Thyavihalli Girijappa et al., 2019) These fibers can be classified into a variety of groups according on where they came from and how they were made (Ho et al., 2012) . From the perspective of their place of origin, natural fibers can be broadly separated into three categories: (1) vegetative fibers (such as hemp, bamboo, jute, and coir); (2) protein-containing components from animals (such as silk, hair, and wool); (3) minerals. even though they are readily available and well suited for extensive geotechnical objectives, In terms of natural fibres, they have been pushed towards plant fibres (Gowthaman et al., 2018).

4. Method preparation for Polypropylene types

A. Natueral polymer

In this investigation, synthetic polypropylene fiber is used. This material was chosen because it is inexpensive and has properties like hydrophobicity and chemical inertness that prevent it from absorbing or reacting with leachate or soil moisture. Low thermal and electrical conductivities, a melting point of 160°C, a 590°C ignition temperature, and high igniting temperatures (Malekzadeh, Mona, 2012) . Additionally, several aggregates or vegetable fibers, Various materials, such as bamboo, jute, cocoa, palm, sugar cane bagasse, rose husk, as well as sawdust, have been utilized in numerous studies to fortify the soil. By adding these elements, we may make the soil more stable (Carlos J. Medina-Martinez , Luis Carlos Sandoval-Herazo & Reyes-Gonzalez, 2022).



Figuer2 : Natueral polymer (Carlos J. Medina-Martinez , Luis Carlos Sandoval-Herazo & Reyes-Gonzalez, 2022)

B. Industrial polymer such as (Fiber glass , fiber plastic)

The soil had been passed through sieve #40 and baked to dry it. The sand had to be mixed with the set amount of water, and the mixture was thoroughly mixed until the soil-water mixture was homogeneous. The fiber followed gradually but the mixture had been continuously agitated.(Rabab'aha et al., 2020) .

5. Previous studies:

The most recent prior studies to use a propylene material, such as glass fiber, organic polymers, and polypropylene fiber, Table 1 below displays the characteristics of the foundation soil that might be improved.

Table 1: Previous studies

Name of author	**Treatment material**	**Type soil**	**The test methods**	**Result**
(Malekzadeh, Mona, 2012)	0%, 0.5%, 0.75%, and 1% polypropylene fiber from clay soil, Average length: 20 mm, diameter: 0.06 mm.	Clay (%) = 52 Silt (%) =40 Sand (%) = 8	Compaction test split tenslle strength test The UCS test	Inclusions of polypropylene fibers increase the unconfined compressive strength. The highest level of cohesiveness can be seen at 1% fiber concentration, or roughly half of that unreinforced soil can support. The highest possible According to the findings of the research that was conducted using the split tensile strength test, the value of tensile strength that was achieved for 1% of fibre inclusion is 2.7 times more than the unreinforced soil.
(Snigdha V. K et al., 2016)	Polypropylene fiber(0%, 0.05%, 0.15%, 0.25%, and 0.35% with the same dry density)	Clay (%) = 13 Silt (%) =52 Sand (%) = 31 Gravel (%)= 4	Compaction Tests The UCS test	When used with the least amount of reinforcement, polypropylene fibers have been found to be an efficient way to enhance the subsoil's mechanical and physical qualities. the strength value rises to 83.71KN/m2 prior to failing the undefined compression test with a polypropylene fiber increase of up to 0.05%.
(Das, 2019)	fiber	sand	Direct shear test	an optimum fibre content of 2.1%. to improvement shear strength parameter
(WANG et al.2017)	GLASS	sand	Permeability test	With an increase in the amount of glass in the specimen, the permeability coefficient rises to a certain point, then falls, and then gradually rises. When the glass mix percentage reaches 20%, the permeability of glass-sand soil is at its highest.
(Liu et al.2018)	Organic Polymers	Sand	The UCS test Direct Shear Test	Increased unconfined compressive force, cohesiveness, and tensile strength of samples having identical dry density was found to be associated with

				the augmentation in the concentration of polymer.
(Hossain et al.2018)	Adding 0-15% lime by the soil weight as well as adding 2% polypropylene fibers by lime weight and the mixing is treated h different types of soil	Clay (%) = 20 Silt (%) =65 Sand (%) = 20	The CBR test The UCS test	As a result of adding 2% polypropylene fibers by weight to lime, the results showed that 10% lime concentration for clay and silt soil was achieved, whereas 7.5% lime concentration with 2% polypropylene fibers by weight lime was achieved for sandy soil. The rise is far greater than the average soil's base strength.
(Abioghli, et al.2018)	Sand stabilized with Fiber	Three different types of sand soil: Porto Alegre sand SM Sand from Khazar's coast, SP -Sand of Bolsar, SP	Triaxial test data for three different types of sand soil were used to calibrate the proposed model for fiber-reinforced cemented sand.	Several consolidated drained experiments on the three various types of sands were done, and the results were compared to those predicted by the modeling. The experimental findings can be used to demonstrate that the proposed model successfully predicts the behaviour of fiber-reinforced cement-based soil.
(Benziane et al.2019)	polypropylene fiber	Sand	Relative Density, Dr (%) Direct shear test	As there are more fibers, cohesion, and friction angle increase. ; at three different relative densities, 30%, 50%, and 80%, respectively. These effects are more pronounced at greater normal stresses and relative densities.
(Jiang et al., 2022)	Polymer-modified microbially	Sand	The UCS test	MICP reactants to the desired that is ability to control the CaCO3 precipitation location in the MICP process
(Sengupta, 2022)	Polypropylene, length 5 mm, 0, 0, 0.1, 0.2, 0.3, and 0.4% by dry mass from the soil	Clay (%) = 28 Silt (%) =57 Sand (%) = 15	Triaxial tests	It was shown that the failure deviator stress for reinforced soils had a minimum and maximum value that, respectively, represented 0.5 and 6%/minute strain rates. Cohesiveness's worth first increased, then it started to fall after an ideal level of reinforcement. with an increase in the rate of strain for the majority of the cases. There was no clear pattern associated with the change in strain rates in the value of angle of internal friction.

(Ghadr et al., 2020)	particle sizes of polymeric fiber (ranging 0.80 to 1.18 mm.)	Sand soil with the silt content greater than 40%	A cyclic triaxial testing device with pneumatic control made by the British company VJ Tech	A larger average number of interactions per particle and dilated pores that encourage the dissipation of pore water pressure are also present , Additionally, lower contact forces and improved liquefaction resistance are produced by increasing fibre content. If the percentage of silt in the sands is higher than 40%, the efficiency of fiber reinforcing diminishes as the sand's median size rises.
(He et al., 2021)	polypropylene (PP) fiber reinforced content (0.35%, 0.60%, 0.85%)	Clay (The soil utilised in this study was gathered in the northwest Chinese province of Shaanxi.)	• razilian split-screening test A straightforward and well-liked method to assess the soil's tensile strength is the Brazilian splitting test. • enetic engineering (GE)	The tensile strength essentially improves as the fiber aspect ratio increases, but the growth rate is only as great as the fiber distribution pattern.
al.*(Al-Saray et al., 2021)*	polypropylene fiber	Sand	Permeability and CBR tests	- The best PPF percentage is 0.6% with higher values of ° and CBR with very little value of k. -percentage permeability that 26% for mixing 0.1% PPF
(Rabab'aha et al., 2020)	Adding glass fiber for different percentages (0.25 and 1.0 %) as percent of weight of the soil	Clay (%) = 64 Silt (%) =31 Sand (%) = 5.0	The ITS test The CBR test The UCS test	According to the test results, adding glass fibers to subgrade soil dramatically raises the unconfined compression strength, ITS, and CBR values while lowering the free swell values.
(Jing et al., 2021)	*Glass Fibers*	sand	Peak Pore Pressure Variation and Shear Strength Variation	Make Stress-Strain Curves of Reinforced Soil improve shear strength of soil
(Nitin Tiwari, 2021)	.25%, 0.5% and 1% polypropylene (PP) fiber	Clay (%) = 71.5 Silt (%) =24.5 Sand (%) = 4	UCS test STS test Chemical and microstructural analysis(H, CCt and EC)test	In this work, various ratios of PP fiber and PA were used in the comprehensive experiments and numerical analysis. 408 samples in all were prepared for the thorough

				investigation. demonstrates how raising pH values causes soil's shear strength to increase.
(Abdulrahman et al., 2021)	polypropylene fiber 1%	s SW-SM, the gypsum content 39% , Sand (%) = 94.0 Clay & silt (%) = 4.0	Model Loading tests for after being treated by blending 1% of plastic fibers into gypseous soil, the foundation - odometer test a the direct shear test,	This indicates that adding fiber to the soil up to a certain depth below the footing may have a positive impact on reducing soil collapse.
(Tiwari & Satyam, 2022)	The polypropylene fber of 12 mm length	Clay's percentage is 71.5, Silt's is 24, and Sand's is 4.	direct shear strength and The UCS test	The findings demonstrate that the shear strength of the reinforced subgrades was greatly boosted by 177% by the addition of a layer of biaxial/triaxial geogrid and polypropylene fibre. The use of polypropylene fibre and geogrid in various configurations has boosted the unconfined compressive strength of expansive subgrades by a range of 3.8% to 139.6%.
(Lihua Li, Xin Zhang & , Jiang Zhang, 2022)	the inclusion of a layer of biaxial/triaxial geogrid and polypropylene fibre significantly increased the shear strength of the reinforced subgrades by 177%.	clay	Standard compaction test the UU triaxial test	The peak deviator stress is most significantly influenced by fibre when the content is between 1% and 1.0%. The peak deviator stress is scarcely affected by fibre lengths more than 12 mm.
(Lihua Li, Xin Zhang & , Jiang Zhang, 2022)	particles of expanded polystyrene foam (EPS), fly ash, lime, water, and polypropylene fibre	soft clay in Shaoxing area. China	the CBR test SEM test	The most effective information has a reinforcing impact of 0.1%. The CBR value of FELS consistently increases as the age at which it has been cured advances. This is as a result of the fact that as one gets older, their skeleton's structure improves, The structure's capacity to withstand shear grows as the ion exchange and hydration reaction progress.
(Jiang et al., 2022)	polypropylene fiber 6 mm	The research depends on testing a nano clay.	Tests of Unconstrained Compressive Strength .STS test: Splitting	(1) The UCS of LS first rises with an increase in fiber content and subsequently falls, however, as fiber content rises—with 0.75% being the

		the type of the clay is Montmorillo nite	Tensile Strength Test	optimal fiber content—the UCS and STS of NLS and STS of LS also climb. (2) The linear relationship is met by the UCS and STS of NFLS and /LVi.
(Shufeng Chen , Tao Luo, 2022)	Polypropylene Fiber(12 mm) and Fly Ash	Clay (in the southern part of Xian, in the NW Chinese province of Shaanxi)	Dynamic triaxial testing were carried out using GDS DYNTTS, an instrument made by Global Digital Systems Ltd.	Although both the shear stress and the shear modulus were increased, The best dynamic performance was demonstrated by 0.5% PP fibre.
(V et al., 2022)	Alcofine-1101 is included in a variety of amounts, including 0%, 5%, 10%, 15%, 20%, 25%, and 30% by weight of soil, as well as 1% of enhanced polypropylene fiber for RS and BCS.	Red and black cotton soils (RS and BCS) are gathered in the northern and southern parts of Karnataka.	Proctor compaction test as usual. unrestricted compressive resistance (UCS). Test for California bearing ratio (CBR) .	The engineering qualities of soil are evaluated experimentally, and the UCS and CBR tests are used to ascertain the shear characteristics of the soil. The data show that adding admixtures improved all of the soil's characteristics and produced superior outcomes. According to the results of the Atterberg limit test, the water content decreases as the amount of admixtures increases. The chemical reactivity with soil and water is enhanced by an industrial waste including cementitious materials and lime. By doing so, the soil becomes less brittle and strengthens the connection between its particles.
(Anouar & Zeineddine, 2022)	- polypropylene fiber 18 mm length -The combined soil-sand-cement (CSV) columns.	Soft soil content (SSC). Sand content (SC).	triaxial compression tests (CD). The design of experiments (DOE).	In CSV materials, adding polypropylene fiber while reducing the amount of soft soil has a significant impact; There are both higher and lower elasticity modulus values.

6. Previous studies analyze

A. The present study investigates a range of materials that have the potential to enhance soil properties, such as polypropylene, fiber glass, and fiber plastic. The text examines the potential of these materials to augment shear strength and enhance soil quality through the reduction of plasticity, permeability, and compressibility, while concurrently increasing soil strength. In addition, the article discusses supplementary substances that can be employed in combination with polypropylene to enhance the properties of soils that are deficient in requisite engineering characteristics. The aforementioned additives comprise bitumen, cement, lime, fly ash, and fly ash. In general, the article offers significant perspectives on enhancing soil quality through the utilization of various forms of polypropylene materials. The significance of sustainable alternatives in guaranteeing the longevity of diverse polymers in soil enhancement is underscored, with a particular emphasis on the necessity for cost-effective stabilization methods.

B. Some researchers have suggested using natural fibers covered with synthetic materials to overcome this constraint. By physically and chemically altering the fiber's surface, they can lessen the fiber's hydrophilicity and slow down the rate at which it degrades in the environment. (Rahman, M.M.; Khan, 2007) .

C. Natural fibers have a number of benefits, including lower cost, lower energy inputs, comparable mechanical properties, Positive characteristics include increased elasticity of polymer composites reinforced with natural fibres, exceptionally low shrinkage, excellent dimensional stability, high-temperature resistance, good fatigue resistance, and adherence to reinforcements (Xie, Q.; Li, F.; Li, J.;Wang, L.; Li, Y.; Zhang, C.; Jie, X.; Chen, 2018) .

7. CONCLUSION

Soil stabilization has become necessary in order to make the subgrade or foundation strong enough to handle the loads. By adding a variety of elements, the stability of the soil is achieved. After reviewing the many products used to enhance soil qualities, the study indicated above came to the following conclusions:

1. Fiber plastic improved the load carrying capacity. Plastic waste can be used as a lightweight building material because it improves the strength and compressibility behavior of fine soils in clayey soil.

2. Upon application of the organic polymer solution onto the sand, the resultant formation of polymer membranes through the amalgamation of the polymer and water facilitated the encirclement and interconnection of sand particles, thereby engendering a stable structure. An increase in polymer concentration results in the formation of a greater number of polymer membranes, which serve to occupy interstitial spaces within the sand matrix, encapsulate individual sand particles, and maintain the overall structural integrity of the sand. The effectiveness of this phenomena depends on the dry density, and an ideal sand density makes the filling of voids and encasing of sand particles easier. In addition, it is easy to see how the sand particles are connected and interlock. These trustworthy and useful discoveries provide the theoretical underpinning for the reinforcement.

3. Glass fibers have a number of key benefits, including fire resistance, stretchability, the fact that they do not quickly degrade, and the ability to preserve mechanical qualities even in humid environments. A better outcome is obtained by using fiber-glass as reinforcement materials in the weaker zones.

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