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Case Study on Application of Coir Geotextiles for Soil Stabilization

Rajesh. P. V

Lecturer in Civil Engineering, Carmel Polytechnic College, Alappuzha, Kerala, India

Abstract: ***Coir geotextiles (Coir Bhoovastra) is one of the non - traditional highly demanded and promising coir product with multi usages as eco - friendly, sustainable and substitutable product for many Civil Engineering applications especially in Geotechnical Engineering. Coir Geo - textiles is an emerging area of coir industry. Kerala, the major coir producing state in India is fast growing in the development and application of Coir geotextile. Coir Geotextile development program is also intended to popularize the coir products as geotextile material in National & International level and to provide internationally accepted standardization for coir geotextile. The use of Coir geotextile is well established in areas of erosion control, blanket drains and as vertical drains. As the synthetic geotextile are non biodegradable, the natural geosynthetics, especially coir geotextile are increasingly preferred. Experimental studies have proved that while cotton and jute degrade within six months, coir geotextile provide good support on slopes for about 5 years. It is resistant to saline water. Its greatest advantage is that it provides an ecological niche for a rapid re - establishment of the vegetation cover. Coir resembles naturals oil in its capacity to absorb solar radiation. Coir mesh mattings are used extensively in erosion control works. Coir geotextile are also used as reinforcement and separator between sub grade and base course. This paper highlights about coir geotextiles and the "Case Studies on Application of Coir Geotextiles for Soil Stabilization", a paper presented by K. S. Beena, Cochin University of Science And Technology, India, in the Seventh International Conference on Case Histories in Geotechnical Engineering 2013. Also, This paper intend to review one of the available published case studies in this area, that is the study of a case of about 1.5 km farm road constructed using coir geotextile in Kerala.***

Keywords: Coir Geotextile; Bhoovastra; Woven; Non - woven; fibre

1. Introduction

Coir geotextiles with its Indianised connotation "Coir Bhoovastra", is a geosynthetic made from the coconut fibre extracted from the husk of the coconut fruit. Being a technology based product, like their polymeric counter parts, coir geotextiles can be synthesized for specific application in geotechnical engineering practice. A range of different mesh matting is available, meeting varying requirements. Coir fibres can be converted into fabric both by woven and non woven process. Coir mesh matting of different mesh sizes are most established coir geotextiles, under quality code numbers H2M1 to H2M10. These qualities represent coir geotextiles of different mesh sizes ranging from 1/8" to 1". Several types of non - woven geotextiles also exist. Most non - woven mats are made from loose fibers, which are interlocked by needling or rubberizing. Non - woven geotextiles are available in several dimensions and have a minimum thickness of 2 mm. Coir geotextiles are eminently suitable for many Civil Engineering applications, which are not yet perceived by most engineers. Majority of geosynthetics used in Civil Engineering (Beena, 2013).

Natural fiber geotextiles can be effectively used for soil stabilization. These natural materials include coir, which is the husk of coconut, a common waste material where coconuts are grown and subsequently processed. Coir fibre is strong and degrades slowly compared to other natural fibers due to high lignin content (Rao and Balan, 2000). The degradation of coir depends on the medium of embedment and climatic conditions and is found to retain 80% of its tensile strength after 6 months of embedment in clay (Rao and Balan, 2000). Coir geotextiles are presently available with wide ranges of properties. Closely woven coir geotextiles possess high tensile strength and pullout resistance (Subaida et al., 2008) which can be economically utilized for temporary reinforcement purposes.

2. Coir & Coir Geotextiles

Coir, which is increasingly being accepted the world over as an eco - friendly, natural resource, is a versatile product. The products made out of it and its application area varies widely right from the coir yarn to coir geotextiles. Besides being foremost among traditional ones, coir industry in India has been cottage based and hence employment oriented. Kerala is one of the main center of coir industry accounting for 42% of total production, providing sustenance to 3.5 lakhs families in the area of costal belt, out of which, 80% are women living mostly below poverty line (Beena, 2013).

Coir Geotextiles or Coir Bhoovastra is a geosynthetic made from the coconut fibre extracted from the husk of the coconut fruit. The term Coir Geotextiles covers the entire range of woven, non woven and composite materials used in the ground and civil engineering applications for improving the soil behaviour, preventing soil erosion and help consolidation of the soil

Coir geotextile is an emerging product of coir industry. This is one of the non - traditional highly demnded and promising coir product with multi usages as eco - friendly, sustainable and substituable product for many Bio engineering and Civil engineering applications especially in Geotechnical engineering. Coir geotextiles can be easily blended with man - made fibers and other natural fibres to get wide range of products. Its low cost makes it attractive for geotechnical applications. The major drawback is its biodegradability. However this very fact can be used to advantage in creating environmental friendly applications. The potential application areas of coir geotextile in civil engineering are erosion control, slope protection, embankments, wasteland development, road underlays, road edge drains, ground improvement, reinforcements etc. Studies conducted in geo - textiles have indicated that coir is better preferred, as compared to jute or other natural material owing to certain characteristics like durability, strength, hairy surface etc. It enables vegetation to take root on the applied area thus making the bonding of the soil very strong. They are ideal for application on hill slopes, road and rail embankments (Beena, 2010).

1) Product Range

There are over five hundred different forms of geotextiles are available and they have been emerging as excellent media for soil Bio - engineering applications in many parts of the world in the form of Meshes, Netting, Needle Felts & Pads, Erosion Control Blankets, Geo Rolls, Vegetation Fascines, Geo Cushions, Geo Beds, Anti - weed Blankets and so on. It is being extensively employed to combat a variety of environmental challenges (Beena, 2010). Coir bhoovasatra is regarded as a complete geo - textile to prevent soil erosion and promote vegetation cover. It is naturally resistant to rot, moulds, and moisture and needs no chemical treatment. Coir bhoovastra is hard and strong, and can not only protect

the soil but can even be used as a protection against sea erosion, dispending with the unsightly rocks that line sea shores and affording better protection against the onslaught of the raging sea in the monsoons. It is also resistant to saline water and has longevity in high coastal regions**.**

2) Classification of Coir Geotextiles

Coir geotextiles are of different types, the two main geo textiles made from coir are

- Woven geotextiles
- Non - woven geotextiles
- Woven geotextiles

Three types of woven geotextiles are currently being manufactured.

- Coir mesh matting of two shaft view.
- Coir woven fabrics with loop construction.
- Coir bags made with latex backed coir matting.

Coir mesh mattings of different mesh sizes are most established coir textiles. Mesh mattings having different specifications are available under quality code numbers H2M1 to H2M10 (Refer table 1). These qualities represent coir textiles of different mesh sizes ranging from 1/8'' to 1''. The selection of geotextile for a particular slope depends upon the type of slope, soil condition and vegetation. If the slope is steep, the mesh size will be closer. The decorticated fiber/bristle fiber spun on machines can also be woven as geotextiles. Since color of yarn is not a criterion for geotextile applications, the brown can be better utilized to produce coir geotextiles at a cheaper rate. This will pave way for manufacture of value added products from brown fiber.

Table 1: Coir mesh mattings of different mesh sizes - quality code numbers

Product No.	Warp ends/dm	Weft picks / dm	Density kg/sq. m
H2M1	9	8	0.65
H2M2	8	7	0.7
H2M3	14	14	0.875
H2M4	19	11	1.4
H2M5	9	8	0.74
H2M6	4.6	4	0.4
H2M7	4	6	1.25
H2M8	11	7	0.7
H2M9	13	7	0.9
H2M10	18	9	1.3

3) Non - woven geotextiles

Several types of non woven geotextiles exist. Most non woven mats are made from loose fibers., which are interlocked by needling or rubberizing. Non - woven mats are available in several dimensions and have a minimum thickness of 2 mm.

The non - woven geo textiles are categorized into three groups.

- Coco logs
- Coir fibre bed
- Coir needle felts

4) Functions of coir geotextiles

Following are the major functions of a coir geotextiles.

- Separation
- Protection
- Filtration
- Reinforcement
- Erosion control
- Water proofing
- Drainage

5) SWOT analysis of coir geotextiles

Strength, weakness, opportunities and threats of geotextiles are analyzed as follows

Strength

The strengths of coir bhoovastra as a geotextile material are considerable. Its greatest strength in the present global scenario is its characteristic of being eco - friendly and bio - degradable. In a world where the return to nature movement and preference for natural products have been growing tremendously, Coir bhoovastra which are entirely natural and bio degradable enjoy this natural advantage. The fact that production of coir, so also Coir Bhoovastra which is predominantly a handloom industry does not involve depletion of nature's resources is extremely important. The other strengths of coir as a geotextile material are:

- Indigenous availability of raw material, skill and labor.
- The properties of Coir bhoovastra like -
- The high tensile strength of coir which protects steep surfaces from heavy flows and debris movement.
- Five to ten years longevity which allows for full plant and soil establishment, natural invasion and land stabilization.
- Being 100% natural and bio - degradable, coir fibre functions as a soil amendment

- Water absorbent coir fibre acts as a mulch on the surface and as a wick in the soil
- . mantle
- The Excellent microclimate coir provides for plant establishment, natural invasion and balanced healthy growth.
- Restoration of terrestrial and aquatic riparian habitat &the coir meshes provides.

The characteristic. of being environmentally responsible & aesthetically pleasing

- Capable of being customised to specific requirements according to the topographical conditions.

Weakness

Indian Coir Industry is a traditional industry mostly following a cottage industry nature except of course those in the organised sector. There has not been any proper production planning. Production continues to be geared on the basis of demand. Being mainly in the handloom sector the possibilities of undertaking mass production are also very limited. Geo - synthetics are the major competing products to coir bhoovastra in the geotextiles market. The synthetic industry has the resources and ability to develop uses for their materials more than those of natural fibers. It is an inevitable result of concentration of production and economics of synthetic fiber prices. The synthetic producers often has production surplus which they get rid of even at price which will not meet their production cost. Moreover they have enormous budget provision to support the industry by way of providing the much needed publicity and propaganda. While this being the case with Synthetic Geotextile industry, in coir industry production is mainly based on demand and this makes it difficult to the industry some times to keep up time schedule in addressing to import requirements. Resource constraints stands in the way of a handful of producers and exporters in coir sector to popularize coir bhoovastra and to project its advantages in a highly publicity conscious global market environment. In India, surface erosion control by run of and re vegetation as a measure of controlling soil erosion and conservation of land have not been practiced very widely. The engineering profession has been concerned mainly with soil conservation and preservation of land space by structural purely civil engineering solutions being followed traditionally and not in terms of bio approach. The result has been lack of adequate familiarity with the latter approach and lack of appreciation of bioengineering applications.

Opportunities

The green movement and growing preferences for natural products provide substantial opportunity to promote the use of coir geotextiles. With the soil erosion and degradation of natures resource taking place at astonishing speed, environment alertness is a global phenomenon and concerted efforts are now on to rejuvenate and restore degraded lands with the help of geotextiles. This opens up new opportunity to natural fibre based geotextiles including coir. Relative scarcity and high cost of sand and gravel, particularly in Europe, necessitated locating an alternate material to face the situation arising out of soil erosion. The phenomenal growth in the consumption of geotextiles materials in the industrialized countries during the last three decades and the expert prediction that the boom in geotextile market will continue points to the potential market that exist for coir bhoovastra, although the present share is not very significant.

Threats

Threats facing the industry are both internal as well as external. Lack of price stability often causes shrinkage in demand for coir made materials. Competition for this product is growing - A wide range of synthetic products as well as all sorts of natural materials such as, straw, wood chips, waste fibers and many other materials on a local base compete with coir for a share of the market. Reportedly, Philippines and Indonesia with abundance of raw material are potential threats as they are increasing production. The Papus New Guinea sending stitched blankets to a number of markets has also increased their production. Geo synthetic materials are manufactured by high tech process and they are invariably applied in high - tech civil and structural hydraulic engineering situations - not normal construction governed by ordinary civil and structural COIR BHOOVASTRA COIR BOARD engineering. The synthetic geotextiles are accepted as highly technical material, perforce highly specified and appliedin comparatively high tech situation and under the aegis of fairly advanced engineering professionals. Non - inclusion of Coir Bhoovastra in the list of approved products and specifications maintained by the local/regional/ national regulatory authorities results is not conferring the required recognition to coir as a soil erosion control material.

6) Advantages of Coir Geotextiles

Among the natural fibres available, coir is the ideal choice for a geotextile material. Experimental studies conducted have proved that while cotton and jute degrades within 6 months coir retains its 20% strength even after one year. Other advantages of coir are:

- It is 100% natural.
- It is biodegradable, still last minimum for 2 seasons.
- It provides excellent micro climate for plant establishment and growth.
- Easy to install.
- Available in plenty.
- Economical.
- Faster binding of soil.
- Excellent air and water permeability.
- Holds the seeds and saplings vegetation.
- Degrades owes a period of time.
- Eco friendly and non - polluting.
- Water course protection including stream ban protection.
- Separation application in rural roads, railways, parking and storage areas. .
- Agricultural and horticultural application like mulching, anti weed, vegetable seeding etc.
- Forestry vegetation.
- Mine site reclamation.
- Landscaping.
- Agricultural and Horti engineering industry.
- Soil stabilization.
- Ready to use lush green natural lawn can be made out of coir geotextiles and coir pith.
- Geotextiles can regenerate the exposed rock patches.

7) Draw backs of Coir Geotextiles

- Bio degradable
- No production Planning
- Resource constraints

8) Applications

Coir geotextiles finds application in a number of situations in geotechnical engineering practice. Coir geotextiles can be used as an overlay or interlay - the former protecting the surface from runoff and the later performing the functions of separation, reinforcement, filtration and drainage. Soil bio - engineering with coir geotextiles finds effective application in the following soil situations.

- Separation application in unpaved roads, railways, parking and storage areas
- Shore line stabilization
- Storm water channels
- Slope stabilization in railway and highway cuttings and embankments
- Water course protection
- Reinforcement of unpaved roads and temporary walls
- Providing sub base layer in road pavement
- Filtration in road drains and land reclamation
- Mud wall reinforcement

Soil stabilization some of the major application areas are detailed below [Babu, 2007].

9) Unpaved roads

Unpaved roads are mainly low volume roads constructed in rural areas. The unsatisfactory performance of roads arises from main two factors. These are poor quality of sub grades and insufficient thickness and quality of sub base and base courses. All these factors can be mitigated by the use of coir geotextiles either alone or in conjunction with other products/ materials. In cohesion less soil lateral confinement by coir geotextiles will be able to improve the shear resistance and bearing capacity and consequently reduces the thickness of the pavement material. In cohesive soils adequate drainage of the subgrade can be created by depressing the water table by use of coir geotextile drains and hence enhanced bearing capacity. In very poor soil the use of coir geotextile composite blankets and strip drains can help in quickening consolidation of non - expansive clays and reducing construction time of high embankments. Coir geotextiles can also be used in pavement layer to reduce thickness, increase fatigue resistance and reduce reflection cracking due to traffic.

10) Embankment Construction in poor soil

The problem of construction of bunds in marshy areas is improvement of low shear strength of soil to support soil fill of required height. Coir geotextiles can be used both for foundation support and also in the fill particularly for filter and separation function so that erosion of the sides can be prevented. Coir fibres are effective in preventing failures due to reversal of pore pressures, through drainage without removal of soil particles. Also with the provision of reinforcements, the compaction of the side faces can be improved which otherwise cannot be taken to edges.

11) Retaining walls

Retaining walls are conventionally built to withstand lateral pressure of soil fill through the action of gravity, which involves additional vertical force. This necessitates a strong foundation or large base width and hence costly. Coir geotextiles can be used in the fill itself so that no additional wall is required to resist the lateral pressure. This is particularly suited to walls having low height and foundation soil is weak. Hence larger heights with surcharge are not advisable to construction with coir geotextiles as the tensile strength of this product is less than what is required.

12) French drains

These are drainage measures for subgrade soil to lower the water table to protect road formations without the use of slotted pipes to take the collected water. Coir geotextiles with high transmittivity like needled felt with mesh core can be used in the place of pipes and thicker layers can be used to reduce the quantity of pervious sand surrounding the drain.

13) Vertical drains

Construction of embankments foundation in soft and sensitive clays requires accelerated consolidation. Several methods such as sand drains, metal drains, geosynthetic PVDs etc. are used. Instead of this coir geotextiles can be used. Even if the coir decays, in course of time, the initial period helps in consolidation and temporary support and long - term stability is not affected.

Case studies

Though less in number compared to polymeric geotextiles, coir geo textiles have been tried for different civil engineering application. Few case studies reported in literature are described below (Ayyar et. al., 2002).

- Protection of mine waste dump in Goa
- Accelerated construction of Calicut bypass
- Coir for erosion protection in Western countries

Coir Board has been doing pioneering efforts in popularizing Coir Bhoovastra as a soil erosion control material. The Board has undertaken various field trials on the use of coir geotextiles to prevent soil erosion in India. Some of them are: (Ajithkumar, 2013)

- Protection of road slopes in the Mettupalayam Coonur Road in Nilagiri District.
- Protection of slow slopes of Cabani Canal in Karnataka.
- Slop protection of Muvattupuzha Valley Irrigation Project
- Protection of road embankment in Muvattupuzha Valley Irrigation Project.
- Protection of road slopes in Elite Gardenia in Trichur.
- Protection of road slopes in Idukki
- Protection of banks of KSEB Reservoir in Kakkayam
- Protection of Railway cuttings in Kudal Sector of Kongan Railway
- Protection of hill slopes Nirjuli in Arunachal Pradesh
- Protection of hill slopes of Gangtok in Sikkim.
- Application of Coir Bhoovastra for Soil Conservation and Erosion Control Studies on hill slops of Dehradun

- Application of Coir Bhoovastra on the slope of the approach road near the railway overbridge connecting the International Airport at Cochin.

Case study of construction of 1, 405 km long farm road in Changaram Padassekharam, Thuravoor, Kerala

Kerala is a land which is rich in backwaters and coastal area, and the nearby people in this region are farmers and fisher men. Hence s mall farm road s across the paddy fields and praw n growing ponds (locally known as Chemmien Kettu) is a common sight in Kerala. Here the design and construction details of such a farm road using coir geotextiles are discussed. The Kerala Land Development Corporation was the executing agency of the work which is named "Construction of farm road at Vallethodu Pulintharamuri Changaram Padasekharam south bund starting from Cherungal Bridge". The agency approached Cochin University of Science and Technology for the Technical guidance for the work.

Site Characteristics

The length of the proposed farm road is 1.405 km. The bund, over which the farm road is proposed, aligned through paddy fields. On one side of the bund, there exists a small canal (thodu) and other side it is fish pond (`Chemmeenkettu`), which will be seasonally converted to paddy field for Pokkali farming. Hence water exists on either side of the bund almost throughout the year. During the rainy season the water may reach the top level of the bund. For the improvement of the agricultural and industrial facilities and also for the development of the local people living near locality, the widening of the bund and forming a farm road became necessary.

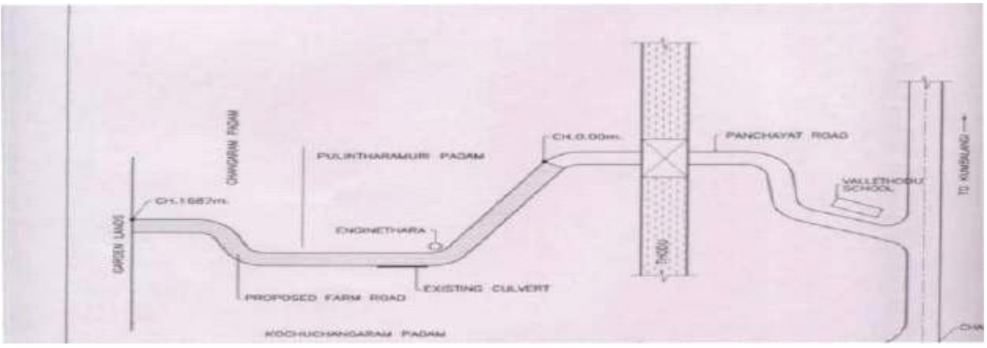

Figure 1: Site plan and location map

The site visit during March 2006, which was a summer season, it was observed that water still exist in the mud canal (having width 3.5 m approximately), and also in the fish farm pond. The bund was expected to become dry in condition by last week of March. Along the proposed farm road, there are 4 curves in the alignment. The height of the existing bund as supplied by KLDC was 1.3m and the bund is required to be raised to 2.2m in order to form the farm road. It is found that the bund is partially filled by locally available red earth.

Figure 2: Photograph of partially filled bund

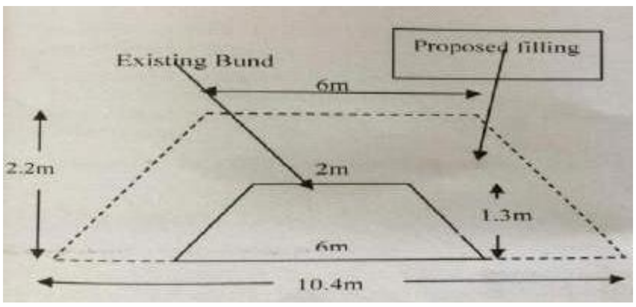

Figure 3: Typical cross section of existing bund and proposed filling

3. Testing and Analysis

Soil samples bought to the laboratory was tested for it s engineering properties like particle size distribution, specific gravity, density, Altenburg's limit etc., as per the current Indian Standard

Specification in the Geotechnical Engineering Laboratory of the institute. The existing bund is of clayey soil with liquid limit = 120% and a plasticity index of 59%. The unit weight of the soil was found to be 13kN/m3 and having a cohesive strength of 10kN/m2. Red earth having an optimum moisture content of 21% and Maximum dry density of 16kN /m3 was used for the formation of the embankment. The uniformity Coefficient and effective grain size of the red earth material was found to be 2.57 and 0.67mm. Trial sections are considered and both internal and external stability analyses were conducted.

Reinforcement is one of the most important functions of geotextiles in improving the soil properties. whether it is used in slope, embankments and retaining wall or in pavements, When reinforcement is placed in soil it can develop bond through frictional contact between the soil particles and reinforcement surface. Deformation in the soil mobilizes tensile or compressive force in the reinforcement depending on the inclination of the later and is ultimately limited by the available bond between soil and reinforcement. hence the shear frictional behavior of soil - geotextile interfaces places a pivotal role while analyzing the overall performance of geotextile reinforced constructions. The interfacial friction depends on - - pressure, grain size

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and shape, surface roughness of geotextiles etc. Modified Direct Shear are suitable for measuring the coefficient of friction between soil and reinforcement.

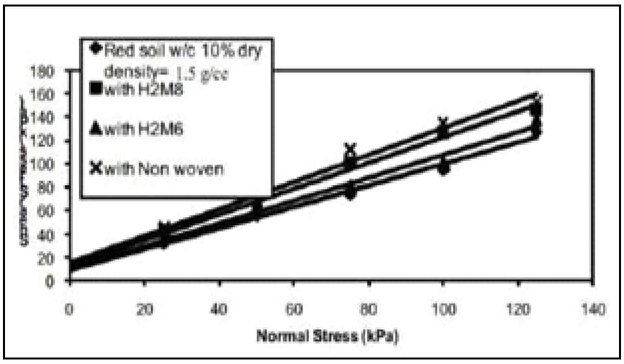

Figure 4: Variation of peak Shear stress vs. Normal stress for red coir geotextile Interface

It could be seen that interfacial friction is more with non woven coir geotextiles. The non woven coir geotextiles are in full contact with the soil, more soil grains are mobilized in the shearing process. Comparing H2M6 and H2M8 woven coir geotextiles, it could be seen that H2M8 coir geotextile performs better than H2M6 coir geotextile in all soils tested. This may be due to lesser contact area of woven coir geotextiles depending on their mesh size.

One of the important function of geotextile is to increase the bearing capacity of the soil. The reinforcement consists of placing elements such as strips, bars, grids, cells, etc. in the soil. This can be placed in a single layer or in multiple layers. In order to understand the beneficial effect of different type of coir geotextiles as reinforcement, load settlement graphs were plotted for a specified value of z/B. Fig.5 shows the load settlement behavior for z/B = 0.5

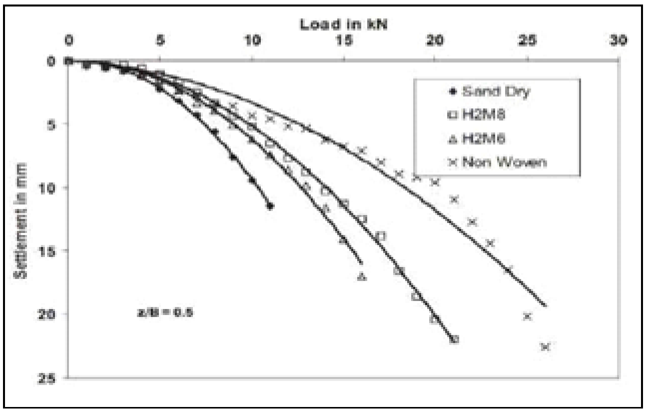

Figure 6: Load settlement behavior with coir geotextile placed at $\pm$/ B=0.5

The separator aspects of coir geotextiles have been studied by performing plate load model tests within a test tank. The test were conducted by applying static loads on base course through a plate of 200mm diameter. The test was repeated by placing geotextile at the interface between soil and base course. he test was conducted with woven and non woven coir geotextiles.

One of the major functions that geotextiles perform is that of filtration. Here water flows through geotextile. permeability test can be done to evaluate the amount of water per unit area passing through geotextile. Here, in case of coir geotextiles, this properties relevant only in non woven the others being mesh with very high permeability. Cross plane permeability of the non woven geotextile tested were found to be approximately 0.025cm/s, which is much higher than that of the usual types of soil.

The strength of the sub grade is most often expressed in terms of California Bearing Ratio (CBR). The values of modulus of sub grade reaction and resilient modulus of soil have been correlated with CBR value. In India the design of flexible pavement make use of primarily the sub grade CBR (IRC: 37 - 2001). It gives in terms of load against standard penetration. A typical test result of the CBR tests conducted is shown which depict the influence of type of coir geotextile in CBR. In all cases the CBR values are found to be much higher than the ordinary soil alone.

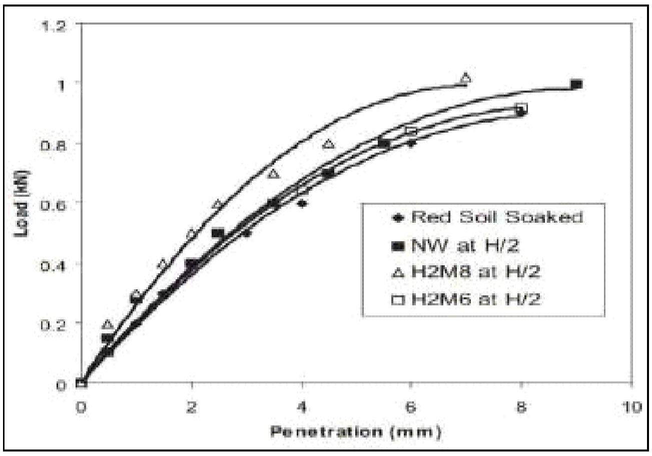

Figure 6: Effect of the type of reinforcement on load penetration

4. Design Recommendations

Based on the test results and the stability analyses, a typical section of the reinforced embankment was recommended as shown in Fig.7, with two layers of coir geotextiles [Beena, 2006]. Frictional or cohesive frictional fill and which are easy to compact and also relatively free draining material is recommended for the fill. The earth filling should be having a minimum dry density of 15kN/m^3. The Coir geotextiles recommended for use is H2M8 having the following minimum properties:

Table 2: Properties of H2M8

Mesh opening	(mm)	= 6 x 10.5
Thic kness at 2 kPa		= 10mm
Mass per unit area		= 900 gm/m^2
Wide width Tensile strength		= 24 kN/m

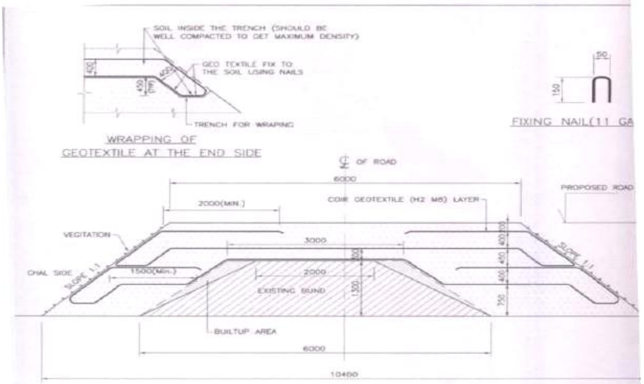

Figure 7: Design of geotextile reinforced farm road

5. Recommendations for Construction

Prepare a level foundation/ surface in accordance with the design parameters. Prior to installation of geotextiles, the sub grade/ slope should be raked or graded to an even surface, free of depressions or projections. Obstructions, which can damage the geotextiles, should be removed. Erect temporary formwork to the face angle if needed to the face angle if needed [Beena, 2007]. The coir geotextiles are coming in rolls and spread it and cut into required length. Position the bottom layer of reinforcement with sufficient allowance at the face for wrap around and turn back into the fill. The geotextiles should be always in intimate cont act with the soil surface of the slope / sub grade. Proper fixing of the geotextiles should be done using fixing nails at 1.0 to 1.5m intervals. Wooden pegs can be used for fixing geotextiles. There should not be any joint of geotextile along the bund, a minimum overlap of 300mm should be provided and should be properly fixed using fixing nails at 300mm.

Special care should be taken whil e laying the geotextiles along the curved alignment. Care should be taken to see that there is no lo ss of fill through the face. The fill should be deposited, spread, leveled and compacted in horizontal layers of appropriate thickness as described in the standard specifications for road works and in accordance with the following recommendations: [Beena, 2006]

- The deposition and compact ion should be carried out so that all layers of coir geotextiles are fixed at the recommended levels on top of the compacted fill.
- Care should be taken to ensure that the coir geotextiles are not damaged or displaced.
- Filling should be done so that no machines or vehicles run on the geotextile. The construction traffic should not pass over the reinforcements before a minimum thickness of 150mm of fill has been placed.
- No portion of the geotextiles should be exposed out.

6. Field Implementation

Some of the photographs for the field implementation are shown below (Fig 8 (a & b)). In actual field execution due to financial constrains of the project, only one layer of coir geotextile was provided and the bottom folded portion is folded back to the middle height of the filled earth with sufficient overlap of 2m.

Prepared bed before laying Geotextile

Bamboo pegs inserted to keep the Geotextile in position
Figure 8 (a): Field implementation of coir Geotextile

Coir Geotextile comes in roll and the bamboo nail

Fill over Geotextile

Bamboo pegs inserted to keep the Geotextile in position

Laying along curved alignment

Roll of Geotextile to be wrap around
Figure 8: (b) Field implementation of coir Geotextile

Regardless of sub grade strength, the site should first be cleared of all sharp objects, tree stumps, and large stones that could puncture the fabric. Unless it is necessary to achieve final grade, the vegetative mat need not be removed, because it can provide extra support during aggregate placement until final compaction. Brush or cushion layers under the non woven fabric are usually necessary, since the fabric prevents soil fines from pumping into the aggregate layer.

Geotextiles should be rolled out onto the sub grade by two people, beginning at a point that allows easy access for construction equipment, yet is consistent with the layout plan. On very soft sub grades, the fabric layout and aggregate placement should begin on the firmest soil on the site perimeter, as an anchor point. From there the fabric can be rolled onto softer sections.

Fabric overlaps and seams should be made as specified. In windy weather, soil or rocks should be placed on the fabric to hold it down until aggregate is placed. Ground securing pins are sometimes used in the overlap sections of the geotextiles.

A compactable, non - moisture sensitive aggregate is then back dumped onto the geotextile beginning on firm soil at a point just in front of the geotextile. This should anchor the geotextile firmly. The aggregate is then spread in one lift to a thickness greater than the needed for stabilization to allow for subsequent compaction. If the thickness from one lift is too great for satisfactory compaction, place more than one lift. In any situation, the first lift should be as thick as necessary to prevent the compaction from overstressing the sub grade. The bulldozer must blade into the load and slightly upward during aggregate spreading for the same reason.

This procedure is followed for each load until the fabric is completely covered.

Over very soft sub grade, care must be taken during aggregate placement to insure the fabric is not moved out of position nor the sub grade overstressed. The bulldozer operator can best determine which spots need additional aggregate for good stability by watching for rutting aggregate layer.

Vehicles should not be allowed to drive directly on the geotextile. If the geotextile is damaged during installation, the damaged section should be exposed and patch of geotextile placed over it. The patch should be large enough to overlap onto unaffected area by 3 to 4 feet (1 to 1.25 meters). The aggregate is then replaced and compacted by the bulldozer. Geotextile panels should be overlapped both side to side and end to end from 1.5 feet to 3 feet (0.5 to 1 meter), depending on sub grade strength.

Final compaction is achieved with a vibratory compactor, first without vibration for several passes, then with full vibration. any weak spots found during final compaction usually inadequate aggregate thickness at those spots. Do not grade ruts down. Instead, fill them with additional aggregate and compact. This rule applies to any future rut maintenance required.

It is important that the construction process be monitored. If field conditions change from the design values, and cause a lower sub grade soil strength value, structural section thickness must be re - evaluated. Monitoring construction cost and early use of the aggregate section pinpoints weak areas missed in soil testing.

Equally important is monitoring the quality of the structural section materials and placement method. The purpose is to detect changes so, if necessary, design adjustments can be made on site before excessive sub grade failures occur. Careful planning and preparation for each installation step speed up the construction and insures good performance and full benefit from geotextiles (fig 9.).

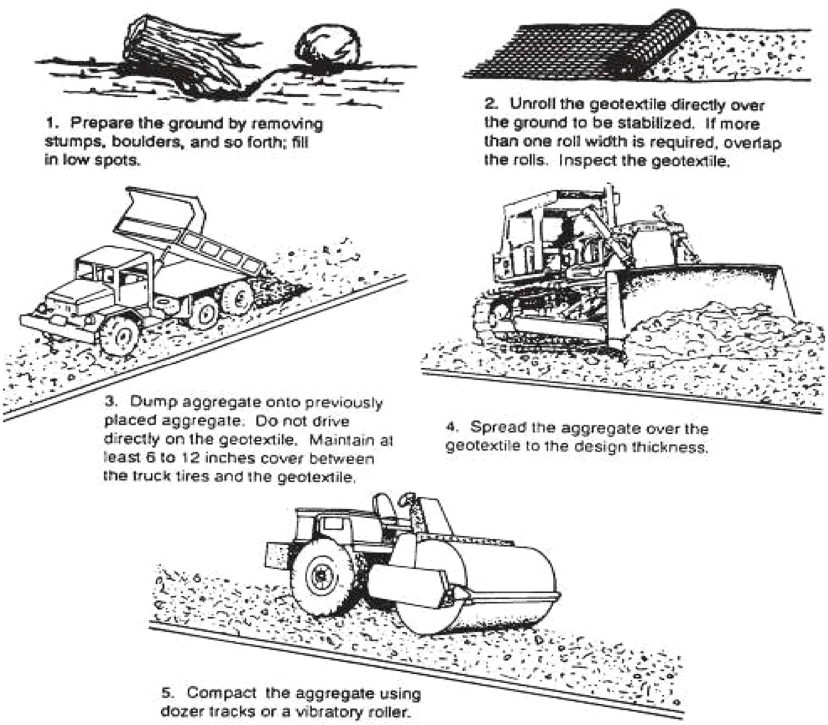

Figure 9: Construction sequence

7. Conclusion

A brief review of coir geotextiles, its potentialities, advantages, application area has been presented here. The documented field studies in this area are very less though there is number of applications in this field, mainly due to the fact that these are employed in small scale applications. A few case studies available in literature is reviewed here. The following benefits of using coir geotextile in unpaved pavements are identified.

- Reducing the intensity of strss on the sub grade (function: separation).
- Preventing sub grade fines from pumping into the base (function: filtration).
- Preventing contamination of the base materials allowing more open - graded, free draining aggregates to be considered in the design (function: filtration).
- Reducing the depth of excavation required for the removal of unsuitable sub grade materials (functions: separation and reinforcement).
- Reducing the thickness of aggregate required to stabilize the sub grade (functions: separation and reinforcement).
- Minimizing disturbance of the sub grade during construction (functions: separation and reinforcement).
- Assisting the increase in sub grade strength over time (function: filtration).
- Minimizing the differential settlement of the roadway, which helps maintain pavement integrity and uniformity (function: reinforcement).
- Minimizing maintenance and extending the life of the pavement (functions: all).

A case study of a farm road of 1.4km long, in which the author was the geotechnical consultant, is described in detail. It is observed that after 5 years of seasonal changes and traffic usage, the road remains pucca without any damage. From these it can be observed that, potentialities of coir geotextiles are very high and is not fully utilized for the advancement of geotechnical engineering. For that, a systematic study on these material, problem specific, is required both in laboratory and in field. Also specifications should be standardized, which is lacking in the industry.

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