



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 11, November 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

 9940 572 462

 6381 907 438

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 www.ijrset.com

Soil Reinforcement Using Pine Needles – Review

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ABSTRACT: A great interest in the research of naturally available materials had been evoked due to the lack of resources that are environment friendly. Randomly distributed fibre reinforced soils have recently been a source of attraction for Engineers. The present work emphasizes on soil stabilization using pine needles. The pine needles are available as scrap material in abundance and therefore can be used for soil stabilization purpose taking into account both cost as well as easy availability of material. This paper is the partial part of the ongoing research work.

KEYWORDS: Soil Reinforcement; Cohesion; OMC; MDD; CBR; Fibre Reinforced; Soil Stabilization; Aspect Ratio.

I. INTRODUCTION



Disintegration of physical and chemical agents leads to the formation of soil. It is formed when rocks, minerals like granite marble sandstone, organic matter both animated and in animated, water and air combine with each other. Soil is by and large falsified due to weathering action of wind, rain, snow, sun which lead to the disintegration of rocks. Humus also leads to the soil formation on combining with rock. Reactions mixed up in chemical process are corrosion, hydration, carbonation and oozing by natural acids and water. Nature of soil can be identified by combination of humus and the size of the grains of rock. The grains may be very small and even, clay is the best example or they may be larger, like grains of sand or may be gravel. Soil is considered to be the important part of environment because it is the place where plants and animals survive and grow. Beside this maximum of rainwater also makes its passage through soil and hence purity of water is maintained by soil. As far as civil engineering is concerned soil is the earliest and used building material. It is also the material which has been used at great numbers. Soil has been classified on numerous bases. The main being residual soil, transported soil, organic soils and volcanic soils. However type of soil can also vary with climate. Mainly for engineering structures residual soil is used further classified as black cotton soil and literate soil. Clayey soils have been selected for the study. In India they are mostly used for the growth of cottons and are found in northern India brownish in color. These soils are expensive. They shrink quickly under the action of applied loads. Optimum moisture content of these soils is very high. These soils are vastly perceptive to dampness alterations, when pressure is applied on sub grade objects. Sub grade and its objectionable distinctiveness needed to be

tailored by use of an appropriate stabilization method. Different methods have been used for improving the stability of soil and its engineering properties. Main aim of stabilization is to increase the stability and strength of soil and then use it for construction of roads and highway pavements in an economical and effective manner. Soil Stabilization is done physically, mechanically or chemically. In Physical stabilization, soil is stabilized electrically, thermally and by action of freeze and thaw vibrating the soil mass. The particular method chosen for a given soil depends upon its formation and types.

Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. It is same as reinforcing concrete, to improve its properties. The strength and stability of all soils improve on compaction. For certain purposes, the strength gained, even after compaction, may not be adequate. Thus in such situations idea is to stabilize soil by reinforcing it using either geosynthetics, natural fibres, manmade fibres, mineral fibres etc. The idea of reinforced soil is quiet ancient and old. It all began like a game, when *HENRI VIDAL*, a highway engineer and architect, was trying to build a sandcastle on the beach. But the sand kept on falling off. Then he made use of pine needles to stabilize the castle. This is how the general principal of reinforced earth came about. Consequently, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering for the second time.

Jammu and Kashmir State is gifted by nature with dense forests, which constitutes 19.95 % of geographical area of the State. Among these forests, a large area of Himalayan region is under dense Pine forest. The Pinus family trees like Chir (Pinus Roxburghii), Kail (Pinus Walichina) and Deodar (Cedrus deodara) are having needle like leaves in cluster form. When these needles become mature and brown in colour, these shed-down in huge quantity on to the ground surface. These pine needles form a carpet and cover entire pine forests, which are prone to fire hazards and also cause severe environmental instability in the forest area.

On the other hand, due to rapid urbanization, there is scarcity of stable ground for construction of various infrastructures. Therefore, utmost efforts are put in-place to use marginal soils after appropriate soil improvement. Among various ground improvement techniques, soil reinforcement technique has been successfully implemented for soil improvement.

Over the last decade, the use of randomly distributed synthetic fibre has recorded a tremendous increase. However, more emphasis is to be laid on use of natural fibres. Use of natural fibre in civil engineering for improving soil properties is beneficial because they are cheap, locally available, and eco-friendly material. The natural fibre reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Among various natural fibres, pine needles are one of such natural fibres, being used as reinforcing material in soil stabilization. Fibres especially those obtained from renewable resources such as natural fibre have attracted an increasing attention during the last decade due to environmental concerns. These natural fibres are considered as the most suitable alternative to synthetic fibre for use in various fields.

A variety of other natural fibre materials such as sisal, bamboo, palm leaf ,coconut coir,coconut leaf, cotton and etc. have been experimented as a soil reinforced material so as to improve the strength of soil. Pine fibre is a similar type of natural fibre available in large amount from pine forests, which is in almost every corner of world. The length of fibres play a significant contribution in the strength enhancement of soil .However studies relating to using of pine needle as soil reinforcement have not been reported so far. The attempt to use this biological waste as reinforcement in soil.

The soil reinforced with pine needles as natural fibre have increased CBR value. This increased CBR value will reduce the thickness of pavement sub grade in rural roads. Thus, using pine needles as soil reinforcing medium has two-fold advantage, firstly, to stabilize marginal soils for construction purpose and secondly to use this unwanted natural waste material to avoid tremendous fire hazards, environmental instability and its bulk utilization at economical cost for sustainable development.



Pine Needles



It is necessary to mention that natural fibers have been used for a long time in many developing countries in cement composites and earth blocks because of their availability and low cost. At this point, some natural fibers and their features in soil projects are briefly described:

a) Coconut (coir) fiber

The outer covering of fibrous material of a matured coconut, termed coconut husk, is the reject of coconut fruit. The fibers are normally 50–350 mm long and consist mainly of lignin, tannin, cellulose, pectin and other water soluble substances. 3.1.1. Coconut (coir) fiber The outer covering of fibrous material of a matured coconut, termed coconut husk, is the reject of coconut fruit. The fibers are normally 50–350 mm long and consist mainly of lignin, tannin, cellulose, pectin and other water soluble substances

b) Sisal

Sisal is a lingo-cellulosed fiber in which its traditional use is as a reinforcement for gypsum plaster sheets in building industry with 60–70% of water absorption and diameter about 0.06–0.4 mm. Sisal fibers are extracted from the leaves of the plants, which vary in size, between 6–10 cm in width and 50–250 cm in length. In general, Brazil, Indonesia and East African countries are the world's main producers of sisal fibers.

c) Palm fibers

The palm fibers in date production have filament textures with special properties such as low costs, plenitude in the region, durability, lightweight, tension capacity and relative strength against deterioration. Fibers extracted from decomposed palm trees are found to be brittle, having low tensile strength and modulus of elasticity and very high water absorption.

d) Jute

Jute is mainly environmental-friendly fiber that is used for producing porous textiles which are widely used for filtration, drainage, and soil stabilization. For instance, GEOJUTE₂ is the commercial name of a product woven from jute fibers used for soil stabilization in pavement engineering.

e) Flax

Flax is probably the oldest textile fiber known to mankind. It has been used for the production of linen cloth since ancient times. Flax is a slender, blue flowered plant grown for its fibers and seeds in many parts of the world. In an effort, **Segetin et al.** improved the ductility of the soil–cement composite with the addition of flax fibers. An enamel paint coating was applied to the fiber surface to increase its interfacial bond strength with the soil. Fiber length of 85 mm along with fiber content levels of 0.6% was recommended by the authors. Two types of natural fibers including wheat straw, barley straw and wood shavings were used by Ashour et al. to make a novel plaster material composed of cohesive soil and sand. They concluded while fibers have remarkable effect on the strength and ductility of plasters, their effects on the elastic modulus of plasters are relatively small. **Abtahi et al.** showed that barley straw fibers are most effective on the shear strength of the soil than Kenaf fibers. The optimized fiber content was 1%. Bamboo fiber is a regenerated cellulose fiber. Bamboo fiber is a regenerated cellulose fiber.

II. APPLICATIONS

A comprehensive literature review shows that using natural and/or synthetic fibers in geotechnical engineering is feasible in six fields including pavement layers (road construction), retaining walls, and railway embankments, protection of slopes, earthquake and soil-foundation engineering. A brief discussion about some cases is presented in the following.

• **Pavement layers**

In 1991, the US ARMY Corps of Engineers demonstrated the improved performance of untreated and chemically stabilized soil layers by using GEOFIBERS₂ soil reinforcement in pavement engineering. The 30 cm fiber-reinforced silty sand section provided a 33% increase in the number of traffic passes versus the similar un-reinforced section. Grogan and Johnson showed that the inclusion of Geofiber allowed up to 90% more traffic passes until failure in the clay, 60% passes until failure in the modified sand, and some enhanced traffic performance was reported for the silty sand. It is necessary to mention that PP Geofibers can be mixed with subgrade soils. Their inclusion raises the maximum density about 5% and reduces the optimum moisture content of the compacted soil mixture about 5% as well. Tingle et al. concluded from full-scale field tests that fiber-stabilized sands were a viable alternative to traditional road construction materials for temporary or low-volume roads. They used a field mixing procedure more or less similar to that of Santoni and Webster. There is an available report (2008) stating that aprons, taxiways, and a helipad



have been stabilized by using high-early strength Portland cement and PP fibers with screened native soil at the Bradshaw Field Training Area in the Northern Territory, Australia. Finally, the most important findings of some research works are that the use of synthetic and/or natural fibers in road construction can significantly increase pavement resistance to rutting, as compared to the resistance of non-stabilized pavement over a weak subgrade.

- **Retaining walls and railway embankments**

Park and Tan showed that use of PP fibers of 60 mm reinforced silty-sand-soil-wall increases the stability of the wall and decreases the earth pressures and displacements of the wall. They also reported that this effect is more significant when short fiber soil is used in combination with geogrid.

- **Protection of and foundation engineering slopes**

Mainly, soils mixed with randomly distributed fibers can be used as patches in the localized repair of failed slopes as it can accommodate the irregular shape of failed slopes. In the reinforcement of soil veneer such as landfill covers, fiber reinforcement eliminates the need of anchorage that exists with planar reinforcement, as well reduces the erosion gullies. The mixture of sand and fiber can be sprayed onto a problematic slope like shotcrete, creating a free-draining gravity retention structure. For instance, a nominal rate of 20 m/s is recommended for glass fibers.

Another concept of using fibers in civil engineering is the construction of foundations in soils with poor bearing capacities, where the costs of a deep foundation solution can be incompatible with the overall costs for low-budget building projects. In these cases, alternatives for the improvement of local soil through the addition of cementitious agents or through the inclusion of oriented or randomly distributed discrete elements such as fibers might be used.

III. EXECUTIVE PROBLEMS

The following executive problems are involved with using fibers in soil reinforcement:

- **Lack of scientific standard**

In spite of the quantity of research conducted into the resultant characteristics of using fiber and shavings for soil improvement, there are still no scientific standard or techniques specialized for real field projects.

- **Clumping and balling of fibers**

Local aggregation (clumping) and folding of fibers (balling) are two problems concerned with fiber–soil composites. In this way, fiber lengths beyond 2-in. (51 mm) were not found to significantly improve soil properties and proved more difficult to work with in both laboratory and field experiments. As well, a successful tumble mixing technique has been identified which is able to improve soil composite uniformity and the ease of manufacture.

- **Adhesion of fiber and soil**

Mainly, adhesion at the fiber–matrix interface has been found to be governed by the following three factors:

- The shear resistance of the soil due to the surface form and roughness of the fiber;
- The compressive friction forces on the surface of the fiber due to shrinkage of the soil; and the cohesive properties of the soil.

Further, each of these three factors is affected by dimensional changes of the natural fiber which can occur due to changes in moisture and temperature. Such changes in fiber dimension can occur during the curing stage of the soil–fiber composite material and this then determines a possible mechanism resulting in a poor interfacial bond. During the mixing and drying stages of production, the hydrophilic nature of the natural fibers can lead it to absorb water and effectively push out on the soil matrix. Then near the end of the curing (drying) period, the fiber loses the water that has absorbed, causing it to shrink back. Because the matrix is now set, a void is formed around the periphery of the fiber and a weakened interfacial bond can result [illustrates](#) this mechanism. Therefore, in looking for an additive to improve the bonding characteristics of fiber soil composites, it is required that the treatment reduces the transfer of water between the matrix and the fiber. Possible additives identified from the literature include water resistant coatings such as asphalt emulsion, rosin–alcohol mixture, paints, bituminous material, a water soluble acrylic, a polystyrene coating and acrylonitrile butadiene styrene (ABS). [Khazanchi et al.](#) with their study of wall panels consisting of soil, 2.5% cement and polystyrene coated wheat straw, reported fiber bond strength of 1.3 MPa. With the same material but using bitumen and acrylic coatings, they also achieved bond strengths of 0.1–0.12 and 0.08–0.125 MPa, respectively. In this study untreated fibers gave bond strengths in the range of 0.07–0.08 MPa.



IV. OBJECTIVES

Use of natural fibre in civil engineering for improving soil properties is beneficial because they are cheap, locally available, biodegradable and eco-friendly material. The natural fibre reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Among various natural fibres, pine needles are one of such natural fibres, being used as reinforcing material in soil stabilization. Fibres especially those obtained from renewable resources such as natural fibre have attracted an increasing attention during the last decade due to environmental concerns. These natural fibres are considered as the most suitable alternative to synthetic fibre for use in various fields.

The project will study the effect of Pine needles stabilization on strength behavior of clayey soil. Pine needles collected from locally available forest (Rajouri, J&K) chopped into 10 to 15mm length has been added randomly in clayey soil at different percentages (i.e. 0.5%, 1% 1.5%) by dry weight of soil. Soil samples randomly mixed with Pine needles were prepared at maximum dry density (MDD) and optimum moisture contents (OMC) and subjected to (California bearing ratio) CBR tests, unconfined compression tests and compaction proctor tests.

V. CONCLUSION

On the basis of analysis and interpretation of results obtained from the previous experimental investigations carried out in this work following conclusion are drawn.

1. It was found that that with addition of pine needles in the parent soil, the dry density decreases and OMC increases. When pines were added dry density reduces, on increasing the percentage of pines from 0% to 1, 8 % dry density decreases from 1.96 g/cc to 1.59 g/cc respectively. As far as OMC was concerned, it was increasing with increasing in quantity of pines in soil that is from 13% to 17.56%. This increase in OMC and MDD was mainly due to flocculation among clay particles and pine needles, thus as a result of rise in percentage of pines, size of pore voids also increases, which result in better water holding capacity of soil mass and as a result the moisture content increases.
2. To overcome the above mentioned difficulty calcium Chloride was added to soil in addition to Pine needles. It was found that optimum percentage for soil remains stable in relevance to all its compaction properties like dry density, Void ratio, OMC.
3. The optimum percentage of both pine and calcium chloride at which soil acquires best results was found to be 0.6% and 3% respectively.
4. Addition of pines to the clayey soil it was found that CBR value increases a little bit but not to a great extent.
5. The optimum percentage at which soil acquires maximum CBR was 1.2% by weight of soil after that CBR decreases. So to increase CBR value Calcium Chloride was added and was noted that significant increase in CBR value of Soil takes place,

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