

Natural Fibers As Geo-Reinforcement-A Review

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Abstract – The improvement in various geotechnical properties of soil is required for better performance. Many soil or ground improvement methods are practiced today for improving the properties. The choice of method, material and equipment's depends upon the type of soil, material available, project importance and longevity and sustainability. Out of these various materials, fibers are also used for soil improvement. Fiber is a form of structural reinforcement either in the form of natural or manmade material. The various synthetics and waste fibres are used for improving strength of soil which are neither economical nor eco-friendly. Hence, the present paper reviews the use of natural fiber for soil improvement and intends to find its suitability for various soil structures. The natural fibers are renewable, cheap, completely or partially recyclable, biodegradable, and environment friendly materials. Due to their availability, low density and price as well as satisfactory mechanical properties, make them attractive alternative reinforcements to glass, carbon and other manmade fibers. Geo reinforcement are used for various purposes like barrier, drainage, surficial erosion control, filtration, protection, reinforcement and separation. The various natural fibers used as geo- reinforcement are jute, coir and banana. The different geotechnical properties such as MDD & OMC, CBR, shear strength characteristics, permeability were investigated by various researchers with different percentage of fibers. The study reveals that these natural fibers can be suitably used for soil improvement. However, study available is limited and detailed investigation is required for the durability and various applications.

Keywords- Natural fibres, Geo-reinforcement, banana fibres, longability, durability

INTRODUCTION

Geo-reinforcement is defined as a technique to improve the engineering characteristics of soil. Soil reinforcement is an effective and reliable technique for improving soil strength in a variety of applications. Combined product had much better engineering properties than the individual constituents. The primary purpose of reinforcing soil mass is to improve its stability, increase its bearing capacity and reduce settlements and lateral deformation. The concept and principle of soil reinforcement was first developed by Vidal (1969). The introduction of reinforcing elements in a soil mass increases the shear resistance of the medium. There are various types of geo-reinforcement like as geotextile, geo-grid, geo-net, geo-membranes, geo-composites and others. Geo-reinforcement are used for various purposes like barrier, drainage, surficial erosion control, filtration, protection, reinforcement and separation. Along with these geo-reinforcement fibers are also used as soil improvement additives. Fiber is a form of structural reinforcement either in the form of natural or manmade material. The various synthetics and waste fibres are used for improving strength of soil which are neither economical nor eco-friendly. The natural fibres such as coir, jute or Banana fibres are studied for as prospective fibres to be used as geo-reinforcement. Hence, the present paper reviews the use of natural fiber for soil improvement and intends to find its suitability for various soil structures.

NATURAL FIBERS

Natural fibers are defined as substances produced by plants and animals that can be spun into filament, thread or rope and further be woven, knitted, matted or bound. The most viable structural fibers typically derive from specifically grown textile plants and fruit trees. Natural fibers are cheaper in cost, environment - friendly, renewable and bio-degradable. Based on their origin, the fibers may be classified as belonging to one of the following two categories: Natural and Man-made. Natural fibers can be further classified according to their origin into three groups. Fig. 1 shows the detailed classification of natural fibres.

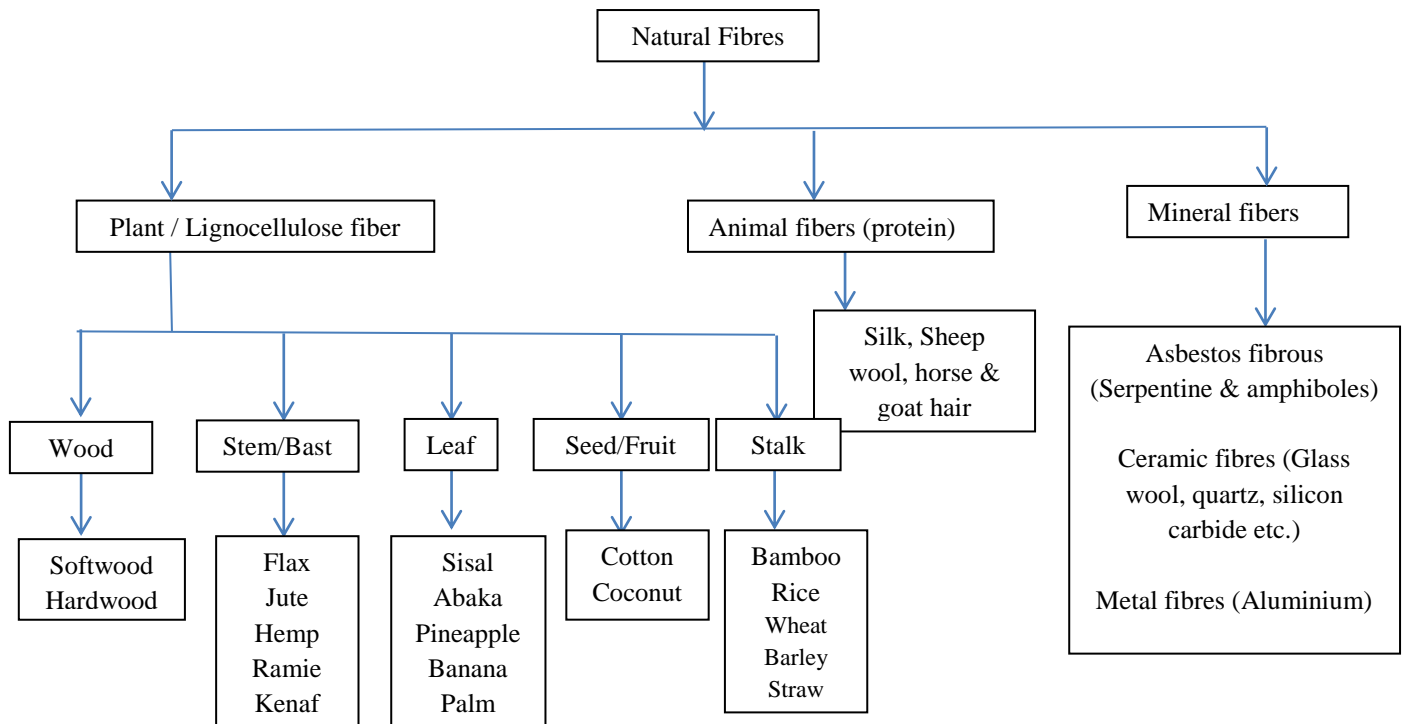


Fig. 1: Classification and Sources of Natural Fibers

The natural fibers mainly classified based on source of the fibers viz. plant, animal and minerals. Many of these fibers are widely used in day to day life of the human kind. The engineering uses of these fibers are also accepted in the practice. The various study carried out on coconut fiber i.e. coir, jute fiber and banana fiber is discussed below.

COIR FIBRES

Coconut (coir) fibers are normally 50–350 mm long and consist mainly of lignin, tannin, cellulose, pectin and other water soluble substances. However, due to its high lignin content, coir degradation takes place much more slowly than in other natural fibers. Rowell *et al.* (2000),described that coir is very long lasting, with in-field service life of 4–10 years. The water absorption of that is about 130–180% and diameter is about 0.1–0.6 mm. Coir retains much of its tensile strength when wet. It has low tenacity but the elongation is much higher.

Ravishankar and Raghavan (2005) confirmed that for coir-stabilized lateritic soils, the maximum dry density (MDD) of the soil decreases with addition of coir and the value of optimum moisture content (OMC) of the soil increases with an increase in percentage of coir. The

compressive strength of the composite soil increases up to 1% of coir content and further increase in coir quantity results in the reduction of the values. The percentage of water absorption increases with an increase in the percentage of coir. Tensile strength of coir-reinforced soil (oven dry samples) increases with an increase in the percentage of coir.

JUTE FIBERS

Jute is mainly environmental-friendly fiber that is used for producing porous textiles which are widely used for filtration, drainage, and soil stabilization. Aggrawal and Sharma (2010) used different lengths (5–20 mm) of jute fibers in different percentages (0.2–1.0%) to reinforce soil. Bitumen was used for coating fibers to protect them from microbial attack and degradation. It was concluded that jute fiber reduces the MDD while increases the OMC. Maximum CBR value is observed with 10 mm long and 0.8% jute fiber, an increase of more than 2.5 times of the plain soil CBR value.

Singh and Bagra (2013) studied the influence of Jute fiber on the CBR value of Itanagar, Arunachal Pradesh, soil which is a typical soil and is normally used in the construction of embankments and pavement. The effects

of different lengths and diameters of Jute fiber on CBR value of reinforced soil have also been investigated and results were compared with that of unreinforced soil. CBR value of soil increases with the inclusion of Jute fiber. When the Jute fiber content is increases, the CBR value of soil is further increases and this increase is substantial at fiber content of 1 %. It is concluded that there was significant effects of length and diameter of fiber on the CBR value of soil. The CBR value of soil increases with the increase in length and diameter of fiber. The maximum increase in CBR value was found to be more than 200 % over that of plain soil at fiber content of 1 % for fiber having diameter 2 mm and length 90 mm.

BANANA FIBERS

Banana fiber is a strong fiber, light weight and has smaller elongation. It has strong moisture absorption quality. It absorbs as well as releases moisture very fast. It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.

Sunny and Joy (2016) studied the properties of marine clay with addition of banana fibers. The addition of banana fiber improved the properties of marine clay. The optimum value for marine clay stabilized with banana fiber was obtained at 0.75%. It was observed that OMC value increased with the addition of banana fiber and dry density decreases. The shear strength increased from 8.5kN/m² to 32.91kN/m² with the addition of 0.75% of banana fiber and CBR value increased from 2.79 to 13.2 which makes it suitable for subgrade soil for road pavements.

Table 1 shows the use of various natural fibers used in the study for various soil improvements. It can observed that depending upon the length of fiber, optimum % of fibers varies. In all soils and fibers, CBR and UCS increases with the use of natural fibers. However, except for expansive soil with coir, in all other cases, MDD decreases and OMC increases.

NATURAL FIBERS REINFORCED THERMOSET COMPOSITES

Begum and Islam (2013) presents a brief overview of the improvement of the mechanical properties (tensile and flexural strength and the corresponding modulus of elasticity) of natural fiber reinforced polymer materials (NFRPCs). A number of thermosetting and thermoplastic polymers have been studied as binding

materials in NFRPCs. Among the most studied thermosetting materials are epoxy resins and unsaturated polyesters, and among the thermoplastics, poly-olefins such as low and high density polyethylene as a well as polypropylene are the most studied. Different natural fibers have been introduced into the polymer compositions with a view to improve their mechanical properties.

The mechanical properties of a composite depend on the nature of the resin, fiber, resin-fiber adhesion, cross-linking agents and not the least on the method of the processing.

Epoxy based polymer composites, polyester based composites and polyethylene based composites are being used to strengthen the natural fiber and increase the strength. The various researchers studied the effect of epoxy, polyester and polyethylene based composites blended with various natural fibers. Table 2 gives the improvement in tensile strength, young modulus, and flexural strength of the fibers.

NEED OF THE RESEARCH

Natural fibers are derived from a renewable resource and do not have a large energy requirement to process, and are biodegradable. Besides ecological considerations natural fibers exhibit many advantageous properties which promote the replacement of synthetic fibers. They are a low-density material yielding relatively lightweight composites with high specific properties. The use of natural fibers untreated or treated with epoxy polymer or polyethylene have large potential to be used in the application of geotechnical engineering such as soil improvement, pavement construction, slope protection, improving bearing capacity and reduction in settlement. Hence, a lot of scope is available in this field for research and bringing natural material in wide applications.

CONCLUSION

The present papers review the suitability of natural fibers in soil improvement and conjunctive use of thermoset composite of natural fiber and polymers. The strength characteristics of soil viz. unconfined compressive strength, CBR increases with the use of natural fibers while MDD reduces and OMC increases. The biodegradability factor of natural fibers puts the use of natural fibers in long term projects in big failure domain. This can be taken care of by treating these natural fibers with suitable polymers or other composites, so that a

sustainable solution will be available for geotechnical engineers with longevity of the reinforced system.

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Table 1: Optimum % of Different Natural Fibres

Sr. No	Soil	Fiber	Optimum Reinforcement	Properties	Author
1	Alluvium soil	Jute	1% , 90mm length & 2mm dia	CBR increased	Singh and Bagra (2013)
2	Alluvium soil	Jute	5% 60-80 mm length	CBR increased	Dharmendra et al. (2015)
3	Black cotton soil	Jute	Jute mats 2 mm thickness	UCS increased	Singh and Yadav (2016)
4	Fine sand	Jute	20 mm length and 1%	Compressive strength increased and dry density decreased	Aggrawal and Sharma (2010)
5	Expansive soil	Jute	Jute mat in multilayer	MDD ,CBR increased and OMC decreased	Singh and Yadav (2016)
6	Marine Clay	Banana	0.75%	OMC ,CBR Increased and MDD decreased	Sunny and Joy (2016)

Table 2: Improvements of the mechanical properties of epoxy, polyester, polyethylene based polymer composites [Begum and Islam (2013)]

Resin	Reinforcing fibers	Investigated mechanical properties	Properties of the base polymer (MPa)	Property improvement*, %	Corresponding Fiber content w, %
Epoxy	Banana Coconut	Tensile strength	23.98	90	-
			-	307.82	30 w
	Banana Bagasse (treated) Coconut	Flexural strength	53.38	38	-
			-	23.34	30 w
Polyester	jute (untreated) pineapple-leaf (untreated) okra (treated) Coir (untreated) Bagasse (treated)	Tensile strength	250	900	60 v
			22.9	176	40 w
			28	135	27.61 v
			-	30	25 w
			10.6	152	65 w

LDPE	Sisal (untreated)	Young's modulus	140	458	30 w
	Sisal (untreated)		140	853	21.5 v
	Wood (treated)		350	272	40 w
HDPE	Hemp	Young's modulus	1070	555	60w
	Rice hulls			181	60 w
	Hardwood-A			349	60 w
	Hardwood-B			349	60 w
LDPE- Low Density Polyethylene, HDPE-High Density Polyethylene					
* Increment in relation to pure polymer (%), w = Fiber content in weight (%), v = Fiber content in volume (%)					