A STUDY ON NEEDLE PUNCHED COIR NONWOVENS USED FOR GEOTECHNICAL APPLICATIONS

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

Geotextiles are textile products that are used in areas where better holding of the soil is needed. The use of geotextiles has increased greatly nowadays, due to the need for long lasting supports in construction of embankments, roads and other civil engineering applications.

A study has been done on needle punched coir nonwovens used for geotechnical applications. Coir fiber has been chosen because of its abundant availability in the country and its cheap production cost. Coir being a natural fiber is eco friendly and biodegradable over the years. This makes this fiber best suited for geotextiles.

The main aim of this project is to study and evaluate the properties of needle punched coir nonwovens which can be used for geotechnical applications. For this, coir fibers were first needle punched and converted into a web form. Different samples were produced by making use of a jute and woven HDPE backing cloth on the web during needle punching. These samples were then tested for properties like areal density, thickness, water retention, transmittivity and impact strength. From the test results, the influence of the fiber and the backing cloth on the nonwoven was observed. By studying the test results, it was found that each of the samples were suited for different geotechnical applications.

தரைத்துகிலுக்கேற்ற தென்னை இழை "நூலில்லாத் தையல் நெய்யாத்துணி" பற்றிய ஆய்வு

சாரம்

தரையைக் கூடுதல் திடமாக வைக்க வேண்டிய இடங்களில் தரைத் துகில் வெகுவாகப் பயன்படுகிறது. இந்தியாவில் சாலைகள், இரயில் பாதைகள் மற்றும் ஆற்றுக்கரை திடமாக்குதலில் தரைத் துகிலின் பயன்பாடு கூடுதலாகும் வாய்ப்பு உள்ளது.

இந்த திட்ட ஆய்வில் தென்னை இழையில் உருவாக்கப்பட்ட நூலில்லாத் தையல் நெய்யாத்துணியின் தரைத்துகிலுக்கு உகுந்த தன்மைப்பற்றி ஆய்வு மேற்கொள்ளப்பட்டது. தென்னை இழை நமது நாட்டில் அதிக அளவில் கிடைப்பதாலும் இது போன்ற மக்கிவிடக்கூடிய சுற்றுச் சூழலுக்கேற்ற இழை என்பதாலும் தென்னை இழை ஆய்வுக்காக தேர்வு செய்யப்பட்டது.

ஆய்வின் முக்கிய நோக்கம் தென்னை இழை நெய்யாத்துணியின் தரத்தை அறிதலும் தரைத்துகிலுக்கு எந்த அளவுக்கு ஏற்றது என கண்டறிதலும் ஆகும். முதலில், தென்னை இழை நூலில்லாத் தையல் நுட்பத்தின் மூலம் நெய்யாத் துணியாக தைக்கப்பட்டது. சணல் மற்றும் பாலித்திலீனாலான அடித்துணிகளைக் கொண்ட நெய்யாத் துணி மாதிரிகளும் தைக்கப்பட்டன. இந்த நெய்யாத் துணி மாதிரிகளின் எடைவீதம், தடிமன், நீர்ப்பிடிக்கும் திறன், நீர் அனுமதிக்கும் தன்மை மற்றும் குத்துவிசை போன்ற தன்மைகள் அளவிடப்பட்டன.

இந்த ஆய்வின் மூலம் துணியின் எடைவீதமும், அடித்துணி வகையும் துணியின் தன்மையை வெகுவாகப்பாதிப்பதும் பயன்படும் இடத்தைப் பொறுத்து துணிவகை தேர்வு செய்யப்படவேண்டும் என்பதும் கண்டறியப்பட்டது.

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1. INTRODUCTION

Geotechnical products find in a wide range of applications in our day to day life. Nowadays every civil constructions like embankments, road laying etc. need the help of geotextiles for support and durability. In recent years, there has been a very high rate of increase in the need for use of geotextiles across the country. Till now we have only been working on short term and low cost plans in the construction areas, which are disadvantageous in the long run.

The western world has already been following the methods of constructing and laying roads using geotextiles which are non polluting and durable over the years. So, it is time for us to start working on long sighted plans for highway constructions and other civil engineering works by making use of geotechnical products.

In this study emphasis has been given on Needle punched coir nonwovens. Coir fiber has been chosen for this study because of its abundant availability in the country and its cheap production cost. Coir fiber has good strength and moisture regain values when compared to other fibers. It is also biodegradable after a few years and hence it does not pollute the environment. Moreover this fiber is a by product of the coconut industry and it does not require any special cultivation means.

The next requirement for producing a geotextile from coir is the technology to convert the fiber in to a fabric or sheet form. For this the needle punching technique has been chosen, because it is a single step process of converting the fibers directly into a fabric form. Hence it helps in reducing the production cost and also this technique is the most eco friendly because it does not employ any chemicals or involve usage of heat energy. Coir being a natural cannot be bonded by any other method. The geotextiles also require properties like water and air permeability, so bonding by using coating techniques is not possible. Therefore needle punching is the best suited technology for producing coir geotextiles.

In this project a study has been done on four different nonwoven samples produced from coir fibers and then to identify the best suited sample for each geotechnical end use by analyzing the important properties.

2. LITERATURE REVIEW

2.1Coir Fiber ([1] to [4]):

Coir is a biodegradable organic fiber and hardest among other natural fibers. It is much more advantageous in different application for Geotextiles. Coir is used commercially for the manufacture of wide range of products for various end use applications.

The fibrous material, forming a part of the soft mass surrounding coconut, the fruit of the tree "Cocos Nucifera" or the coconut palm is world over known as coir. Coconut husk is the raw material for the coir industry, which is available in enormous quantities. The palm is essentially a plant of tropics and it thrives within 20^{o} of the equator. Philippines, Indonesia, Thailand, India, Sri Lanka, pacific territories, east and West Africa and the West Indies are the important coconut producing countries in the world. India and Sri Lanka account the major contributions out of the above. Coconuts are usually harvested at the end of every 45 days all throughout the year.

Production of Coconuts world wide*

Indonesia	: 27%
Philippines	: 23%
India	: 22%
Sri Lanka	: 6%
Mexico	: 3%
Vietnam	: 2%
Other Countries	: 17%

Production of Coir Fiber world wide*

India	: 79%
Sri Lanka	: 16%
Thailand	: 3%
Other countries	: 2%

**FAO Statistics*

According to FAO sources, out of the total annual global production of coconuts, only 10% of the coconut husk is being used for fiber extraction amounting to an estimated 0.5 million metric tons of coir. From the above data, it is also seen that India ranks 3rd in the production of coconuts, but it is the largest producer of coir fiber.

Coir is a versatile hard fiber obtained from the husks of coconut. The Coir fiber is one of the hardest natural fibers because of its high content of lignin; Coir is much more advantageous in different application for erosion control, reinforcement and stabilization of soil and is preferred to any other natural fibers. The fiber is hygroscope, with moisture content of 10% to 12% at 65% humidity. Of all natural fibers coir possesses the greatest tearing strength, retained as such even in very wet conditions. The physical appearance and quality of the fibers varies widely. The color of the fiber is not only influenced by the species of the nut from which it is derived but also its maturity, time lapse between dehusking and retting etc. However under identical conditions of these variables, the fibers extracted from infant nuts exhibit a pale yellow color. The intensity of color and thickness increase with age and the fibers are remarkably stiff and posses good extensibility.

Morphologically, coir is a multi cellular fiber with 12 to 24 microns in diameter and the ratio of length to thickness is around 35.Cells of the fiber surface are occasionally covered with the silicised stigmata. The chemical constituents have found to be cellulose, lignin, hemi cellulose and pectin. The percentage of the ingredients in the fiber is largely governed by the age of the nut from which it is derived. Cellulose and lignin are the major constituents and higher lignin content makes the fiber stiffer and tougher.

The physical properties and chemical composition of coir fiber are shown below.

Physical Properties:

Length in inches	: 6-8
Density (g/cc)	: 1.40
Tenacity (g/Tex)	: 10
Breaking elongation	: 30%
Diameter in mm	: 0.1 to 1.5
Swelling in water	: 5%
Moisture at 65%RH	: 10.5%

Chemical Composition:

Lignin	: 45.84%
Cellulose	: 43.44%
Hemi-Cellulose	: 0.25%
Pectin Compounds	: 3.00%
Water soluble	: 5.25%
Ash	: 2.22%

2.2Geotextiles ([1] to [15]):

2.2.1Need for Geotextiles:

One of the major ecological threats that the world faces today is soil erosion, particularly of the topsoil. The fertile, thick topsoil is the one which sustains life and civilizations on earth .About 36% of the world cropland is losing topsoil at an alarming speed, threatening the food security of several countries. The developing countries are the worst affected. It takes thousands of years to form a thin layer of surface soil but needs only a few minutes to lose it through erosion caused either by water or wind or mindless human interference.

In India, it is estimated that 27% of land area is subject to soil erosion leading to a loss of about 6000 million metric tons. of topsoil annually. If left unchecked it can convert precious cropland into barren wasteland. Deforestation is one major factor contribution to soil erosion. The most eco-friendly method of erosion control is through re-vegetation preferably using a Geo-textile.

2.2.2 Essential properties of Geotextiles:

The three main properties which are required and specified for Geotextiles are its mechanical responses, filtration ability and chemical resistance. These are the properties that produce the required working effect. They are all developed from the combination of physical form of the fibers, their construction and chemical characteristics.

Mechanical responses include the ability of a textile to perform work in a stressed environment and its ability to resist damage in an arduous environment. Usually the stressed environment is known in advance and the textile is selected on the basis of numerical criteria to cope with the expected imposed stresses and its ability to absorb those stresses over the proposed lifetime of the structure without straining more than predetermined amount.

The filtration performance of a geotextile is governed by several factors. In general, filters remove particles suspended in a fluid; quite the opposite state of affairs exists with geotextile filters. The geotextiles function is to hold intact a freshly prepared soil surface, so that water may exude from the soil surface and through the textile without breaking down that surface. If water is allowed between the textile and the soil interface, with particles in suspension, it will tend to clog up the textile which will fail in its function. The actual process taking place is the passage of a liquid from a solid medium that is held intact by a permeable textile.

Geotextiles are rarely called upon to resist extremely aggressive chemical environments. Particular examples of where they are, however, include their use in the basal layers of chemical effluent containers or waste disposal sites. Another example might be use of geotextiles in contact with highly acidic peat soils, where in tropical countries; pH values down to2 are encountered.

2.2.3Natural fibers for Geotextiles:

The general properties of chemical fibers compared to natural fibers still tend to fall into distinct categories. Natural fibers possess high strength, modulus and moisture uptake, and low elongation and elasticity.

Regenerated cellulose possesses low strength and modulus, high elongation and moisture uptake and poor elasticity. Synthetic fibers have high strength, modulus and elongation with reasonable amount of elasticity and relatively low moisture uptake.

Natural fibers can be of vegetable, animal or mineral origin. Vegetable fibers have the greatest potential for use in geotextiles because of their superior engineering properties.

The pertinent factor for a geotextile, especially for reinforcement is that it must posses a high tensile strength. It is known that the best way of obtaining this criterion is in the form of fibers which have a high ratio of molecular orientation. This is achieved naturally by vegetable fibers, but for synthetic fibers the molecules have to be artificially oriented by a process known as stretching or drawing .Hence nature provides ideal fibers that can be best used in geotextiles.

Nature provides plants with bundles of fibers interconnected together by natural gums and resins to form a load bearing infrastructure, these fibers are pliable, have good resistance to damage by abrasion and can resist both heat and sunlight to a much greater extent than most synthetic fibers. However all natural fibers will biodegrade in the long term as a result of the action of microorganisms.

Vegetable fibers contain a basic constituent, cellulose which has the elements carbon, oxygen and hydrogen. They can be classed morphologically, that is according to the part of the plant from which they are obtained.

1. Bast or phloem fibers:

They are enclosed in the inner bast tissue of the stem of dicotyledonous plants, helping to hold the plant erect. Retting is employed to free the fibers from the cellular and woody tissues. E.g. Jute, flax and hemp.

2. Leaf fibers:

These run hawser like within the leaves of monocotyledonous plants. These fibers are part of the fibro vascular system of the leaves. They are extracted by scraping the pulp from the fibers with a knife. E.g. Abaca and Sisal.

3. Seed and fruit fibers:

They are produced by the plant not to give structural support, but to serve as a protection for the seed and fruit, which are the most vulnerable parts of the plants attacked by predators. E.g. Coir and cotton.

Of the 1000 to 2000 fiber yielding plants throughout the world there are some 15 to 25 plants that satisfy the criteria for commercial fiber exploitation. These main fibers are jute, flax, hemp, coir, kenaf, nettle, ramie, roselle, sunn, urena, abaca, banana, sisal, cantala, palm, henequen, pineapple, cotton and kapok.

2.2.4Coir Nonwoven Geotextiles:

The coir Nonwoven as long term biodegradable geo-textile has been well acknowledged. The coir geotextiles are available in nonwoven form as needled felts, pads, erosion control blankets, anti-weed blankets, geo-rolls etc. The permeable fabric is easy to install and follows the contours of the soil surface. It is particularly useful for uneven and rocky terrains. It can be used as an overlay for surface cover or as an interlay for separation, filtration and drainage. It protects the soil surface and promotes growth of vegetation during its formative stage. It can dissipate energy of flowing water and absorb solar radiation. The non woven webs hugging on to the surface acts like micro check dams retaining moisture for the seed to germinate and the saplings to take roots both in terrestrial and aquatic habitat. The effective product life varies from one to three years, depending on the terrain weather condition, type and quality of the fiber used. In under water applications it may extend up to five years or even more. Thereafter it degrades into mulch and gets assimilated in the soil, which gives it an edge over the synthetics.

Coir Nonwoven has a variety of applications as in soil stabilization, slope stabilization, water course protection, stream bank protection, shoreline protection, storm water channeling, road pavement, road surface stabilization, fly ash dump protection, mine site reclamation, forest re-vegetation, water shed management, mud wall reinforcement, landscaping etc. But the sad part is that while several countries abroad have recognized its worth as proven by the increasing exports, it is yet to find its legitimate place in our own country. Geotextiles made of coir are ideally suited for low-cost applications as the coir is available in our country in abundance at very low prices compared to other synthetic made products.

The unique advantages of coir for geotextiles are given below:

1. Faster binding of the soil.
2. Excellent air and water permeability.
3. Enough sunlight passes through.
4. Holds the seeds and saplings in place.
5. High water retaining capacity
6. Excellent medium for quick vegetation.
7. Degrades over a period of time (2.5 to 6 years).
8. Allows for deep rooting of plants and provides nutrients.
9. Easy to install and follows the contour of the soil surface.
10. Eco-friendly and nonpolluting.

2.2.5Applications:

2.2.5.1 Erosion control:

The presence of netting on the slope controls the surface erosion in the following ways.

(a) The surface run-off gets divided into a number of small paths due to the numerous obstructions caused by the presence of netting. As a result, the overall damaging impact of flowing water is reduced.

(b) The soil and seeds are thereby preserved in place providing increased chances for germination and growth of vegetation.

The slope once covered with vegetation prevents the erosion in a number of ways. The vegetation cover on the slope reduces the impact of falling rain drops and retards the velocity of running water. The root network that penetrates deep into the soil binds the soil particles together to improve the resistance to erosion and thereby improves the stability against failure of the slope.

Technique of Surface Control Using Coir Netting:

The slope is first leveled to remove any unevenness present like deep irregular gullies, projecting stones.

Earth work excavation and gravel backing is to be done, wherever necessary.

A suitable fertilizer is mixed with the soil at the rate of 0.5 kg/10 sq. meters.

Seeds of selected variety of deep rooted and quick growing grass are then spread over the slopes.

Half the quantity of seeds is spread prior to covering of the slopes with netting and the other half subsequent to laying of the netting.

The rolls of the Coir Netting are spread out of the slope and each roll is given overlapping of 4" with the adjacent one, and anchored firmly into the ground by steel staples.

The above full-scale field trail establishes the effectiveness of coir netting for erosion control. The process is not only simple and quick but also very economical, saving more than 50% in cost compared to conventional gravel lining process.

2.2.5.2. Agriculture

Coir having the strong characteristics of retention of moisture is preferred for the agricultural applications. It is naturally resistant to rot, moulds and moisture. To suit specific applications, the coir fiber can be used as such or by making a suitable product, which adapts the specific needs. Coir can be converted to coir yarn and then to woven mesh matting, which is used mainly controlling soil erosion and conditioning the soil.

One more conversion of coir is to coir non-woven which is also used for controlling soil erosion and conditioning the soil by more ground cover and soil retention. Non woven coir used in the manufacture of basket liners, mulching mats, grow sticks, cultivation mats for plants, roof green applications, portable lawn or instant lawn and many more applications. The coir fiber is also used for coco logs and coco beds for shore protection and stream banks.

1. Erosion control blankets for controlling slope erosions:

The natural coir material is having a very good application in erosion control blankets for landscaping. The mesh of woven coir matting acts as miniature dams and prevent the seeds or seedlings which used to be washed away by rain and wind and facilitating their growth. The netting breaks up run off from heavy rains and dissipates the energy of flowing water. Once the growth of vegetation is occurred the function of the coir is over and the vegetation will takeover the protection of soil further. Coir also promotes the growth of new vegetations by absorbing water and preventing the topsoil from drying out Non-woven erosion blanket protects the soil from effective erosion and creating microclimates and mulching action. The blankets will be much suited for dry lands and low fertile soil.

2. Mulch blankets:

Coir due to its property can retain moisture for longer period. The coir non-woven or closely woven matting acts as a filter allowing the water to flow across its plane as well as separator. The mulch mats will suppress the weeds and retain moisture in the soil, which will protect the roots from winter frost and scorching summer sun.

3. Basket liners:

Coir basket liners are used for hanging baskets. These coir pads facilitate better aeration of the growing media. As air can flow on more easily through the pores of coir pad, it will help the roots to grow faster and more vigorously. Coir non-woven felt cut in different shapes depending upon the size of the wire basket are used as basket liners. Coir non-woven felt due to its permeability will increase the growth and retain moisture for longer period and separate the pot soil by filtering the excess water.

4. Bio-rolls:

Coir non-woven felt mats made in the form of rolls filling it with peat moss/coir pith composite are used for bio-rolls. Rapid root growth is observed using these bio-rolls. The natural product combination will support the development of plant.

5. Roof greening mats:

Roof greening mats are manufactured with coir non-woven felt spread with seeds or seeds in laid with stitch bonded coir pads. These roof greening mats will spread on the roof surface and the seeds on the coir pads will sprout out and grow evenly on the surface.

6. Grow sticks:

Grow sticks are used as natural supports for plants and creepers. They consist of wooden pole wrapped with the layer of coir fiber or non-woven felt. The roots of the plant can easily penetrate on the pores of coir pad.

7. Coco logs:

Coco logs are used along stream, river, and lake banks to protect against scour. It consists of coir fiber or coir non -woven pads in the form of rolls and covered with coir nets. Coco logs are kept at the edge of the bank secured by wooden pegs may be used on alternate sides of logs. Coco logs work as a brake on waves and reduces the impact of erosion. The natural product combination will support the development of plant by root binding, which eventually takes over the protection of the bank.

8. Grow media:

Apart from coir fiber the other bi-product of the coir industry is the coir pith, which is mainly used as a growing media for the plants and also has replaced as a pot mixture by converting it to compost.

Coir is having a very high potentiality in agro textile application. Its moisture retention capability and high wet strength has been excellent and the characteristic has been made use extensively in agro textile applications.

2.2.5.3 Soil Consolidation

Construction of high and heavy embankment directly over weak and soft soil, in slushy and marshy areas leads to long term settlement problems. They are likely to undergo shear failure. A primary solution in such areas is the removal of the soft soil, the thickness of such extraction depending upon the height of the embankment and other design considerations. The embankment materials have also to be compacted in thin layers using suitable mechanism at specified intervals, to the designed height. The stability of these embankment soils, like weak clays, black cotton soils and very soft slushy soils can be ensured and enhanced with other shear strength improvement techniques

1. Consolidation:

The soft clayey deposit has a very large void space filled with water, which is termed as pore water. When loaded these deposits undergo large settlements and have very low load carrying capacity. The process of expulsion of pore water and reduction in void space is termed as consolidation. The reduction of void space increases the shear strength of the deposit. The pre-consolidation and strengthening of such deposits by pre-loading is one of the most widely used methods for ground improvement. However, the time required for consolidation goes into years depending upon the thickness of strata, as the permeability of clayey deposit is very low.

2. Vertical drains:

The installation of the vertical drains is one method, which would reduce the time for the consolidation of the soft clay layer considerably. The vertical drains, which are commonly used, are sand drains, sandwiches, or geo-synthetic drains. Ground improvement with vertical drains has been an accepted practice for improving soft, clay deposit and has been widely used. The time required for settlement to occur is considerably reduced as the length of drainage path thorough soil is reduced. Vertical drains are required to have high permeability and sufficiently high drainage capacity, so that pore water escapes in horizontal direction towards the nearest drain.

Functioning of the vertical drain:

The process paves way for the water in the soft clay subjected to excess pore pressure under surcharge to permeate into the vertical drains and to dissipate as fast as possible, and so to achieve the desired degree of consolidation of the foundation soils. The consolidation takes place rapidly due to such radial and vertical movement of the pore water, which finally escapes through the horizontal layer at the top. The water then flows freely vertically along the drain to the draining blanket placed on the soil surface. The pore water from the vertical drains is further drained into adjacent drains through Horizontal drainage blanket. Non-woven coir, which is highly permeable, can be used as horizontal draining blanket.

3. Horizontal coir draining blanket:

The first draining layer consisting of a mixture crushed stone to aggregate 1.5mm to 3mm proportion spread to the thickness of 20cms. It is then well compacted till it attained a density of 1.83t/m3. Over this layer Non-woven Coir Needled Felt (1000grm/m^2) is laid. The felt is double the width of the base of the embankment and is laid with equal projections on both sides, so that when it is folded towards the center a second layer is formed. The projecting ends of the Coir Felt are then folded towards the center to cover the primary layer, except for a 2.00m width at the center. The ends of the Coir Felt are kept unconnected with a gap in the middle, so as to allow for and to accommodate any deformation due to the possible settlement of the foundation layers, under the loads imposed by the embankments. Laying of the crushed stone aggregate layer compacted to a density of 1.85t/m3, as laid earlier, is then repeated over the above Coir Needled Felt blanket.

4. Functions of the blanket:

The unique qualities of the coir contribute liberally to the functions of the blanket in different capacities and measures, as under.

The Coir Needled felt laid as blanket over the vertical drains allows the pore water, which gets collected and accumulated through and into the drain, to move freely to the sides. The Needled felt here acts as separator, filter, and filter reinforcement and facilities drainage during the function. While performing as a separator, the Coir Needled felt at the same item will act as a filter allowing water to pass freely through or into the plane. Again, it tends to confine the supporting aggregate to retain a degree of reinforcement within itself. The installed Coir Felt permits the water entering to be transmitted laterally, away from the areas of loading also. As a barrier, the blanket prevents the inter mixing of materials from either sides also.

5. Construction of embankment:

The construction of the embankment has to be undertaken in stages, after ensuring that the primary consolidation is over. Sufficient provisions for effective drainage of the surface water from the sub-grade soils are also insisted to keep it free from soaking, which could only ensure long-term satisfactory performance of the embankment and the pavement, thereon.

Consolidation of weak and soft soil in slushy and marshy areas can be achieved by adoption of vertical drains coupled with horizontal coir blankets. . Thus it is a versatile product, available abundantly throughout the country, at cheaper costs. It is a sure and economical answer to the problems related to primary consolidation.

2.2.6 Needle Punching ([16] to [24]):

Mechanical bonding refers to the strengthening of the web by inter-fiber friction as a result of the physical entanglement of the fibers. Needle punching is a process of bonding non-woven web structures by mechanically interlocking the fibers through the web. Barbed needles, which are mounted on a board, punch fibers into the web and are then withdrawn, leaving the fibers entangled. The needles are spaced in a non-aligned arrangement, and are designed to release the fiber as the needle board is withdrawn. The needles enter and leave the web while it is trapped between two plates called a bed plate and a stripper plate. The web is pulled through the needle loom by drawing rolls.

Fibrous webs, which are characteristically bulky, are obtained by web forming processes of:

- Carding, cross-lapping or carding-cross-lapping;
- Air laid, except pulp fibrous webs;
- Spun-bonded webs.

2.2.6.1 Parts of a Needle Loom:

1. The needle board:

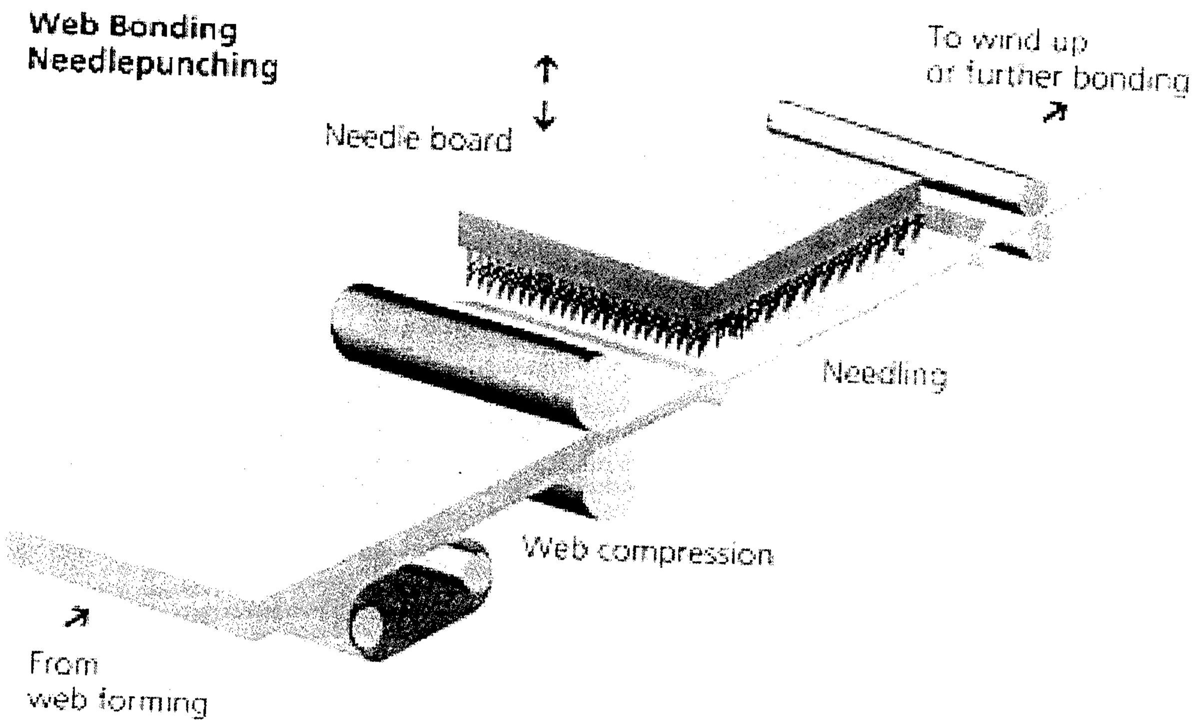
This is the base unit into which the needles (ranging in number from 500 per metre to 7,500 per metre of machine width) are inserted and held. The needle board then fits into the needle beam that holds the needle board into place.

2. The bed plate and stripper plate:

These are two plates between which the web passes, the bed plate is on the bottom and the stripper plate is on the top. Corresponding holes are located in each plate, and it is through these holes that the needles pass in and out. The bed plate is the surface, the fabric passes over when the web passes through the loom. The needles carry bundles of fibers through the bed plate holes. The stripper plate does what the name implies; it strips the fibers from the needle so the material can advance through the needle loom.

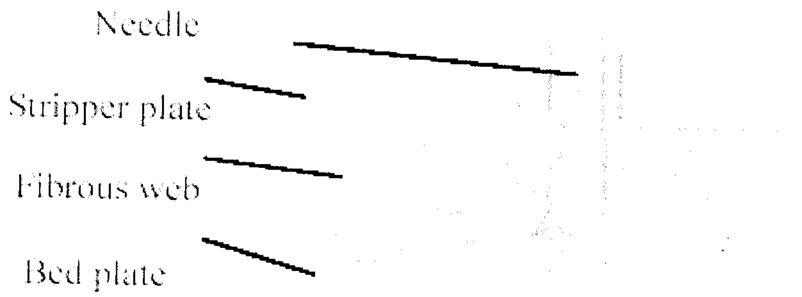
3. The web feeding and fabric take up mechanisms:

These are typically driven rolls, and which facilitate the web's motion as it passes through the needle loom.



2.2.6.2 Theory of needle Punching:

According to Hearle's model, the vertical structure of a needle punched fabric consists of fibers pulled through the web by needles and the horizontal structure consists of fibers following curved paths around the vertical tufts. Both these structures are interconnected, so individual fibers can pass through both horizontal and vertical sections.



2.2.6.3 Studies on influence of parameters on needled fabrics:

- Bulky webs need wider setting between stripper plate and bed plate.

- The web derives its strength from the entanglement and interlocking of fibers.

- Increase in the amount of Needling increases fabric modulus, strength, abrasion resistance and stiffness.

- Increase in the amount of Needling decreases air permeability.

- Increase in depth of needle penetration increases fabric modulus, density and strength.
- To secure higher strengths, longer and finer fibers should be used.

- High fiber friction leads to greater consolidation and thus greater resistance to slippage.
- Stretching of web during Needling improves the Dimensional stability, Modulus and Elastic recovery.

- The Mechanical property of the web is affected by fiber length, fineness, friction, degree of interlocking and fabric thickness.

- A more porous structure offers higher air permeability and good thermal insulation.

- Decrease in web weight decreases the density, and therefore the Air permeability increases and thermal insulation decreases.
- At lower web weights, increase in depth of needle penetration or Needling density increases the Tenacity.

- At higher web weights, increase in Depth of Needle penetration increases the Air permeability.

- Increase in web weight, depth of needle penetration or Needling density, decreases the breaking elongation.

- Increase in web weight, depth of needle penetration and Needling density, increases the initial modulus, compressive and tensile resilience

3. PROJECT OBJECTIVE

The main objective of the project is to produce and study needle punched coir nonwoven samples suitable for geotechnical end use. By studying the properties, the best suited end use for each type of sample is determined. Also the properties of the different samples are compared and analyzed for effect of parameters like fiber type, usage of backing cloth etc.

4. METHODOLOGY

4.1 Production of Samples:

Retted brown Coir and palm fibers with staple length 6-8 inches were first cleaned and opened by passing through an opener. The opened fibers were then passed through a Roller clearer card to form a coir web.

The coir webs were then needle punched in a Feherer Needle loom to form three different types of products:

The first type of product was produced by directly Needle punching the coir webs.

The second type of product was produced by placing a layer of woven jute sack with 10 ends per inch and 9picks per inch as backing and then Needle punching it.

The third type of product was produced by placing a woven HDPE sack with 13 ends per inch and 12picks per inch as backing and then Needle punching it.

The fourth product was produced by needle punching the palm fibers directly.

4.2 Testing of samples:

The samples produced by the above methods were then tested for properties like GSM, thickness, water retention, Impact strength, water transmittivity.

4.2.1GSM testing:

The produced sample is cut into a square specimen of size 10cm x 10cm and placed in a physical balance. The weight of the sample in grams in noted. The obtained weight reading is multiplied by 100 to get the GSM of the material. Similarly ten such samples were tested to get the average GSM.

4.2.2 Thickness testing:

The thickness of the samples is measured by using a thickness tester. The sample is placed between the two presser plates of the thickness tester. The thickness value is directly noted from the dial gauge reading. Similarly the thickness for each sample is tested at ten different places to calculate the average thickness.

4.2.3 Water Retention testing:

The water retention capacity of the sample is measured by cutting a sample of 10cm x 10cm and first calculating its dry weight. The sample is then immersed in water and allowed to attain equilibrium by placing in normal atmosphere for 30 min. when the excess water is expelled from the sample. The wet weight of the sample is then noted. The difference between the two weights gives the amount of water held by the sample in grams. When the difference value is divided by the dry weight and multiplied by 100 we get the water retention percentage of the sample. This test is repeated for ten specimens of each sample type to get an average value.

4.2.4 Impact strength:

The impact strength value of the samples is tested by cutting a specimen of size 12 inches x 2inches and then making a slit in the middle for 10 inches length of the specimen. This specimen is then mounted on the jaws of the Ballistic strength tester. The impact strength value is then noted by allowing the load to tear the sample. Similarly ten specimens in each sample type are tested to obtain the average impact strength value.

4.2.5 Transmittivity rate:

The transmittivity rate of the samples is tested by placing a sample specimen of size 10cm x10cm horizontally and then allowing water to drop on it at the rate of 3 drops per 2 seconds and calculating the time taken for the water to pass through the sample and come out through the other side. This gives the time for flow in seconds. By dividing the thickness value and time for flow, the transmittivity rate in cm per second is obtained. The similar test is carried out for ten specimens in each sample to calculate the average value.

5. RESULTS AND DISCUSSION

5.1 Studies on Areal density:

It is seen from table 5.1and the graph 5.1, the areal density of the four Needle punched samples lie within the range of 700 to1200 GSM. The density of the fiber also influences the GSM, which can be clearly seen from the high GSM value for palm fiber nonwoven. Similarly the backing cloth used also influences the GSM value. The cv % within the same samples was found to be less than 1.5% for all the samples. This shows that there is not much of a variation in the GSM values throughout the sample length.

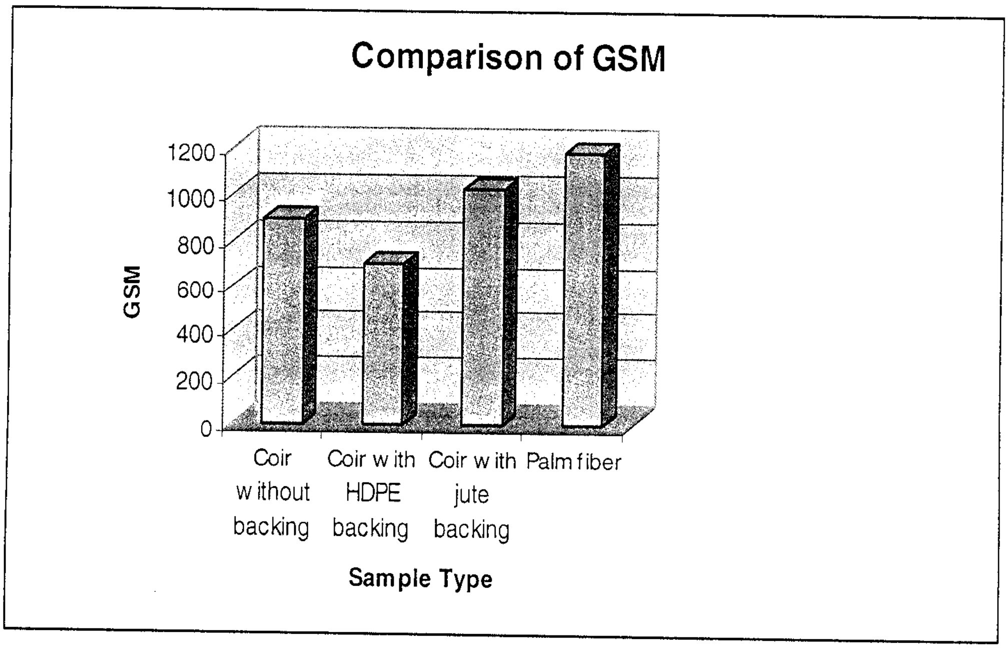


Fig5.1 Areal density values of different samples

Table5.1 Areal density values (g/m^2) for different samples

Sample Type / Test No.	Coir geotextile without backing	Coir geotextile with HDPE backing	Coir geotextile with Jute backing	Palm fiber geotextile without backing
1	894	696	1020	1175
2	887	698	1038	1181
3	869	721	1055	1194
4	911	715	1016	1187
5	895	703	1011	1180
6	898	709	1025	1198
7	903	691	1042	1168
8	915	702	1035	1172
9	907	687	1008	1188
10	884	695	1027	1193
Mean Areal density value(g/m^2)	**896.3**	**701.7**	**1027.7**	**1183.6**
Standard Deviation	**13.81**	**10.67**	**14.83**	**10.03**
C.V. %	**1.54**	**1.52**	**1.44**	**0.84**

5.2 Studies on thickness:

The table 5.2 and the graph 5.2 show the thickness values for the four needle punched nonwoven samples. It is seen that the values range from 8 to 10 mm. It is also found that the palm fiber geotextile has the greatest thickness of 10.44mm due to the bulky nature of the fiber and the coir geotextile with HDPE backing has the least thickness of 8.24mm. The cv% within the coir nonwoven with backings and palm fiber nonwoven was found to be less than 2.4%, but the coir fiber without any backing showed a cv of 3.6% due to the unevenness in the fiber structure and also less cohesion between the fibers.

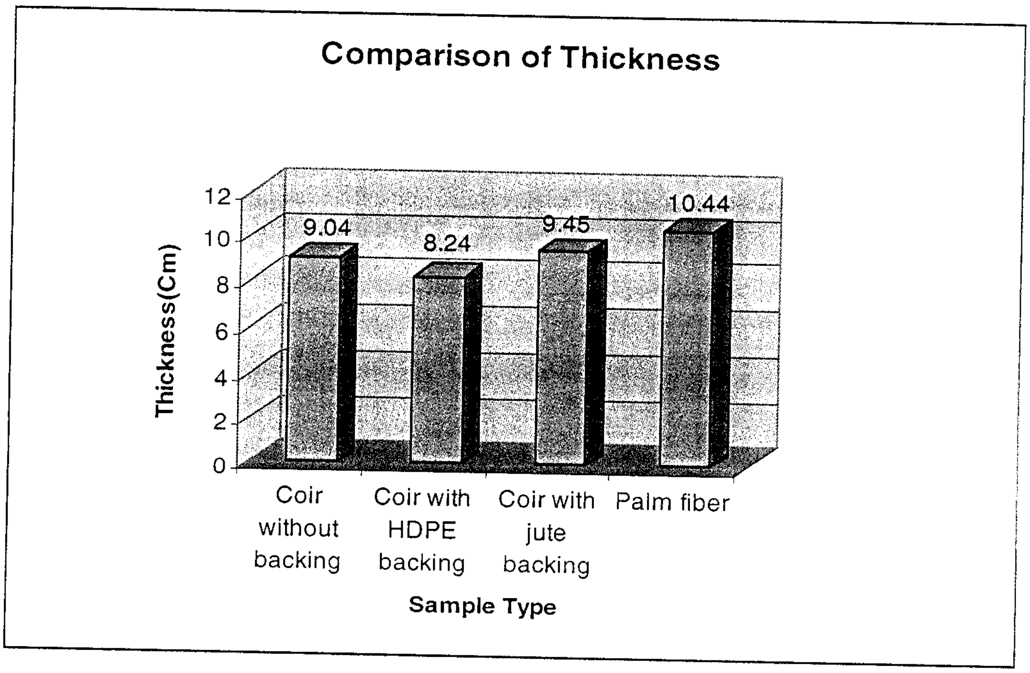


Fig5.2Thickness values of different samples

Table5.2Thickness values (cm) for different samples

Test No. \ Sample Type	Coir geotextile without backing	Coir geotextile with HDPE backing	Coir geotextile with Jute backing	Palm fiber geotextile without backing
1	8.3	8.1	9.8	10.5
2	9.1	8.6	9.6	10.2
3	8.9	8.2	9.4	10.7
4	9.3	8.3	9.7	10.4
5	9.5	8.1	9.3	10.3
6	9.2	8.4	9.1	10.5
7	9.0	8.3	9.5	10.3
8	8.8	8.2	9.6	10.6
9	9.1	7.9	9.3	10.1
10	9.2	8.3	9.2	10.8
Mean thickness value(cm)	**9.04**	**8.24**	**9.45**	**10.44**
Standard Deviation	**0.32**	**0.18**	**0.22**	**0.22**
C.V. %	**3.62**	**2.30**	**2.40**	**2.12**

5.3 Studies on Transmittivity

The table5.3 and the graph5.3 show the transmittivity values of the four types of samples. It is found that the Coir nonwoven without any backing has the highest transmittivity rate of 0.56 cm/sec which is slightly higher than the palm fiber nonwoven 0.46 cm/sec. Also, the coir nonwoven with HDPE backing has zero transmittivity rate due to the presence of a closely woven polyethylene structure at the back. The cv% within the coir nonwoven without any backing is around 10%, The reason for this high level of variation is the uneven distribution of fibers in the web. This value is slightly lesser for palm fiber nonwoven (7%) and coir nonwoven with jute backing (4%).

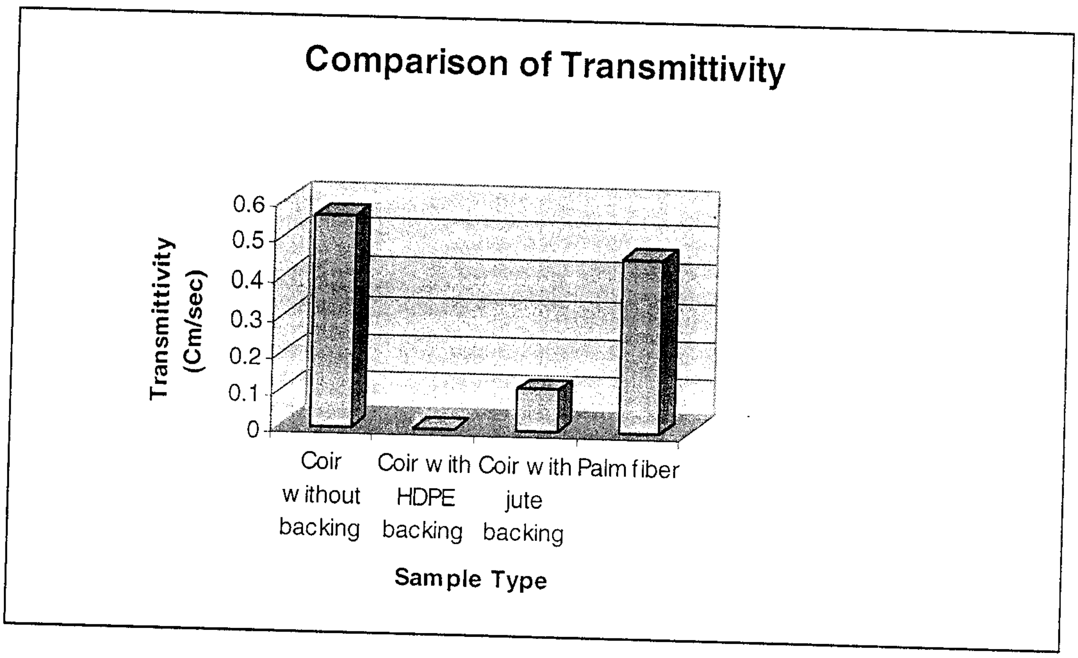


Fig5.3Transmittivity values of different samples

Table5.3 Transmittivity values (cm/sec) for different samples

Sample Type / Test No.	Coir geotextile without backing	Coir geotextile with HDPE backing	Coir geotextile with Jute backing	Palm fiber geotextile without backing
1	0.49	-	0.12	0.46
2	0.51	-	0.12	0.44
3	0.49	-	0.11	0.49
4	0.62	-	0.12	0.43
5	0.59	-	0.11	0.45
6	0.54	-	0.11	0.42
7	0.50	-	0.11	0.49
8	0.59	-	0.11	0.48
9	0.65	-	0.11	0.42
10	0.58	-	0.11	0.51
Mean Transmittivity value(cm/sec)	**0.56**	-	**0.11**	**0.46**
Standard Deviation	**0.06**	-	**0.005**	**0.032**
C.V. %	**10.39**	-	**4.39**	**6.98**

5.4 Studies on Water Retention Percentage values:

The table5.4 and the graph5.4 show the water retention values for the four needle punched nonwoven samples. It is seen that the coir nonwoven without backing has the least retention value of around 80%.This is due to the very open structure of the nonwoven and less cohesion in the fibers. The coir nonwovens with backings have slightly higher retention values (90% and 110%). The palm fiber geotextile shows the highest water retention capacity of 130% due to the highly cohesive nature of the fiber and its bulkiness. The cv% within the samples was found to be less than 2.5% which is normal.

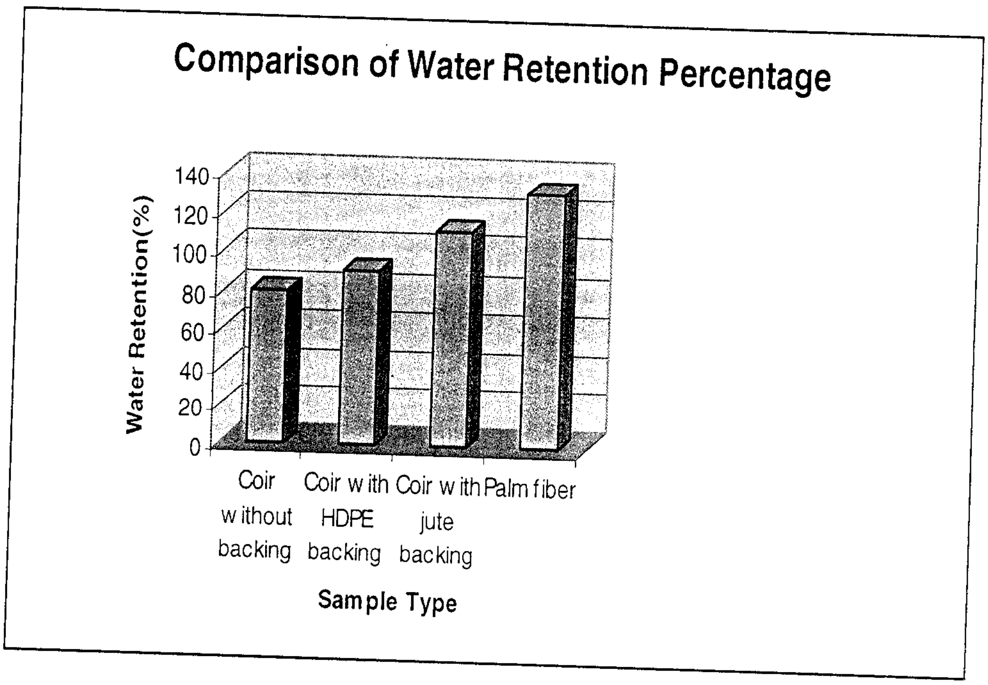


Fig5.4 Water Retention percentage values of different samples

Table5.3 Water Retention percentage values for different samples

Test No. \ Sample Type	Coir geotextile without backing	Coir geotextile with HDPE backing	Coir geotextile with Jute backing	Palm fiber geotextile without backing
1	81.99	90.95	111.96	132.94
2	80.95	89.97	112.91	130.99
3	82.97	94.87	111.94	129.98
4	79.91	89.93	107.97	135.97
5	77.99	91.89	109.99	133.14
6	77.39	91.96	113.95	130.97
7	80.95	89.87	116.99	135.27
8	78.91	90.88	108.99	132.94
9	83.9	93.89	113.00	129.97
10	81.9	92.95	109.93	131.94
Mean Retention value (%)	**80.69**	**91.72**	**111.76**	**132.41**
Standard Deviation	**2.12**	**1.74**	**2.65**	**2.05**
C.V. %	**2.63**	**1.90**	**2.37**	**1.55**

5.5 Studies on Impact strength values

It is seen from the table5.5 and the graph5.5, the impact strength value for both coir and palm fiber nonwoven without backing was low (95lbs and 105lbs). The impacts strength values for coir nonwoven with HDPE backing was around 115lbs and for coir nonwoven with jute backing was around 125lbs., this is due to the woven HDPE and jute structure present below the nonwoven which acts as a support. The cv% within the sample was around 2% which is quite normal.

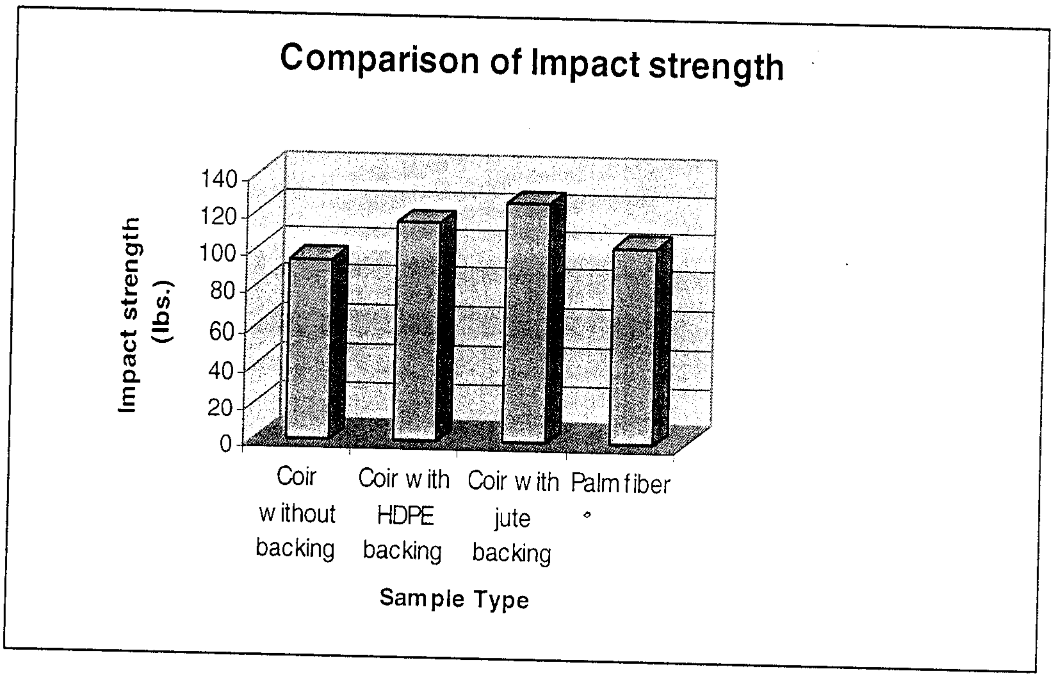


Fig5.5 Impact Strength values of different samples

Table5.5 Impact strength values (lbs) for different samples

Sample Type / Test No.	Coir geotextile without backing	Coir geotextile with HDPE backing	Coir geotextile with Jute backing	Palm fiber geotextile without backing
1	95	117	127	104
2	93	115	128	101
3	95	118	130	101
4	97	119	132	102
5	98	116	125	107
6	94	111	129	103
7	97	114	125	105
8	96	113	124	106
9	91	115	122	104
10	92	114	126	102
Mean Impact strength value(lbs)	**94.8**	**115.2**	**126.8**	**103.5**
Standard Deviation	**2.30**	**2.39**	**3.01**	**2.06**
C.V. %	**2.42**	**2.07**	**2.37**	**1.99**

6. CONCLUSIONS

From the test results and the discussion done for the four different Needle punched samples, the following conclusions have been arrived at:

The areal density of the coir nonwoven with HDPE backing was the least (around 700gsm) and the palm fiber nonwoven had the highest value of around 1200gsm. From the thickness values, it is found that coir nonwovens with HDPE backing had a thickness value of 8mm and the palm fiber sample had a thickness of 10mm. So it can be concluded that there is a direct effect of the areal density on the thickness of the sample. It can also be concluded that palm fiber nonwoven is bulkier than the others.

The percentage of water retention by the nonwoven was found to be very high for palm fiber nonwoven (around 130%), due to the cohesiveness in the fibers and the bulkiness. Due to a very open structure and less cohesion, the coir nonwoven without backing has low retention of about80%.

The transmittivity rate value was high for nonwovens without any backing (around 0.5cm/sec.). This is due to a more porous structure of the nonwoven. Also the coir nonwoven with HDPE backing has zero transmittivity due to the close structure of yarns in the HDPE fabric.

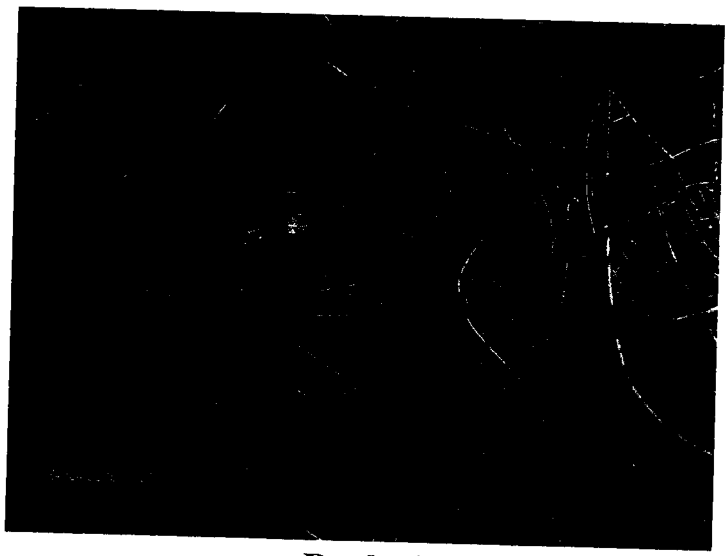
From the impact strength values of the different samples, it can be concluded that nonwovens with backing posses higher strength values of the order of 120lbs which is only about 95 to 100 lbs for those without backing.

Further we can also conclude saying that:

- In places where strength is important, the geotextile made from coir with woven jute backing suits best (E.g. Road laying, Constructions).
- In places where the geotextile should retain water, the palm fiber geotextile suits best (E.g. Agricultural fields, etc).
- In places where durability is needed and no water should pass through, the coir nonwoven with HDPE backing is best suited.
- In places where there should be easy flow of water, a plain coir fiber nonwoven is best suited (E.g. drainages, etc.)

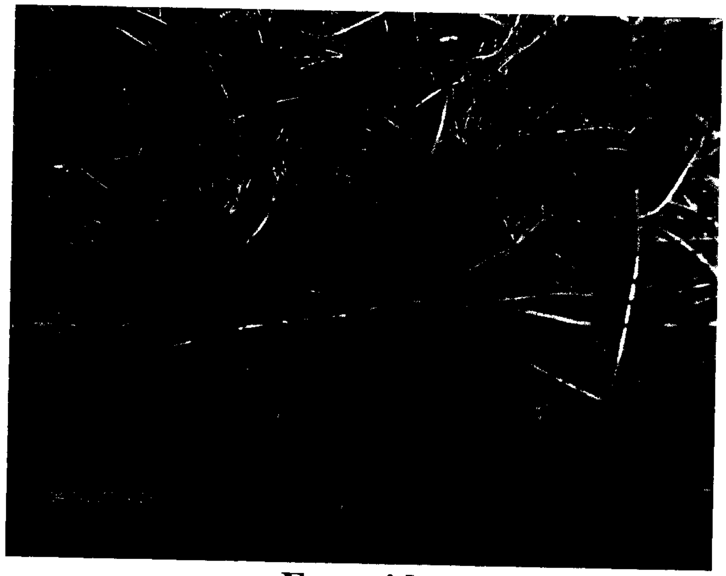
ANNEXURES

Face side



Back side

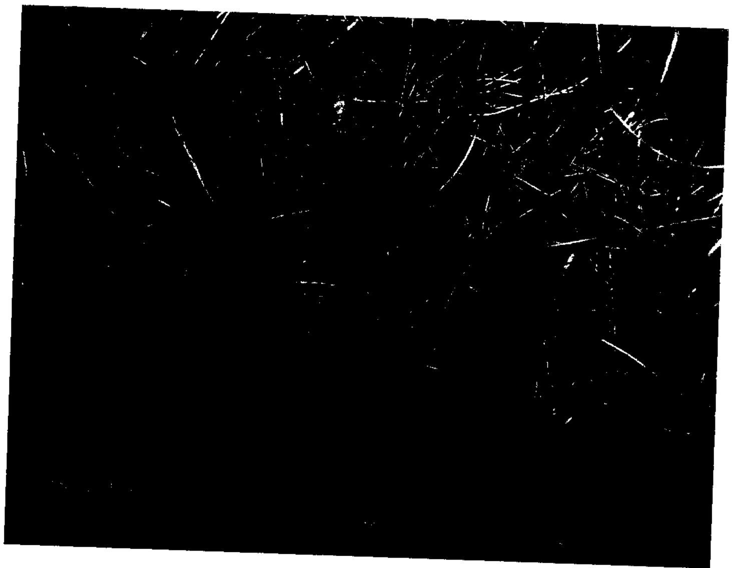
Fig.8.1 Coir sample without backing



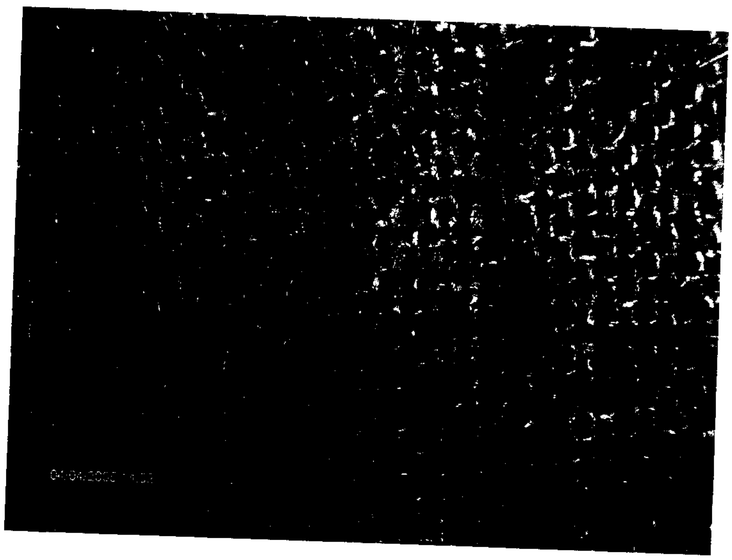
Face side

Back side

Fig. 8.2 Coir sample with HDPE backing



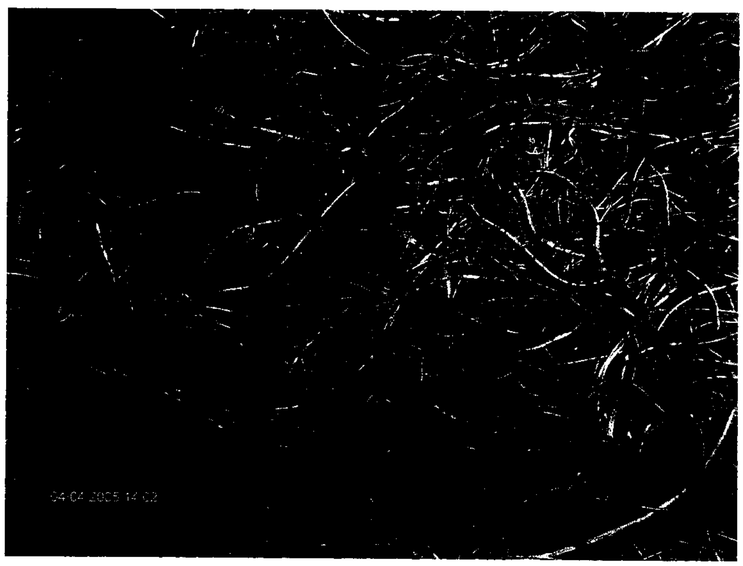
Face side



Back side

Fig.8.3 Coir sample with jute backing

Face side



Back side

Fig.8.4 Palm fiber sample

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