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An Observation of Soil Load Bearing Capacity by Involving Prepared Nonwoven Fabrics

Meenambika P* and Sunitha R

Department of textiles and clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India

Abstract

This paper discusses the behaviour of Coir, Jute, Sisal and Polyethylene terephthalate (PET) blended needle punched fabrics in withstanding load as an application as geo textile material. The nonwoven fabrics were prepared through Needle punching technique. The fibers were blended in different composition in order to obtain four different fabric samples such as Coir/Jute/PET (CJP), Coir/Sisal/PET (CSP), Jute/Sisal/PET (JSP) and Coir/Jute/Sisal/PET (CJSP). The load withstanding capacity of the soil was analyzed by inserting the four different fabric samples. The comparison was made with the standard soil sample which had no fabric insertion. The study revealed that the soil inserted with fabric samples showed improved load withstanding capability when compared to the standard one. Whereas among the four different samples good withstanding capacity was observed in Jute/Sisal/PET (JSP).

Keywords: Geo textile; Needle punching; CBR

Introduction

It is only in recent times that the construction industry has started seriously considering geotextile materials as vital ingredients for road construction. Essentially, a geotextile is any textile material that is permeable and may be made of synthetic or natural fibers. The main purpose of designing the geotextile to be permeable is to permit the flow of liquids through it. Geotextile materials can be used to increase the strength and stability of the underlying soil in a roadway.One of the most important uses of geotextile fabrics is to maintain a separation between layers of different sized soil particles. Nonwovens have been a part of our daily life and yet we may not even be aware of them. They are a sheet, web or of natural and/or man-made fibers or filaments, excluding paper, that have not been converted into yarns, and that are bonded to each other either mechanically or chemically [1]. Needle punched nonwovens are created by mechanically orienting and interlocking the fibers of a spun bonded or carded web. This mechanical interlocking is achieved with thousands of barbed felting needles repeatedly passing into and out of the web. Bonding using needling requires no water and consumes little energy. It is an ecologically friendly technology, as it permits the use of recycled materials including that from Polyethylene terephthalate (PET) bottles and regenerated fibers from apparel, as well as natural fibers [2]. Non-woven geotextile material has a greater likelihood of stretching when compared to its woven counterpart [1].

Historically geotextiles have been made of natural plant, modern geotextiles are usually made from a synthetic polymer (such as polypropylene, polyester, polyethylenes and polyamides) or a composite of natural and synthetic material. Plant fiber-based erosion control geotextiles are subject to decomposition and have a limited shelf life before their inherent durability suffers [2]. The synthetic polymers have the advantage of not decaying under biological and chemical processes. Blending of two or more fibers offers an effective means of projecting the positive attributes and overcoming negative ones. The properties such as good resistance to rot in Jute, high tensile strength in coir and good mechanical and physical properties of sisal made the researcher blend the above said fibers with recycled Polyethylene terephthalate (PET) fibers which generally work well in blends with natural fibers [3].

Materials and Methods

Conversion of fibers into fabric

Preparation of fibers: The fibers namely, Coir, Jute, Sisal and PET, were prepared before they were converted into web. The natural fibers were cut to 20cms length for mixing with PET fibers of 3 cms length. The fibers were weighed and mixed well manually (Table 1).

Ninety per cent of natural fibers were blended with ten per cent of PET fibers in samples CJP, JSP and CSP. The proportion of each fiber in clearly given in Table 1.

Pre-opening: The objective of an opening line is to reduce the size of the fiber tufts from the bale to the chute feed, and supply to the web forming machine. The fiber were picked up from top of the bales by two opening role in conjunction with the partial air vacuum, the opening head transversed back and forth across the bale lay down, starting and stopping on demand from the blending hopper. This ensured maximum efficiency and blending.

Mixing: The blending feeders gently open the tufts of fibers by interaction of an inclined needle lattice apron and an evener roller equipped with needles. Blending of the tufts from different bales also took place in the opening and mixing achieved by the inclined apron and the evener roller. The opened tufts were deposited in a weigh pan controlled by load cells which dump the fibers onto a feed conveyer.

Samples	Proportion (per cent)			
	Coir	Jute	Sisal	PET
CJP	45	45	-	10
JSP	-	45	45	10
CSP	45	-	45	10
CJSP	30	30	30	10

Table 1: Proportion of fibers taken for mixing.

***Corresponding author:** Meenambika P, Department of textiles and clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India, Tel: 91-422-2440241; E-mail: meenambikaponnusamy@gmail.com

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Fine opening: The fiber opened by opening roll was transported by air to the feed box of the fine opener. The fine opener consists of two opening rolls, one evener roll and a cylinder roll all of which were wound with metallic clothing. The opener reduced the tuft size by using the principle of carding points between. The reduced tufts were transferred to the cylinder which delivered the opened fibers into an air stream to the web.

Web formation

Carding: The main objective of carding is to separate small tufts into individual fibers, to begin the process of parallelization and to deliver the fibers in the form of a web. The principle of carding is the mechanical action in which the fibers were held by one surface while the other surface combs the fibers causing individual fiber separation. At its centre was a large rotating metallic cylinder covered with card clothing. The card clothing was comprised of needles, wires or fine metallic teeth embedded in a heavy cloth or in a metallic foundation. The top of the cylinder may be covered by alternating rollers and stripper rolls in a roller-top card.

The fibers were fed by a chute and condensed into the form of a lap. The needles of the two opposing surfaces of the cylinder and flats or the rollers were inclined in opposite directions and moved at different speeds. In the roller top card the separation occurred between the worker roller and the cylinder. The stripping roller stripped the larger tufts and deposited them back on the cylinder. The fibers were aligned in the machine direction and formed a coherent web below the surface of the needles of the main cylinder.

Cross lapping: Naik and Pancholi [3] describe cross lapper machine as the machine that continuously lays a web so that its fibers are oriented in cross direction. The web is laid on the conveyor moving at right angles.

Web formations can be made into the desired web structure by the layering of the webs from the card. Layering was carried out to reach the desired weight and web structure. Cross lapping can be done by using two different devices namely vertical and horizontal cross lappers. Vertical cross lapper consists of a pendulum conveyor after the doffer roll on a card. Pendulum conveyor reciprocates and lays the carded web into folds on another conveyor belt.

Needle punching: Fehrer needle loom was utilized for the needle punching process. The width of loom used was 150 cms. The web was passed into the preloom where downward punching took place with 1500 needle at the rate of 150 strokes/min with stroke height of about 40mm in the preloom. This was then passed through the main loom which functioned with 400 strokes per minute with 2000 needles at stroke height of 40 mm. Passing through the above given process, the needle punched fabric of various proportions were prepared.

California Bearing Ratio

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of roadsubgrades and base courses. The test was performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. California Bearing Ratio test was carried out for the soil by inserting a layer of prepared needle punched fabrics to find its potentiality in the field of geotech. The test was carried out for the samples as per IS:2720 (Part XVI) to assess the strength added to the weak soil due to the insertion of fabric (Figure 1).

For preparing the samples the mould of 175 mm height, 150 mm internal diameter, 6.800 kg weight and capacity of 5 kg were used. The weak soil of 5 kg with 500 ml of water was mixed thoroughly. The prepared mix of soil were filled as four layers with three fabric samples sandwiched between each layer of the soil. The layers were made compact by blowing 56 times using the rammer of 8.294 kg. The penetration plunger was kept in contact with the soil and load at the penetration rate of 1.2 mm per unit was applied. The load at penetration of 2.5 mm and 5 mm were recorded.

Results and Discussion

Load withstanding capacity of fabric samples

The results of the needle punched fabric samples' load withstanding capacity in California Bearing Ratio (CBR) test is shown in Table 2.

From Table 2 it is clear that the load withstanding capacity of the soil at 2.5 mm was about 14.69 kg(f)/cm^2. The capacity was maximum in sample JSP inserted soil of about 53.72 kg(f)/cm^2 followed by sample CJP, CJSP and CSP inserted soil of about 19.75 kg(f)/cm^2, 16.31 kg(f)/cm^2 and 15.41 kg(f)/cm^2.

The load withstanding capacity of soil at 5.0 mm was maximum in JSP of about 49.78 kg(f)/cm^2 followed by CJSP, CSP and CJP of about 22.48, 21.84 and 17.98 kg(f)/cm^2 respectively. Further, load withstanding capacity of soil without the fabric samples was found to be the least of about 13.2 kg(f)/cm^2 only.

This concludes that in both the cases when 2.5 mm of load and 5.0 mm of load were imparted the sample JSP, had the highest load withstanding capacity. The load withstanding capacity of the soil had drastically increased due to the insertion of fabric samples.

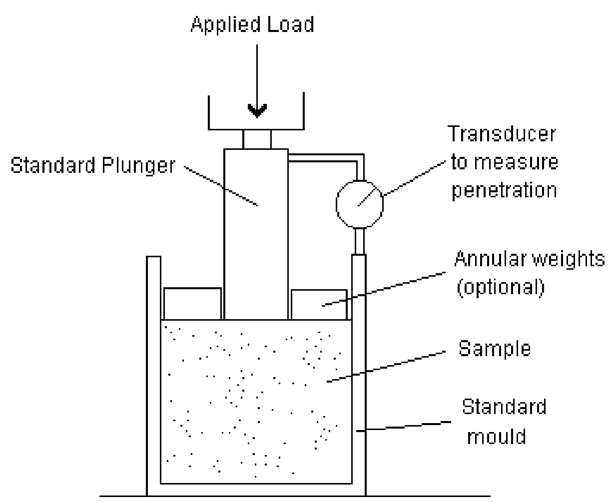

Figure 1: California bearing ratio tester.

S.No.	Samples	Unit standard load Kg(f)/cm^2 at 2.5 mm	Unit standard load Kg(f)/cm^2 at 5.0 mm
1	Soil	14.69	13.2
2	CJP	19.75	17.98
3	JSP	53.72	49.78
4	CSP	15.41	21.84
5	CJSP	16.31	22.48

Table 2: Needle punched fabric samples' load withstanding capacity in california bearing ratio (CBR) test.

Conclusion

As per the execution of the study it is clear that improvisation in road construction could be made with the interference of the prepared samples. Also better results could be obtained through the Blend Jute, Sisal and PET. Jute and Sisal are abundantly available low cost fibers. Utilization of available natural resources helps to evolve the geo textile as eco textile.

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