FEASIBILITY STUDIES ON APPLICABILITY OF LOW COST MATERIALS FOR FARM ROAD CONSTRUCTION AND SLOPE PROTECTION

By

DHANYA, V.

FAROOQ, A. NIZAR.

ROHINI, R. P.

ULLAS, P. K.

Department of Irrigation and drainage engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR - 679573, MALAPPURAM

KERALA, INDIA

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PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree

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In
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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM

KERALA, INDIA

2011

DECLARATION

We hereby declare that this project report entitled "**Feasibility studies on applicability of low cost materials for farm road construction and slope protection**" is a *bonafide* record of project work done by us during the course of academic programme in the Kerala Agricultural University and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

Dhanya, V	**Farooq, A. Nizar**	**Rohini, R. P**	**Ullas, P. K**
(2007-02-033)	**(2007-02-011)**	**(2007-02-039)**	**(2007-02-025)**

Dated: 07-12-2011

Kelappaji College of Agricultural Engineering and Technology

Tavanur

CERTIFICATE

Certified that this project report entitled **“Feasibility studies on applicability of low cost materials for farm road construction and slope protection”** is a bonafide record of project work jointly done by Dhanya, V. *(Admn. No. 2007-02-033)*, Farooq, a. Nizar. ***(Admn. No 2007-02-011),*** Rohini, R. P. *(Admn. No 2007-02-039) and* Ullas, P. K. *(Admn. No 2007-02-25)* under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship, or other similar title of any other University or Society to them.

Place: **Tavanur**

Date: 07-12-2011

Er. D. Sasikala

Associate Professor

Dept. of irrigation and drainage engineering

K.C.A.E.T, Tavanur.

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Dhanya, V **Farooq, A. Nizar** **Rohini, R. P** **Ullas, P. K**

Dedicated

To Our

Beloved

Parents

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SYMBOLS AND ABBREVIATIONS

AASHTO	American Association of State Highway Transport Officials
AGC	Association of General Contractors
ARTBA	American Road and Transportation Builders Association
ASCE	American Society of Civil Engineering
CBR	California Bearing Ratio
cm	centimeter
ECB	Erosion Control Blankets
ECRM	Erosion Control Re-vegetation Mats
FHA	Federal High way Associations
g	gram
KCAET	Kelappaji College of Agricultural Engineering And Technology
Kg	Kilo gram
Kpa	Kilo Pa
MMV1	Mesh Matting Vaikom 1
M_2V_4	Mesh Matting 2 Vaikom 4
m	metre
mm	mille metre
PVC	Poly vinyl chloride
3PT 1000D Master weeder	3 Power tiller 1000 Diesel Master weeder
RECS	Rolled erosion control systems
US	United States
UV	Ultra violet
%	Percentage
°C	Degree centigrade
°	Degree

INTRODUCTION

Chapter 1

INTRODUCTION

An estimated 80% of the roads in the world are unpaved and approximately 20% of the pavements fail due to insufficient structural strength. Rural transport services at all levels in developing countries play an important role in assisting agricultural development and enhancing the quality of life for the rural population. Limited resources are available for repair and maintenance and so a sustainable option is to develop an innovative pavement stabilisation technique with suitable reinforcement that improves the structural strength and minimise maintenance cost.

Vehicle performance and operating costs can be predicted but the condition and quality of the infrastructure (bitumen, gravel, earth road, track or footpath) has a significant effect. For the rural farm roads the natural earth track is incapable of supporting heavy agricultural machineries especially for low bearing capacity soils. So there is a need to develop an innovative pavement stabilisation technique with suitable reinforcement alternative to improve the overall structural strength and minimise maintenance cost. There is an increased trend in using natural geotextile in the making of paved and unpaved roads. A geosynthetic interphase in between the base and the sub base distributes the wheel load efficiently and provide the necessary wearing surface. Flexible pavement consists of a relatively thin wearing surface built over a base course and a sub-base course, and they rest on compacted subgrade. The flexible pavements are able to resist only very small tensile stresses.

Soil stabilization may be broadly defined as the alteration or preservation of one or more soil properties to improve the engineering characteristics and performance of the soil. Most of the construction projects demand site specific protective measures for its stability. Presently used techniques involve bench terracing, gabion wall, masonry revetment walls, additives etc. However the above mentioned processes are costly and require a higher level of expertise. Several slope protection methods are currently used to stabilize slopes. Among these methods biotechnical methods, making use of natural vegetation are becoming more popular mainly for environmental and economic reasons.

For many years, road engineers have used additives such as lime, cement and cement kiln dust to improve the qualities of readily available local soils. Laboratory and field performance tests have confirmed that the addition of 6% to 10% of such additives can increase the strength and stability of such soils. However, the cost of introducing these additives has also increased in recent years. This has opened the door widely for the development and introduction of other kinds of soil additives including highly cost effective liquid enzyme formulations.

Geotextiles, with their high strength and defined filtration qualities, have a solid history of long term performance in applications involving separation, filtration, drainage and erosion control. They also improve the performance of asphalt pavement overlays and are beneficial in many other applications.

2 Road construction

In the present work, an effort is made to compare the traditional; low cost road construction with road construction using modern reinforcing materials like geotextile, jute, tyre shreds etc. for sub base or base course improvements for soft soils.

1. 1. 1 Geotextiles

Geotextiles play a significant part in modern pavement design and maintenance techniques. The growth in their use, worldwide, for road construction applications in particular. Geotextiles is found to enhance the performance and extend the service life of paved roads.

The use of geotextiles saves an aggregate placement and repair cost associated with constructing and maintaining unpaved roads characterized by soft sub grades, high traffic loads and large deformation tolerances. A soft sub grade covered with geotextile stabilizes the road by spreading applied loads over a wider area, reducing rut depths and preventing aggregate contamination by underlying sub grade soils. This reduces maintaining cost and improves roadway life.

The mode of operation of a geotextile in soil stabilization application in road construction is defined by five discrete functions: separation, filtration, drainage, reinforcement, sealing and protection.

Depending on the application the geotextile performs one or more of these functions simultaneously.

1. 1. 1. 1 Separation

Separation is the introduction of a flexible porous textile placed between dissimilar materials so that the integrity and the functioning of both the materials can remain intact or be improved. In transportation applications separation refers to the geotextile's role in preventing the intermixing of two adjacent soils.

1. 1. 1. 2 Filtration

It is the equilibrium of geotextile to soil system that allows for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration. To perform this function the geotextile needs to satisfy two conflicting requirements: the filter's pore size must be small enough to retain fine soil particles while the geotextile should permit relatively unimpeded flow of water into the drainage media. A common application illustrating the filtration function is the use of a geotextile in a pavement edge drain.

1. 1. 1. 3 Drainage

This refers to the ability of thick non woven geotextile whose three-dimensional structure provides an avenue for flow of water through the plane of the geotextile. Here the geotextile promotes a lateral flow thereby dissipating the kinetic energy of the capillary rise of ground water.

1. 1. 1. 4 Reinforcement

This is the improvement in the total system strength created by the introduction of a geotextile into a soil and developed primarily through the following three mechanisms: One, lateral restraint through interfacial friction between geotextile and soil/aggregate. Two, forcing the potential bearing surface failure plane to develop at alternate higher shear strength surface. And three, membrane type of support of the wheel loads.

1. 1. 1. 5 Sealing Function

A nonwoven geotextile performs this function when impregnated with asphalt or other polymeric mixes rendering it relatively impermeable to both cross-plane and in-plane flow. The classic application of a geotextile as a liquid barrier is paved road rehabilitation. Here the nonwoven geotextile is placed on the existing pavement surface following the application of an asphalt tack coat. The geotextile absorbs asphalt to become a waterproofing membrane minimizing vertical flow of water into the pavement structure.

The geotextile used in transportation applications mainly act as a reinforcement, which absorbs the additional shear stresses and improves the load distribution on the subgrade, thus reducing the fill thickness.

1. 1. 2 Jute

Jute is a ligno-cellulosic, composite natural bast fiber. Cellulose, hemi-cellulose and lignin are its major constituent components and its three dimensional structure is formed by different inter and intra-molecular forces resulted from various physical, chemical, and hydrogen bonds, between them. The commercial fiber consists of hairy strands of cylindrical networks of ultimate jute fiber. Properly retted and washed jute fibers are fairly lustrous with moderate strength but rough to touch. The color of the fiber also varies from creamy white to brown.

Jute and jute products are biodegradable, photodegradable, thermal degradable, nontoxic, non plastic, acidic, anionic, hydrophilic, with higher moisture and UV absorbing capacity and higher tenacity. Most of the cellulose is present in crystalline part of it. Amorphous parts are mostly non cellulosic in nature due to the presence of hemi cellulose and lignin. It has similarity with soft and hard fiber and cotton and wood simultaneously. A vast range of diversified jute products can be manufactured through vertical and horizontal modification. A wide range of fabrics can be produced with the variation of drafts, twists, dollop weight and design. Moreover, nonwoven, knitted and netted jute fabrics can also be manufactured by needle punching, stitching and chemical bonding, with different strength, thickness, porosity and permeability according to need..

Divergent and prospective applications of jute and modified jute products can be used as a solution of various problems related to geotechnical, erosion control, mulching and environment related activities. Recent studies have been reported on the use of jute as a separator/reinforcement in the construction of paved and unpaved roads so that by the time jute has degraded, the soil has been stabilized. The advantages of jute is that it is agro based, low cost, high tensile strength, anti-slip nature, high moisture absorption and biodegradable.

1. 1. 3. Tyre shreds

Waste tyres have been a disposal problem in the past and are continuing to accumulate throughout the earth today. Using shredded waste tyres as a lightweight fill material for road construction has proven to be a beneficial use of this waste product.

Shredded tyres exhibit many advantages as a lightweight fill material. To begin with, shredded tyres are non-biodegradable either above or below the water line under normal conditions. This provides for a stable road base for a longer time period than some other lightweight fill materials. Wood products like sawdust, bark, and wood chips tend to biodegrade over time if not completely submerged. In addition, shredded tyres weigh only 320 - 640 kg per cubic meter. Because of their low density, tyre shreds can be used to build roads over unstable soils. This is important for proper drainage of highway base grades. Additionally, using shredded tyres as fill material will help to free up other valuable road building resources, namely sand and gravel for other use.

Shredded waste tyres have many beneficial engineering properties as a lightweight fill material. To begin with, compacted shredded tyre material is more porous than washed gravel. When used in the road base or sub base, shredded tyres will improve drainage below the pavement and therefore should extend the life of the roadway. Additionally, tyre shreds are very elastic. This property enables the tyre material to better distribute the roadway loads over unstable soils. Furthermore, shredded tyres are easily compacted and consolidated.

In the present work, an effort is made to construct low cost unpaved roads using various alternative materials like geotextiles, jute and tyre shreds as a separation between the base and sub-base course for soft soils with low bearing capacity and a performance evaluation of the constructed road is done and compared with the performance of unpaved earthen road.

1. 2 Stability of slopes

Stability of the slopes, whether manmade or natural, is important for the construction of roads in hilly areas. The degradation of natural or artificial slopes is the result of mass movement which occur mainly due to the action of gravitational forces, seepage force, sudden lowering of water and forces due to earthquake. Slope stability can be generally described as the inherent structural integrity of a slope to resist failure. Failure can occur as slides, cracks and slope movement. Therefore a sensible design of the slope of these structures is very essential since a structural failure may lead to loss of human life and money.

One of the efficient methods in embankment stabilization on the soft to very soft clayey sub grades is utilizing of geotextile sheets. In recent years many researchers dealt with assessment of actual performance of geotextile from design and construction as well as from performance points of view many full scale tests for evaluation of geotextile performance under embankment on soft clay have been undertaken. The objectives of the study were economy and safety, and involve the maximization of the angle of inclination of the slope while assuring stability.

We need an easy and accurate way to study a slip surface to find factors of safety against failure, and to check the improvements from reinforcement. The common method of a slope stability analysis of natural slopes and slopes formed by cutting and filling are based on limiting equilibrium. In this type of analysis the factor of safety with regard to the slope stability is estimated by examining the condition of equilibrium where incipient failure is assumed along a predetermined failure plane and then comparing the strength necessary to maintain equilibrium with the available strength of the soil.

Slope stability, or the lack thereof, rests upon the ability of a slope to resist stress excess to what is normally acceptable for the material property of the soil or rock inherent to the construction slope. Slope movements, such as translational or rotational slope failures occur when sheer stress exceeds sheer strength of the materials forming the slope. Factors contributing to high shear stress include: lack of lateral support, excessive surcharges, lateral pressures and removal of underlying support. On the other hand, low shear strength, due to inherently weak materials, soil weathering (swelling, shirking and cracking) and low inter granular force due to seepage pressure, also contributes to slope instability.

Over the past decade, geosynthetics have played a significant role in geo-environmental engineering applications. Woven and nonwoven geosynthetics have been used in various applications such as soil stabilization, turf reinforcement, erosion control, separation, filtration and drainage. Depending on the application, they are available under various trade names such as rolled erosion control systems (RECSs), geosynthetic mattings, geotextiles, erosion control blankets (ECBs), erosion control re-vegetation mats (ECRMs) and turf reinforcement mats. However, strength properties of natural fibers are often superior to synthetic fibers.

In the present study, the factor of safety of slopes stabilized using geotextiles and jute for various slopes were determined

1. 3 The objectives

The objectives of the present study are:

1. Study of engineering properties of the soil with the materials used in road construction
2. Construction of sample plots of farm road with coir geotextiles, jute, tyre shreds and coarse aggregate
3. Performance evaluation of these materials in road construction
4. Slope stability analysis on different slopes for various materials

REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

The first use of fabricated material to enhance pavement performance in the US was in the 1920s. The state of South Carolina used a cotton textile to reinforce the underlying materials in a road that had poor quality soils.Woven cotton fabrics were used as an early form of geotextile or geomembrane in a series of road construction field tests started in 1926 by the South Carolina Highways Department. As the fabric was covered with hot asphalt during construction, its function was more akin to that of a geomembrane than of a geotextile in this early application. Although these tests were continued for nine years and the published results for this application seemed encouraging.

A woven monofilament geotextile was first used as a filter in a shoreline erosion control application in Florida in 1957. Since that time, the use of geotextiles has become commonplace and has grown to include the broader category of geosynthetics. However, a geotextile is the most common geosynthetic used in shoreline erosion control.

In 1982, the Committee on Materials of AASHTO, the American Road and Transportation Builders Association (ARTBA) and the Association of General Contractors (AGC) formed Joint Task Force 25 (TF 25) to review the suggested geotextile specifications being proposed by the Federal Highway Association (FHWA) Geotextile Manual.

2. 1 Geotextile as a material for road construction

In 1972, nonwoven fabrics were used in Europe in road support applications on soft soils and at construction sites. The results were positive and so, DuPont, an established nonwoven fabric producer, developed a program to produce a geotextile for use in similar applications. As part of that program, several materials were evaluated under roads in several locations and several existing fabrics were installed in unpaved road test sections for performance evaluations.

Brown et al. (1984) found that the geotextile and the interlocked material provided a dense, stiff and closely bound layer of particles of material in the body of the reinforced material which had a higher modulus than material which surrounded it. This stiff layer was found to resist vertical permanent strains as well as tensile strains. The efficiency of this layer was dependent on the degree of closeness of its packing which depended on compaction.

Michael and Eugene (1992) found out that when the sub grade is cohesive and reaches a moisture content at or above its plastic limit, localized bearing failures may occur at the aggregate-sub grade interface resulting in sub grade intrusion. This sub grade intrusion initiated a progressive failure mechanism, resulting in a need for continuous roadway maintenance. Placement of geotextile as a separation layer between the base and sub grade has been an effective use of geotextiles.

Koerner *et al.* (1994) suggested that geotextile functions are in effect to varying degrees when a geotextile is used in the separation/stabilization application beneath paved and unpaved roads. The life of a geotextile was considered indefinite because of the harsh treatment the geotextile received during the actual construction, and not the long term use. Durability testing has shown that polypropylene geotextiles can last over 200 years in the ground.

Eiksund *et al.* (1998) suggested that geotextiles play a significant part in modern pavement design and maintenance techniques. There was a clear correspondence between the initial tension stiffness of a geotextile and the deformation after cyclic loading.

Sudhir and Guru (2000) suggested that the permeability characteristic of the fabric aids in fast dissipation of pore pressure and ensures better drainage which resulted in better long term performance of the pavement. Geotextiles play a significant part in modern pavement design and maintenance techniques.

Khalid *et al.* (2004) provided an overview of the current geotextile technologies and highlighted the functions the geotextiles performed in enhancing the performance and extending the service life of paved roads. Three key application areas of geotextiles, namely, the construction of pavements, in asphalt concrete overlays and for drainage systems, along with impetus on the current design methodologies available in geotextile design and selection were addressed.

William *et al*. (2007) studied the current information on a geotextile separator used experimentally in an unpaved road 35 years ago. At that time, geotextiles were largely untested, and the site was set up to determine the comparative performances of several potential geotextiles, in an accelerated field test. After the initial few years of successful performance and durability; the ultimate potential lifetime became the major factors in assessing the value of geotextiles in unpaved roads. A primary issue in the long-term test turned out to be the lack of adequate cover, in some cases, less than the minimum recommended 6 inches of stone for protection of the geotextile in this application. The polymer stabilization package used when the fabrics were produced, but not designed for this application was inadequate and has since been properly designed.

The geotextile layer enabled the permanent separation and filtration of the subgrade and base aggregate to keep the subgrade fines from migrating up into the aggregate base while allowing the base layer to drain was studied by Jake *et al*. (2008). This important function maintained the long-term strength and drainability of the aggregate base. In addition, the added layer enhanced the stabilization of both the subgrade and the base aggregate through confinement and local reinforcement. The design and cost benefits gained from using a geotextile were impressive. The geotextile layer used costs no more than 1-2 inches of aggregate and provided significant life-lengthening and maintenance-saving qualities to the road.

Jurg *et al.* (2009) suggested that geotextiles serve mainly as barrier and filtration material to permanently separate the soil from water and ultimately to prevent water pressure buildup, therefore preventing the water's flow causing erosion. Geotextiles are also used in civil engineering projects, such as dam, retaining walls and for road and reservoir slope stabilization.

Numerous field trials and full-scale laboratory investigations have illustrated that geosynthetics used to reinforce unpaved roads on soft subgrade facilitate compaction (Bloise and Ucciardo, 2000), improve the bearing capacity (Floss and Gold, 1994; Huntington and Ksaibati, 2000; Meyer and Elias, 1999), extend the service life (Cancelli and Montanelli, 1999; Collin et al., 1996; Jenner and Paul, 2000; Watts et al., 2004), reduce the necessary fill thickness (Bloise and Ucciardo, 2000; Cancelli and Montanelli, 1999; Huntington and Ksaibati, 2000; Jenner and Paul, 2000; Martin, 1988; Miura et al., 1990), diminish deformations (Chan et al., 1989; Jenner and Paul, 2000), and delay rut formation (Cancelli and Montanelli, 1999; Knapton and Austin, 1996; Meyer and Elias, 1999).

2. 2 Application of geotextile in slope stabilization

Geotextiles are frequently used in slope stabilization applications. They are used to retain soil particles while allowing liquid to pass freely. In erosion control the geotextile protects soil surfaces from the tractive forces of moving water or wind and rainfall erosion. If erosion is allowed to proceed unchecked, there is every possibility that the damage may spread laterally thus increasing the depth of erosion, eventually resulting in a much larger damaged slope area. Use of geotextile is one of the most important corrective measures.

Rotar *et al.* (1996) have reported that channel bank stabilization of various slopes between 1V:2H and 1V:3H was successfully done by the use of coir geotextiles. Coir geotextiles were recommended on longer slopes where increased run off velocities necessitated greater durability and effectiveness.

Sutherland and Ziegler (1996) suggested that, despite synthetic geotextiles dominating the commercial market, geotextiles constructed from organic materials are highly effective in erosion control and vegetation establishment. Coir geotextile (MMA3 and MMV2) was found capable of preventing surface erosion along the surface of a slope and facilitated in sedimentation of soil on previously exposed rock surfaces. Geotextiles was used in combination with vegetation to provide a composite solution of soil erosion control.

Anil and Sebastian (2003) in their study using coir geotextile (MMV1) on different slopes showed that there is considerable reduction in soil erosion in the treatment plots. In the treatment plots with a slope of 20%, the soil conservation was 77 times higher compared to control plots; on a slope of 30–40% it was 17 times higher. Also there is considerable reduction in the time that it takes for the different treatments to achieve slope stabilization. Plots with geotextiles stabilized earlier than control plots.

Reduction in soil loss is mainly due to the coir matting, which reduces the raindrop impact as it intercepts the direct contact with soil.

Balan *et al.* (2003) in his study using coir geotextile (MMV1) for gully plugging in the high land region of Kerala showed that gullies on the upstream side have a siltation of 45 cm and on the downstream side a siltation of 10cm after one monsoon season.

Lekha (2004) in her field trial using coir geotextile (MMA3) for slope stabilization, observed that after seven months of laying, coir retained 22% of the strength of a fresh sample. Also the reduction in soil erosion and increase in vegetation is significant in plots treated with geotextile.

Choudhury (2006) suggested that open wave geotextile is capable of arresting migration of the soil particles along the steep slope and creating a congenial ambience for the growth of vegetation and plants. Geotextiles create a stable, non-eroding environment and, if constructed using natural materials, they could be effective, affordable and compatible with sustainable land management.

Sinha *et al*. (2007) found that for the slope stability analysis different methods gave different critical circle and different factor of safety for same situation, namely, earth fill material and ground soil properties. Even for the same slip surface different methods gave different factor of safety. However, the methods, which considered same set of forces and same factors produced similar results. For example, Morgenstern-Price and Spencer methods for constant function produced same factor of safety. It was found preferable to adopt a method which satisfied both moment equilibrium as well as force equilibrium

Smets *et al.* (2007) suggested that geotextiles are used for many engineering applications to improve soil properties. On steep erodible slopes, where the vegetation growth is limited by erosive forces of rain and runoff, geotextiles can serve as a temporary replacement of vegetative cover. Treatment with geotextile in combination with grass is an effective eco-hydrological measure to protect steep slopes from erosion.

2. 3 Desirable properties of geotextiles

Being 100% natural and bio-degradable, coir fiber functions as a soil amendment. Coir geotextile has high tensile strength which protects steep surfaces from heavy flows and debris movement. The excellent microclimate coir provides for plant establishment, natural invasion and balanced healthy growth.

Giroud and Wager (1971) used woven fabrics as a filter in the upstream face of an earthen dam. They initiated the use of woven fabrics as reinforcement for embankments constructed on very soft foundations.

Naemura *et al*. (1996) studied the effectiveness and practicability of a construction method using geotextiles to reinforce high embankments constructed using high water content clayey fill. The spun bonded non woven geotextile provided drainage which accelerated embankment consolidation, and tensile reinforcement ensuring trafficability during construction, as well as, embankment stability.

Ajitha and Jayadeep (1997) studied the frictional characteristics of sand –coir geotextile interface by direct shear test and reported a high value of shear parameters compared to geosynthetics. In addition, as coir yarns are highly flexible the passive resistance offered by weft yarns may be less compared to frictional resistance.

Ziegler *et al.* (1997) found that natural geotextiles helped to suppress extreme fluctuations of soil temperature, increased soil moisture content, provided seeds with a better chance to germinate and increased infiltration by reducing surface sealing. Geotextiles are biodegradable, providing organic content matter to stabilize the soil, and their permeability makes them suitable for use on cohesive soils.

Ogbobe *et al.* (1998) studied the effectiveness of geotextiles in decreasing soil erosion which depended mainly on several properties, such as percentage of open area, mass per unit area, thickness, tensile strength, mass of geotextiles per unit area when wet, design and drapability**.** It was also suggested that the use of geotextile mats on bare soil significantly reduced soil splash height by 51% and splash erosion by 90%.

Schurholz *et al.* (2000) conducted a test for material testing on jute, sisal, coir and cotton over a prolonged period of time in highly fertile soil maintained at high humidity

(90%) and moderate temperature. The study revealed that coir retained 20% of its strength after one year whereas cotton degraded in six weeks and jute degraded in eight weeks. It was also found out that even after seven months, the matting retained 56% of its original strength against the reported value of 56% reduction in strength in six months.

Benediktas *et al.* (2008) has investigated the application of geotextile mats, constructed from the palm leaves of *Borassus aethiopum* (Borassus) and *Mauritia flexuosa* (Buriti), at the Kaltinenai Research Station of the Lithuanian Institute of Agriculture. Field studies on a steep (21–25°) roadside slope demonstrated that cover of Borassus and Buriti mats improved the germination and growth of sown perennial grasses. The biomass of perennial grasses significantly increased (by 52–63%) under cover of Borassus mats and by 19–28% under cover of Buriti mats. The geotextiles (Borassus and Buruti, respectively) decreased soil losses from bare fallow soil by 91 and 82% and from plots covered by perennial grasses by 88 and 79%, respectively. This illustrated that geotextiles have a notable potential as a biotechnical soil conservation method for slope stabilization and protection from water erosion on steep industrial slopes and may be integrated with the use of perennial grasses to optimize protection from water erosion.

Chandrakaran *et al.* (2008) conducted pullout tests on individual warp and weft yarns in a small size box and the data obtained was used to evaluate the contributions of frictional and bearing resistances of yarns towards total pullout force of geotextiles. The results showed that the spacing of warp and weft yarns influenced both interface friction and passive resistance. An estimate of total pullout capacity of geotextile could be obtained using the results of individual yarn tests and it was also observed that the contribution of warp yarns is more compared to weft yarns towards total pullout resistance.

2. 4 Application of tyre shreds in road construction

In most parts of the world, discarded tyres have become an on-going serious environmental problem. Over 500 million tyres are discarded in the United States per year. These tyres are left stockpiled in landfills or illegally dumped, providing breeding beds for harmful insects and rodents. At the end of 2005, approximately 299 million scrap tyres were generated from 500 million discarded tyres in the United States.

Ahmed *et al.* (1993) suggested that discarded tyres can be used in a number of forms, as whole tyres, slit tyres, shredded, in chips, or as ground rubber or crumb rubber shapes. Either on their own or with soils, discarded tyres have been used in many civil engineering applications including highway construction, highway embankments, landfills as leachate drainage material, lightweight backfills for walls and bridge abutments, for slope stabilization, stacked bales, and subgrade insulation for roads. These applications of discarded tyres not only provided a new construction material but also helped to solve environmental and economic problems.

Humphrey and Sandford (1993) suggested that a soil cap 0.6-1.8 m thick be placed on top of tyre chip embankments to prevent excessive deflection of overlying layers. Tyre chips can be used to replace aggregate, improve drainage, and provide thermal insulation. Preloading can control the compressibility of tyre chips. They recommend a soil cap at least 1 m thick be placed over tyre chips or tyre chip-soil fills to limit settlements under traffic loads or surcharge. The compressibility of tyre chips can be reduced significantly by adding 30-40% sand by volume.

Bosscher *et al.* (1994) have reported that sand can be reinforced using tyre chips. Adding tyre chips increases the shear strength of sand, with friction angles as large as 65° being obtained for mixtures of dense sand containing 30% tyre chips by volume. However, the strength decreased when the tyre chip content increased beyond 30% because the sand-tyre chip mixture behaved less like reinforced soil and more like a tyre chip mass with sand inclusions.

Foose *et al*. (1996) reported that pure tyre chip mixtures have a friction angle of *20-35°* and cohesion of 3-11.5 kPa based on large-size direct shear tests. Triaxial tests conducted on small tyre chips (40 mm long) indicated that the friction angle can be in excess of *40°* and that the cohesion intercept is negligible. Field evidence also existed that supports high friction angles for pure tyre chips.

Tatlisoz *et al.* (1997) found out that adding tyre chips to the clay resulted in a decrease in shear strength, and no desirable benefits for retaining wall or embankment construction. It was reported that the compressibility of tyre chips can be reduced significantly by adding 30-40% sand by volume.

Nilay, Tuncer and Craig (1998) showed that the geosynthetic pull-out force in tyre chip and soil tyre chip backfills increased with displacement ie no peak pull-out force is generally obtained, at least for displacement less than 110 mm. Pull-out interaction coefficients for tyre chip backfills were typically greater than 1, whereas for soil tyre chip backfills they typically ranged between 0.2 and 0.7, even though the pull-out capacity for soil-tyre chip backfills was similar to or greater than the pull-out capacity in a soil backfill. The higher strength, lower unit weight and good backfill-geosynthetic interaction obtained with soil-tyre chip backfills resulted in walls requiring less geosynthetic reinforcement than walls backfilled with soil. In addition, embankments can potentially be constructed with steeper slopes and a smaller volume of material when soil-tyre chip fill is used, while providing greater resistance against lateral sliding and foundation settlement.

Lee *et al.* (2007) characterized the behaviour of rigid-soft particle mixtures with the fixed size ratio sr = *D* rubber /*D* sand of 0.25. The stiffness of the rigid-soft mixtures increased with an increase in the sand volume fraction irrespective of size ratio between rubber and sand particles. The small and middle strain moduli, however, do not linearly increased with an increase in the sand fraction. The small strain behavior of the rigid-soft mixtures can be grouped into rubber like behavior and sand like behavior with the sand fraction. Particle characteristics and volume fraction of two rigid particles in the mixture controlled the minimum porosity of the mixture, and small particles in the rigid particle mixture play a dominant role in the change of porosity regardless of the vertical effective stress. However, the effect of the sand fraction for the minimum porosity of rubber-sand mixtures decreases with an increase in the vertical effective stress because the rubber particles distort and fill the voids between the sand particles.

2. 5 Application of jute in road construction

Jute textiles have been used for technical applications since the early 20th century, from mills in Scotland to Strand Road in Calcutta in the 1930s.The performance of pavements constructed on soft soils can be improved using jute. Jute fabric when used as separator prevents the penetration of subgrade material into voids of granular base course. The permeability characteristic of the fabric also aided in faster dissipation of pore pressures and ensured better drainage which resulted in better long term performance of the pavement. Provision of fabric enabled subgrade to develop its full bearing capacity and thus control rutting. Jute was used as a separator between subgrade and sub-base layers.

Christopher *et al*. (1985) found that road constructed with jute geotextile provided filtration essentially same as with graded filters. They found that jute retains the soil fins thus allowing a relatively unimpeded flow of water throughout the life of the structure. The introduction of jute placed between dissimilar materials so that the integrity and functioning of both remain in tact or be improved.

Subgrade stabilisation is the largest single application for geotextiles by volume. As environmental and population pressures become more severe, infrastructure projects will be directed further towards locations where ground conditions are marginal. Lawson *et al.* (1996) found that the thickness and quality of pavement materials is dependent upon the level of serviceability required of the completed pavement structure. The required geotextile properties were dependent upon the strength of the subgrade, the particle size of the granular layer above the geotextile, and groundwater conditions. Selection of the appropriate geotextile properties for subgrade stabilisation was most commonly performed by a combination of empirical classification and design.

Valentine *et al.* (1997) concluded that geotextile extended the service life of roads, increase their load-carrying capacity, and reduce rutting. The research found that for weak subgrade the geotextile extent the service life of a flexible pavement section by a factor of 2.5 to 3 compared to non-stabilized section. The geotextile effectively increased the pavement sections total AASHTO structural number by approximately 19%.

Bindumadhava *et al.* (1998) substantiated the proven concept that limited durability of jute is not a discouraging factor in as much as soil gets consolidated to its maximum within a year or so in view of its catalytic function for a limited initial period. The consolidation is effected as a result of arrest of movement of soil particles on the one hand and concurrent release of pore water due to imposition of extraneous loads on the other. Separation of sub base and sub grade also contributed to gradual and natural consolidation of the sub-grade. It has been found from extensive case studies that the soil consolidation maximizes between one and two years depending on the type of soil, its moisture content and the extent and frequency of extraneous loads. In their field study the control CBR value got enhanced to more than 3 times despite strength loss of jute.

Rao *et al. (1998)* suggested that water content, void ratio and compression index decreased while dry density of the sub grade soil increased by the use of jute. Jute appears to be very effective even in weak sub grade soils in reducing their strength as reflected from the good performance even after a lapse of seven years.

Mark *et al*. (1999) found that **the presence of properly installed paving fabric inter layer reduced the permeability of a pavement by one to three orders of magnitude. By reducing the infiltration of moisture, the paving fabric maintained the strength of the subgrade, subbase and base course, limiting the damage due to saturated condition pore pressures.**

James and Jason (2000) reported that the average CBR value of the subgrade before application of jute was 3.5 %. It was evident from their study that the subgrade had strengthened by the application of jute and reached a CBR value of 6.0 %. Jute performed the desired function. Use of right type of jute for the separation purpose was found desirable to obtain optimum result.

Maccai *et al*. (2004) presented that geotextiles play a significant part in modern pavement design and maintenance techniques. It is an effective tool in handling the civil engineering problems.

Madhavi *et al.* (2005) found that the Jute Geo-textile strengthened the soil sub-grade by preventing intermixing of sub-grade and sub-base by acting as a separation layer and further it prevented migration of fines of a sub-grade by acting as a filtration materials. There was cost saving of about 12% in road construction. It is environment friendly. Jute can be more effective, eco-friendly and economical if used judiciously and jointly with other measures.

Tapobrata (2006) suggested that used jute-bags filled with locally available fine aggregates may provide for quick construction/restoration of pathways. In unpaved rural roads, ruts develop due to clay content in the riding surface which causes ‘slip’ between the wheel and the riding surface. The lack of wheel grip exerts a kind of kneading effect reducing the shear strength of the riding surface. Ruts developed as a consequence deepens. The problem can be obviated by arraying bags encapsulating appropriate aggregates on the road surface as indicated.

Bhattacharya *et al.* (2007) suggested that jute appears to function quite close to synthetic counterpart. The plate load tests confirmed that the Jute significantly improves the bearing capacity and settlement behavior of the sub grade soil. The strength and condition of jute beyond one year after placement should not be any concern as by that time it helps provide a self-sustaining sub grade. The jute seemed to operate mainly through considerable reductions in run-off. Jute is the most effective product with the higher intensity rain and also showed a tendency to become more effective with time. This is due in part to the drapability of the product when wet which helps to maintain close contact between the jute and the soil surface.

Abdullah, B. M. (2008) studied the use of jute in river bank protection and found to be an efficient alternative to conventional method in respect of capital investment and recurring maintenance cost. The undistributed bank after 11 years implied that jute performed its designated functions and helped in natural consolidation of the bank soil and durability of jute beyond 1-1/2 years, even under continuing adverse conditions, provide to be redundant due to catalytic function of jute.

The study by Paul Guyer *et al*. (2009) covered physical properties, functions, design methods, design details and construction procedures for jute as used in pavement stand drainage applications. Jute functions described include pavements, filtration and drainage.

MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

The method used and methodology adopted for conducting the experiments are described in this chapter.

3. 1 Location

Theoretically any site that is accessible for man power and equipments are suitable for the field testing of geotextiles for the road construction, slope stabilization and erosion control. The factors to be kept in mind while selecting the appropriate site is

- The site for slope stabilization should have an appropriate slope
- The site should be free from disturbances
- The site should have enough water application facilities

The experiment was conducted in the KCAET campus at Tavanur in Malappuram district of Kerala. It is situated at 5° 52' 30'' N latitude and 76° E longitude.

3. 2 Climate

Kerala has a humid tropical climate with temperature averaging between 20°C and 30°C throughout the year. The mean annual precipitation averaging between 2000 and 4000 mm is distributed over 125 rainy days. The experimental area falls within the border line of north zone, central zone and kole zone. Climatographically the area is in high rainfall zone. The area receives rainfall mainly from south west monsoon and a certain extent from the north east monsoon.

3. 3 Site selection

For the performance evaluation of various materials used in the construction of low cost roads for soft soils, a site was selected near the north-east of Vasudevapuram temple. The site was cleared for construction of road sections making use of the various study materials. A laboratory study of the various engineering properties of the soil at the site is conducted.

Fig. 3. 1 Site selected for road construction

3. 4 Study of engineering properties of soil

3. 4. 1 Sieve analysis

The distribution of different grain sizes affects the engineering properties of soil. To determine the percentage of different grain sizes contained within the soil, a mechanical sieve analysis is performed to determine the distribution of coarser particles and a hydrometer analysis to determine the distribution of fine grained particles. A grain size distribution curve is drawn and the soil is classified based on the distribution.

3. 4. 2 Field density

Field density is used in calculating the stress in the soil due to its overburden pressure it is needed in estimating the bearing capacity of soil foundation system, settlement of footing earth pressures behind the retaining walls and embankments. Stability of natural slopes, dams, embankments and cuts is checked with the help of density of those soils. It is the density that controls the field compaction of soils.

Permeability of soils depends upon its density. Core cutter method in particular, is suitable for soft to medium cohesive soils, in which the cutter can be driven.

A core cutter, consisting of a steel cutter of 10 cm diameter and 13 cm height and a 2.5 cm height dolly is driven in a cleaned surface with the help of a suitable rammer, till about 1 cm of the dolly protrudes above the surface. The cutter containing the soil is dug out of the ground, the dolly is removed and the excess soil is trimmed off. The mass of the soil in the cutter is found. By dividing it by the volume of the cutter the bulk density is determined the water content of the excavated soil is found in the laboratory, and the dry density is computed.

$$\text{Bulk density} = \frac{\text{Md}}{\text{V}}$$

where

M_d = mass of dry soil

V = volume of core cutter

3. 4. 3 Compaction properties

Soil placed as engineering fill is to be compacted to a dense state to obtain satisfactory engineering properties. The objectives of compaction are to increase the shear strength thereby increasing the bearing capacity of soil and to reduce voids ratio thereby reducing permeability. The variation in compaction with water content and compactive effort is first established in the laboratory. Laboratory compaction tests provide the basis for determining the percentage compaction and moulding water content needed to achieve the required engineering properties, and for controlling construction to assure that the optimum water contents and compaction are achieved. Higher compaction is required for heavier transportation and a modified proctor test was developed to give higher standard of compaction

The relation between percentage compaction with water content is first established in the laboratory. Target values are then specified for the dry density and/or air-voids content to be achieved on site.

The Proctor compaction test is a laboratory method of experimentally determining the optimum moisture content at which a given soil type will become most dense and achieve its maximum dry density. These values were obtained by plotting water content-dry density plots.

3. 4. 4 Shear strength

In many engineering problems (design of foundation, retaining walls, slab bridges, pipes and sheet piling) the value of the angle of internal friction and cohesion of the soil involved are required for the design which can be determined in the laboratory by various tests like triaxial test, direct shear test, unconfined compression test, vane shear test etc. which determines the shear strength of the soil at failure. The shear strength is one of the most important engineering properties of soil and is related to the bearing capacity of soil. Direct shear test can be used to predict these parameters quickly.

Direct shear test is one of the oldest soil strength tests done in the laboratory. The soil shear testing involved the sliding of one portion of the soil specimen on another by using the shear box test. Hence, the direct shear device will be used to determine the shear strength of a cohesionless soil, such as the angle of internal friction. From the plot of the shear stress versus the horizontal displacement, the maximum shear stress is obtained for a specific vertical confining stress.

The shear strength is one of the most important engineering properties of a soil, because it is required whenever a structure is dependent on the soil's shearing resistance.The shear strength is needed for engineering situations such as determining the stability of slopes or cuts, finding the bearing capacity for foundations, and calculating the pressure exerted by a soil on a retaining wall.

3. 5 Land preparation

For the construction of farm road five plots of 3m length and 1.2 m width was required. One of the plots was selected as a control plot. The plots were protected from branches of trees to avoid interception losses. To protect the measured area and to prevent the entry of cattle into the plots,a fencing was provided. Polythene sheets were used to cover the edges of the plots to prevent the passage of runoff into and out of the plots. The plots were constructed using different materials like coir geotextile, jute geotextile, tyre shreds and gravels.

The plots of dimension of 3×1.2m were selected for road construction. The optimum moisture content for each plot were found out and the plots were prepared by compacting the soil with that volume of water. A sub grade of 30 cm soil was laid and compacted with roller. The total thickness of base and sub grade was made 35cm in all the plots.

An arrangement was made to collect the runoff water from all the plots. For that a PVC pipe having diameter 10 cm was laid at the end of each plots. These pipes were directed towards a pit where the bucket of 12 litres was kept to collect the runoff water. The buckets were closed by a polythene sheet to prevent the entry of direct rain water into it.

Fig. 3. 2 Road construction using coir geotextile as the base material

3. 6 Road construction

Clear the area of any sharp objects, stumps and debris. The existing vegetation and root mat were removed by using a rotovator. A sub grade made of 30 cm thick subgrade soil was compacted by rolling. At the time of compaction, optimum water is added to each plot to obtain maximum bulk density. Level the plot and divide it into five equal plot size.

3. 6. 1 Plot 1-road construction using geotextile

The road was constructed using coir geotextile as the separating material between sub grade and sub base. For this 30 cm sub-grade layer is formed. Commercially available geotextile M_2V_4 having weight of 740g/ m^2 is used. Then the geotextile is unrolled by hand along the line of the road directly on the prepared area and it is properly clamped to the ground by using J- clamps. This geotextile layer is then wetted by sprinkling water. Over the sub grade layer a sub base layer was provided with soil and the whole plot was rolled twice. Necessary arrangements for the runoff collection were also made.

Fig. 3. 3 Road construction using coir geotextile as the base material

3. 6. 2 Plot 2-road construction using jute

In the second plot commercially available jute bags of size 1m × 1.2 m was laid as base layer. An overlapping of 15cm was provided for the jute bags in the length direction. To protect and maintain the overlap, J-clamps were used to hold the fabric in place. After the installation, jute bags were made wet by spraying water over it and a sub base of 4 cm was constructed over the jute layer. After laying the sub base the whole plot was rolled 2 times using the roller then the sides of the plot was covered with plastic sheet.

Fig. 3. 4 Road construction using jute as the base material

3. 6. 3 Plot 3-road construction using tyre shreds

Available used tyre is cut into tyre shreds of 10 cm × 2cm dimension and is used as base course in the third plot. Initially the sub grade was covered by jute bags, the jute bags being clamped to the subgrade using J-clamps and bamboo rails. 2 cm thickness tyre shreds spread over the jute bag. The tyre shreds were spread over jute manually. The total sub base thickness was made 35 cm and the plot was rolled 2 times.

Fig. 3. 5 Road construction using tyre shreds as the base material

3. 6. 4 Plot 4-road construction using crushed rocks

The plot 4 constructed using crushed rock as the separating layer. 40 mm coarse aggregates were laid uniformly over which a sub base of 3 cm was laid then the plot was rolled 2 times.

Fig. 3. 6 Road construction using coarse aggregate as the base material

3. 6. 5 Plot 5-Control plot

The fifth plot was taken as a controlled plot and the sub grade of 30 cm was constructed. Then the sub base was laid at a height of 5 cm.

All plots were made to the same level

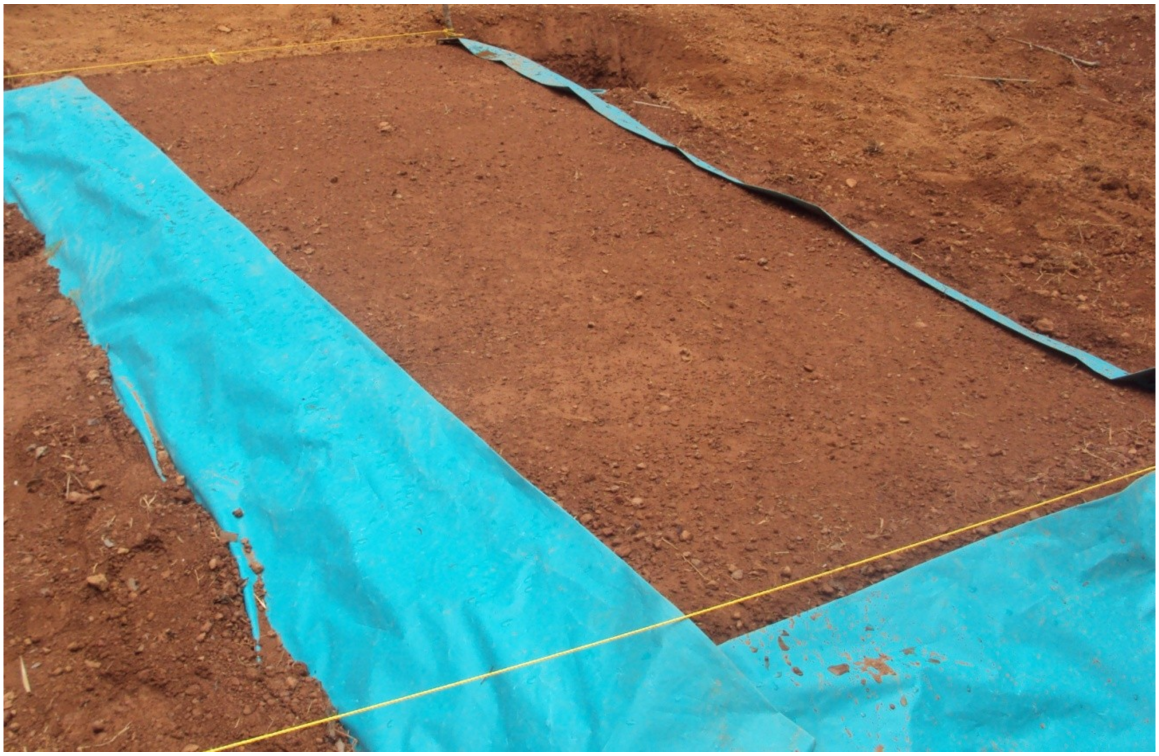

Fig. 3.7 Road construction without any treatment

Fig. 3. 8 Five plots of roads reinforced with different materials

3. 7 Load test

The load tests on the plots were performed by three methods.

1. Concentrated loading by a single wheeled trolley using different combinations of counter weights
2. Loading by Master weeder
3. Loading by tractor

3. 8 Performance evaluation

The data collected from all the plots were analyzed and their performance characteristics were evaluated using different graphs drawn with the test results.

3. 9 Slope stability

In the assessment of slopes, geotechnical engineers primarily use the factor of safety values to determine how close or far the slopes are from failure. Stability of slopes is particularly important for any hill road. Disturbance to slope can occur due to erosion caused by rain-fall and run-off and consequent slides. During monsoons the road network in hill roads experiences slips, erosions and major and minor landslides at many places. Hence, slope stability is therefore vital for control and prevention of landslides or slips.

In determining the stability of slope, first a potential failure surface is assumed and the shearing resistance mobilized along the surface is determined. This is the force that resists the movement of soil along the assumed failure surface and is known as resisting force. The forces acting on the segment of the soil bounded by the failure surface and the ground level are also determined and these forces attempt to move the soil segment along the failure surface. This is known as the activating force. Stability of the slope was found out theoretically using Swedish circle method.

In order to test the stability of the slope of a soil trial slip circle is drawn and the material above the assumed slip surface is divided into a convenient number of vertical strips or slices. The forces between the slices are neglected and each slice is assumed to act independently as a column of soil of unit thickness and of width *b*. The weight W of each slice is assumed to act at its centre. If this weight of each slice is resolved into normal (N) and tangential (T) components, the normal components will pass through the centre of rotation (O) and hence do not cause any driving moment on the slice. However the tangential component causes a driving moment $M_D = T \times r$, where r is the radius of the slip circle.

For the entire slip surface AB,

Driving moment, $M_D = r \sum T$

Resisting moment $M_R = r\,(c \sum \Delta L + \tan \varphi \sum N\,)$

Where;

$\sum T$ = algebraic sum of all tangential components

$\sum N$ = sum of all normal components

$\sum \Delta L = \hat{L} = \frac{2\pi r \delta}{360^\circ}$ = length AB of slip circle.

Hence factor of safety against sliding is $F = \frac{M_R}{M_D} = \frac{c\hat{L} + \tan \emptyset \sum N}{\sum T}$.

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

The performance of earth roads using coir geotextiles, jute, tyre shreds and coarse aggregate as reinforcing material between the base and sub-base is studied in this work and the results of the laboratory tests and the field tests are discussed in this chapter.

4. 1 Engineering properties of soil

4. 1. 1 Sieve analysis

The results of the mechanical sieve analysis is plotted to get a particle size distribution curve (Fig. 4.1) with the percentage finer as the ordinate and the particle diameter as the abscissa, which is plotted on a logarithmic scale. It can be observed from the particle size distribution curve that the soil contains mainly coarse grained particles in the range .1 to 2 mm and the soil is well graded. Textural classification of the soil shows that the soil is in the sand region with 95% of sand and 5% of silt.

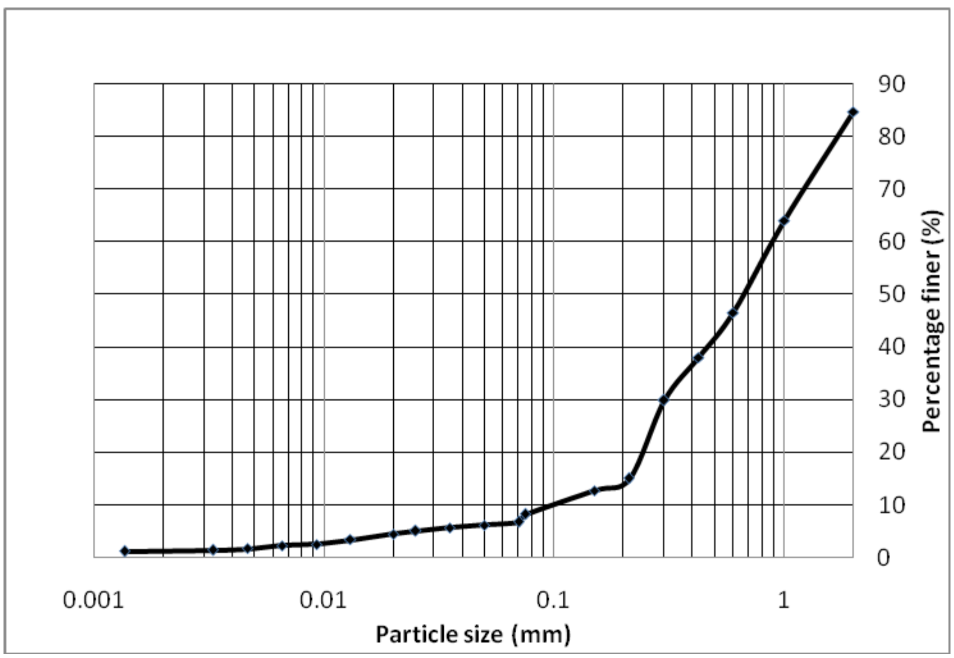

Fig. 4. 1 Particle size distribution curve of field soil

4. 1. 2 Modified Proctor test

The bulk and dry density of soil with various materials (coir geotextile, jute geotextile, tyre shreds and crushed stones) for the road section is found out by modified Proctor test and the dry density calculations tabulated in Tables. 4.1 to 4.5. A graph of dry density Vs water content is plotted in Fig. 4.2. A comparison of the plots show that the soil with geotextile has the lowest value of maximum dry density at an optimum moisture content of about 12%. Of the various materials used in the study, soil with coarse aggregate has the highest value of maximum dry density at the same optimum moisture content. Jute attains the maximum dry density at a higher value of optimum moisture content (15%), whereas for tyre and soil, the optimum moisture content is lesser (10%).

Table. 4. 1 Dry density calculations of modified Proctor test for geotextile reinforced road section

Particulars	Trial1	Trial 2	Trial 3
Mass of the mould (g)	2346.50	2346.50	2346.50
Mass of the mould+ compacted soil (g)	3853.0	3982.00	4000.00
Mass of the compacted soil (g)	1506.5	1635.50	1654.00
Bulk density (g/cm^3)	1.599	1.74	1.75
Water content (%)	7.15	12	17
Dry density (g/cm^3)	1.49	1.55	1.496

Table. 4. 2 Dry density calculation of modified Proctor test for jute reinforced road section

Particulars	Trial1	Trial 2	Trial 3
Mass of the mould (g)	2346.50	2346.50	2346.50
Mass of the mould+ compacted soil (g)	3925	4159.00	4167.00
Mass of the compacted soil (g)	1578.5	1812.50	1820.5
Bulk density (g/cm^3)	1.68	1.92	1.93
Water content (%)	7.7	15	20
Dry density (g/cm^3)	1.57	1.67	1.61

Table. 4. 3 Dry density calculation of modified Proctor test for tyre shreds reinforced road section

Particulars	Trial1	Trial 2	Trial 3
Mass of the mould (g)	2346.50	2346.50	2346.50
Mass of the mould+ compacted soil (g)	3872.5	4022.50	3956.50
Mass of the compacted soil (g)	1526.0	1676.00	1610.00
Bulk density (g/cm^3)	1.62	1.78	1.70
Water content (%)	5.14	10	16
Dry density (g/cm^3)	1.54	1.62	1.47

Table. 4. 4 Dry density calculation of modified Proctor test for road section with stone aggregate

Particulars	Trial1	Trial 2	Trial 3
Mass of the mould (g)	2346.50	2346.50	2346.50
Mass of the mould+ compacted soil (g)	4035	4152.00	4139.00
Mass of the compacted soil (g)	1688.5	1865.50	1712.50
Bulk density (g/cm^3)	1.79	1.98	1.90
Water content (%)	3.5	12	18
Dry density (g/cm^3)	1.73	1.77	1.61

Table. 4. 5 Dry density calculation of modified Proctor test for controlled section

Particulars	Trial1	Trial 2	Trial 3
Mass of the mould (g)	2346.50	2346.50	2346.50
Mass of the mould+ compacted soil (g)	3886.5	4046.5	3915.50
Mass of the compacted soil (g)	1540.0	1707.00	1569.00
Bulk density (g/cm^3)	1.63	1.80	1.67
Water content (%)	3.5	10	15
Dry density (g/cm^3)	1.57	1.63	1.45

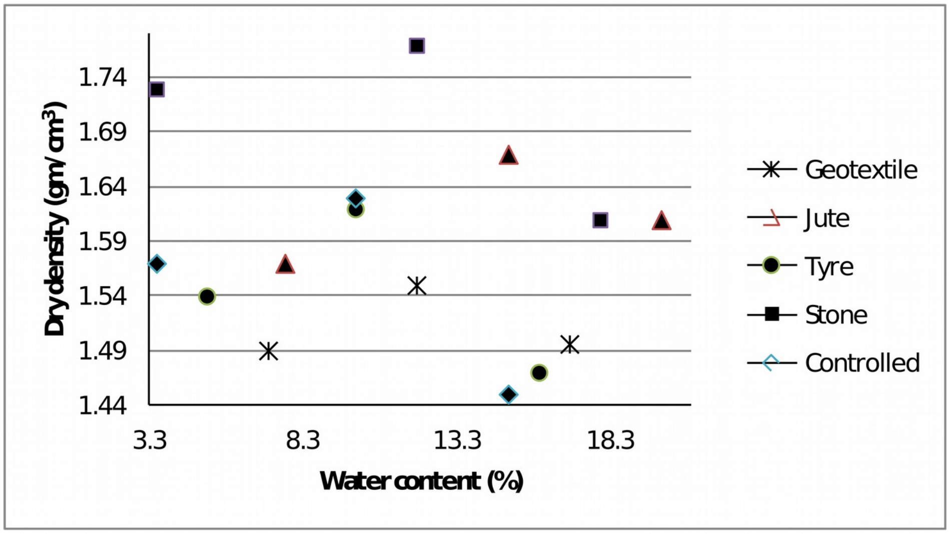

Fig. 4. 2. Water content versus dry density curve from Modified Proctor test

4. 1. 3 Direct shear test

The shearing stresses for various normal stress are determined using the direct shear test and the observations of the direct shear test is given in Tables 4.8 to 4.11. The angle of internal friction and cohesion for soil with the various low cost materials is obtained from the strength envelopes or *c*-φ diagrams(Fig. 4.3) A comparison of the curves show that road section with geotextiles and tyre shreds have high shear strength compared to that with jute and control section. The *c* and φ values obtained from the graph are used for the calculation of stability of slopes.

Table. 4. 6 Calculation of shear stress for the road section containing geotextile

Sl. No	Weight Added (kg)	Proving ring reading	Normal load (N)	Normal stress (N/cm^2)	Shear load (N)	Shear stress (N/cm^2)
1	1.10	111	5.5	0.153	24.087	0.669
2	2.52	164	12.6	0.350	35.588	0.988
3	3.94	185	19.7	0.547	39.928	1.110
4	4.10	202	20.5	0.569	43.834	1.230
5	5.20	220	26.0	0.722	47.740	1.330

Table. 4. 7 Calculation of shear stress for the road section containing jute

Sl. No	Weight Added (kg)	Proving ring reading	Normal load (N)	Normal stress (N/cm^2)	Shear load (N)	Shear stress (N/cm^2)
1	1.10	98.5	5.5	0.153	21.37	0.594
2	2.52	152	12.6	0.350	32.98	0.916
3	3.94	168	19.7	0.547	36.46	1.013
4	4.10	175	20.5	0.569	37.98	1.050
5	5.20	189	26.0	0.722	41.01	1.139

Table. 4. 8 Calculation of shear stress for the road section containing tyre shreds

Sl. No	Weight Added (kg)	Proving ring reading	Normal load (N)	Normal stress (N/cm^2)	Shear load (N)	Shear stress (N/cm^2)
1	1.10	122	5.5	0.153	26.47	0.735
2	2.52	165	12.6	0.350	35.81	0.990
3	3.94	190	19.7	0.547	41.23	1.145
4	4.10	204	20.5	0.569	44.27	1.230
5	5.20	223	26.0	0.722	48.39	1.340

Table. 4. 9 Calculation of shear stress for the road section containing soil

Sl. No	Weight Added (kg)	Proving ring reading	Normal load (N)	Normal stress (N/cm^2)	Shear load (N)	Shear stress (N/cm^2)
1	1.10	91	5.5	0.153	19.747	0.548
2	2.52	158	12.6	0.350	34.286	0.950
3	3.94	164	19.7	0.547	35.588	0.988
4	4.10	178	20.5	0.569	38.626	1.070
5	5.20	193	26.0	0.722	41.881	1.160

Table 4. 10 Comparison of Shear stress values for various materials under different normal stress conditions

Normal stress N/cm^2	Shear stress N/cm^2			
	Geotextile	Jute	Tyre	Soil
0.153	0.669	0.594	0.735	0.548
0.350	0.988	0.916	0.990	0.950
0.547	1.110	1.013	1.145	0.988
0.569	1.230	1.050	1.230	1.070

0.722	1.330	1.139	1.340	1.160

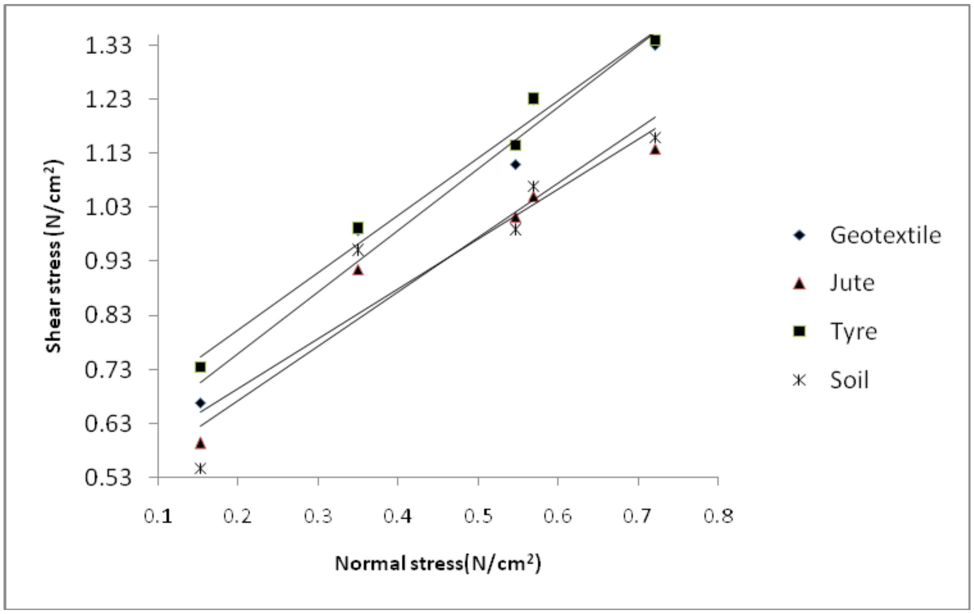

Fig. 4. 3 Normal stress versus shear stress graph of five different materials

Table. 4. 11 c-φ values for various materials

Parameters	Coir geotextile	Jute	Tyre shreds	Soil
Cohesion	0.46	0.42	0.41	0.39
Angle of internal friction	34	28	27	20

4. 3 Load test

4. 3. 1 Concentrated loading

Loading was applied on each plot by passing a single wheeled trolley as concentrated loads. By adding counter weights and combination of these weights, the load applied on the road was gradually increased. Similar loading was done in all the five plots. The corresponding settlements were noted and is tabulated in Table 4.6.

Table 4. 12 Settlement of road in different load condition

Sl. no	Load (kg)	Plot 1 (Geotextile) (cm)	Plot 2 (Jute) (cm)	Plot 3 (Tyre shreds) (cm)	Plot 4 (Crushed stones) (cm)	Plot 5 (Soil) (cm)
1	44.35	0.1	0.4	0.5	0.2	0.7
2	48.85	0.3	0.5	0.6	0.5	0.8
3	49.65	0.4	0.6	0.65	0.5	0.9
4	50.1	0.4	0.65	0.7	0.6	1.0
5	54.9	0.5	0.7	0.75	0.6	1.1
6	63.2	0.65	0.8	0.8	0.8	1.2
7	82.85	0.7	1.3	1.3	0.9	1.5
8	102.95	0.9	1.5	1.7	0.95	1.8
9	127.85	1.0	1.7	1.8	1.2	2.5
10	181.39	1.3	2.3	2.4	1.5	3.4

A load settlement graph was plotted for roads with different materials. A study of the graph shows that there is no characteristic performance variation under lower loads. The performance of geotextiles reinforced road was better compared to other sections for higher loads. The settlement of controlled road section is 165% more than that for geotextile reinforced road section. It may be due to the uniform distribution of load by the geotextile (base layer).

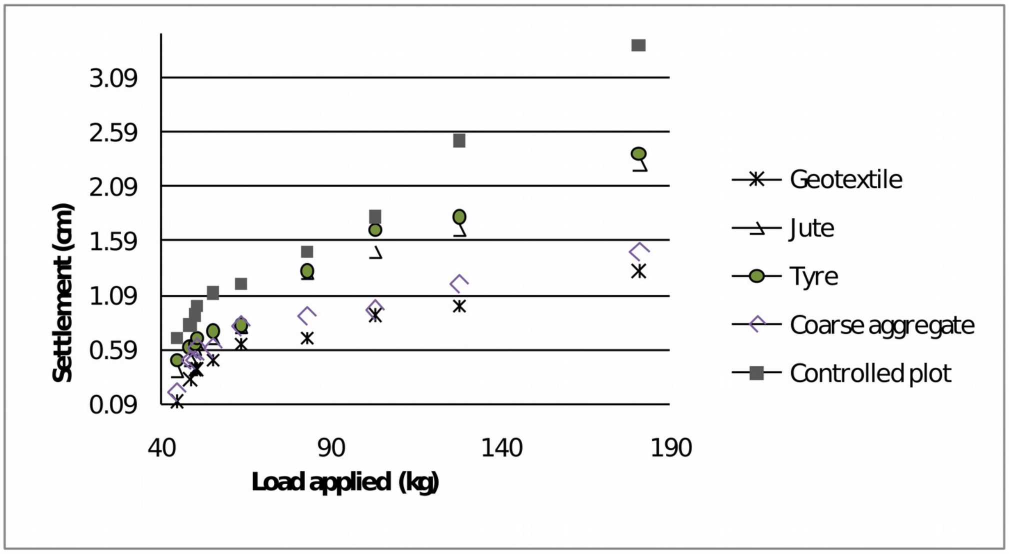

Fig. 4. 4 Settlement of road section on concentrated loading

4. 3. 2 Loading by master weeder

3PT 1000D Garuda master weeder weighing 300 kg was used for applying heavier load and the settlement was measured by following the same procedure as adopted for the concentrated loading. The master weeder was made to operate under low speed gear. The settlement of the road under load is given in Table 4.7 and in Fig. 4.4 for the different roads. The controlled road section is found to settle 47% more than the geotextile reinforced road.

Table 4. 13 Settlement of road section containing different material under moving load

Sl. No	Load (kg)	Plot 1 (Geotextile) (cm)	Plot 2 (Jute) (cm)	Plot 3 (Tyre shreds) (cm)	Plot 4 (Crushed stones) (cm)	Plot 5 (Control) (cm)
1	300	1.7	2.2	2.5	2	2.5

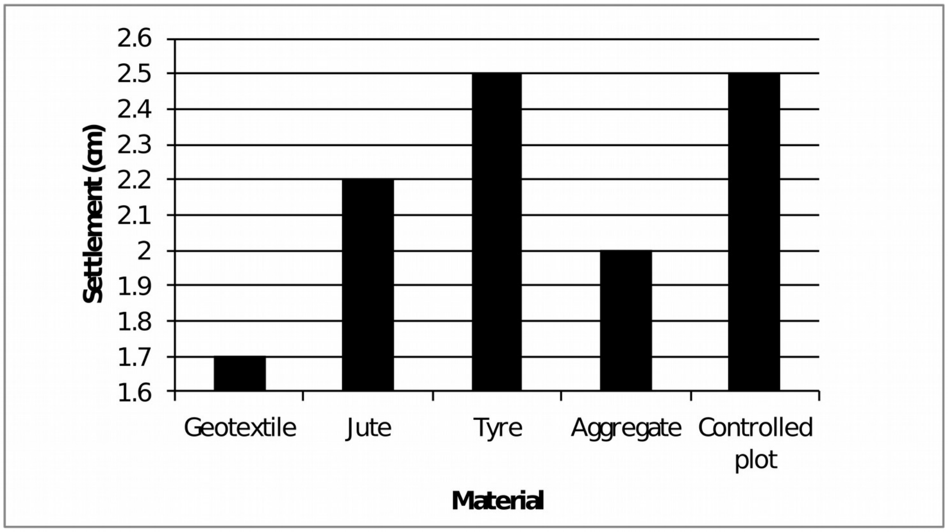

Fig. 4. 5 Settlement of road section under loading by Master weeder

4. 3. 3 Tractor loading

The road was tested for tractor loading using John Deere 5310 weighing two tons and the controlled road with no reinforcement only showed visible depression meaning all other roads are safe for carrying heavy loads. A photo of the depression made by the tractor is also given. For a complete study of road performance, a long term study extending for at least two seasons for the possibility of rut formation, is to be conducted.

Fig. 4. 6 Settlement of road section by tractor loading

4. 4 Stability of slopes

Slope stability is analyzed theoretically by putting the values of cohesion and angle of internal friction in the Swedish slip circle method. It shows that the factor of safety is highest for coir geotextile. This is because of the higher value of angle of internal friction and comparatively higher value of cohesion. Factor of safety directly related with the stability of slope. The factor of safety with different side slopes were given in the Table 4. 14

Table. 4. 14 Factor of safety of road section having different side slope

Side slope	Factor of safety			
	Coir geotextile	Jute	Tyre shreds	Soil
0.58:1	0.902	0.71	0.683	0.492
1:1	1.11	0.874	0.84	0.6
1.5:1	2.016	1.594	1.528	1.099

SUMMARY AND CONCLUSION

Chapter 5

SUMMARY AND CONCLUSION

Natural fibre geotextiles like jute and coir have recently gained increasing popularity in the field of geotechnical engineering all over the world, due to growing environmental concern. Coir fibres are stronger and more durable compared to other natural fibres. Hence coir geotextile is recognized as an ideal material that is capable of offering an ecologically sustainable solution to many of the environment related issues. These products are found to be more feasible for temporary reinforcement where they are meant to serve only in the initial stage and final strength is attained by soil consolidation.

Feasibility study of various low cost materials like coir geotextiles, jute, tyre shreds and coarse aggregate is studied in this work. For that first the various engineering properties of the soil at the site of road construction were studied. The results of the study were plotted as particle size distribution curve, water content versus dry density curves and shear strength envelopes. Road was constructed and a performance evaluation of different low cost materials (Geotextile, Jute, Tyre shreds, Coarse aggregates) was conducted by constructing road with these materials and the testing it for various types of loads.

It is found that the settlement is lowest for geotextile reinforced road. A study of the rut formation is necessary for complete testing of the road. For an effective evaluation of road performance a long term study extending at least for two years is necessary.

The roads may be constructed with natural or artificial slopes and a study of the stability of the slopes is also important for the construction of roads. So a theoretical analysis of the stability of the slopes was also done and the factor of safety for various materials and various slopes were calculated. The result of the study is that geotextile is the safest of materials studied for stabilizing the slope.

REFERENCE

Abdullah, B. M. (2008). Jute geotextiles and their applications. *Journal of Geotechnical and Geoenvironmental Engineering. ASCE*. 129 (2):125–136.

Benedictas, S. J., Temel, Y., Muge I. and Orhan, E. I. (2008). A study on bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay. *Geotextiles and Geomembranes* 23: 174- 183.

Bhattacharyya, S. K., Basu, G., Roy, A. N. and Ghosh, S. K. (2007). Construction of unpaved rural road using jute- synthetic blended woven geotextile - A case study. *Geotextiles and Geomembranes* 27 : 506–512.

Bindumadhava, H. D., Ranjan, G., Vasan, R. M. and Charan, H. D.(1998). Probabilistic analysis of randomly distributed fiber reinforced soil. *Journal of Geotechnical Engineering, ASCE*. 122 (6): 419–426.

Bosscher, M., Edil, W., and Dresher, A. (1993). Development of Engineering Criteria for Shredded or Whole Tyres In Highway Applications-Brieff summary of Activities and Findings. *University of Wisconsin*. 3(7): 587- 595.

Brown, H., Arry,C. S. and Worth, S. (1984). Shear Stress-Strain Properties of Soft Clay. *Elsevier Scientific Publishing Company*. 311-362.

Choudhury, P. K. (2006). Performance evaluation of jute geotextile. *J. agric. Engng Res*. 78 (1): 99- 107.

Christopher, G. K., Giroud J P; Noiray L (1985). Design of geotextile reinforced unpaved roads. *Journal of Geotechnical Engineering*. 107: 1233- 1254.

Eiksund, K., Rudolf, H., Rudolf, R., Robert, B., and Pierre, M. (1998). Full-scale field tests on geosynthetic reinforced unpaved roads on soft sub grade. *Geotextiles and Geomembranes* 24 : 21-37.

Foose, A. F., Geisler, E., Cody, W., and Niemi, M. K.(1996). Tires for Subgrade Support. *The Manhole Messenqer*. 1(2): 27-36.

Giroud, J., Wager, V. (1971). Investigation of factors influencing behavior of single geocell-reinforced bases under static loading. *Geotextiles and Geomembranes* 28 : 570- 578.

Jake, H. N., Donald, E. H., and Leonard, J. S. (2008). Design concerns and performance of geomembrane anchor trenches. *Geotextiles and Geomembranes* 15 : 403- 417.

Jurg, M. B., Dimaggio, J. A. and Cribbs, M. M. (2009). The Role of Geosynthetics on USA Highways. *Geotextiles and Geomembranes* 14 **:** 243-251.

Khalid, C., Dov, L. and Ralph, H. B. (2004). Geosynthetic reinforced soil structures. *J. of Geotechnical Engineering.* 115: 10.

Koerner, P. J., Leroueil, E. G. and Rowe, K. (1994). Embankments over Soft Soil and Peat. *Geotechnical and Geoenvironmental Engineering Hand Book*. 463-499.

Lawson, M. D., Michalowski, R. L.and Zhao, A. (1996). Failure of fiber-reinforced granular soils. *Journal of Geotechnical Engineering, ASCE* . 122 (3): 226–234.

Lee, A. S., Changho, L., Hung, Q. T., Woojin, L. and Jong, S. L. (2010). Characteristics of Rubber-Sand Particle Mixtures according to Size Ratio. *J. of Materials in Civil Engineering*. 22: 4.

Maccai, M., Maher, M. H.and Gray, D. H.(2004). Static response of sands reinforced with randomly distributed fibers. *Journal of Geotechnical Engineering, ASCE* .116 : (11). 1661–1677.

Madhavi, V., Pawan, N. G. and Chandrashekar, B. P. (2005). A critical review of innovative rural road construction techniques and their impacts. *India Highways, Indian Roads Congress*. 33(5) : 87- 98.

Michael, N. J., and Eugene, H. K. (1992). Performance evaluation of silty sand reinforced with fibres. *Geotextiles and Geomembranes* 28: 93- 99.

Naemura, R. P., John, L. G., George, R. K. and Frank, S. B. (1996). Geotextile reinforcement of soft landfill process sludge to facilitate final closure: An Instrumented Case Study. *Geotextiles and Geomembranes* 14 : 377- 391.

Nilay, T., Tuncer, B. and Craig, H. B. (1997). Interaction between reinforcing geosynthetics and soil-tire mixtures. *J. of Geotechnical and Geoenvironmental Engineerin.*124: 11.

Ogbobe, D. A., Fowler, J. and Edris, E. V. (1988). Fabric reinforced embankment test section. *Geotextiles and Geomembranes.* 6:1- 31.

Paul, G., Yetimoglu,T., Muge, I. and Orhan, E. I. (2009). A study on bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay. *Geotextiles and Geomembranes* 23 : 174- 183.

Rao, E. T., Ramaswamy, S. D. and Aziz, M. A. (1998). Properties of jute geotextiles for civil engineering applications. *Textile Trends*. 29- 40.

Rotar, J. W., Benjamim, C. V., Bueno, B. S., Lodi, P. C. and Zornberg, J. G. (1996). Installation and ultraviolet exposure damage of geotextiles. *Euro Geo 4 : 226.*

Schurholz, O., Peila, D., Oggeri, C. and Castiglia, C. (2000). Ground reinforced embankments for rockfall protection: design and evaluation of full scale tests. *Landslides* . 4:255- 265.

Sinha, B. N. (2008). Advance methods of slope-stability analysis for earth embankment with seismic and water forces. *IRC Journal* 68(3) : 201- 222.

Smets, D. L., Josle, L. B., and Antonio, S. C., (2007). Overall stability of geosynthetic-reinforced embankments on soft soils. *Geotextiles and Geomembranes* 20 : 395- 421.

Sutherland, W. F. and Ziegler, S. T. (1996). Subgrade Stabilisation with Geotextiles. *Geosynthetics International*. 2 (4) : 741- 763.

Tapobrata, S. (2006). Novel use of jute bags for rural roads in developing countries. *J. of Materials in Civil Engineering*. 22: 4.

Tatlisoz, W. D., Loney, B. and Rudd, J.C. (1997). The use of shredded tires as a lightweight subgrade on 9- ton road. *Braun Intertec*. 4(3): 42- 51.

William, N. C., Charbel, N. K., Gerald, A. M., and Kianoosh, H. (2007). Unsaturated soilegeotextile interface behavior. *Geotextiles and Geomembranes* 29 : 17- 28.

Ziegler, K. E., Hoe, I. L. and Fumio, T. (1994). Performance of anisotropic geosynthetic reinforced cohesive soil mass. *J. of Geotechnical Engineering*. 120: 7.

FEASIBILITY STUDIES ON APPLICABILITY OF LOW COST MATERIALS FOR FARM ROAD CONSTRUCTION AND SLOPE PROTECTION

By

DHANYA, V.
FAROOQ, A. NIZAR.
ROHINI, R. P.
ULLAS, P. K.

PROJECT REPORT

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Kerala Agricultural University

Department of Irrigation and drainage engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM

KERALA, INDIA

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ABSTRACT

Geotextile play a significant part in modern pavement design and maintenance techniques. The growth in their use worldwide for road construction application in particular has been nothing short of phenomenon. Geotextile enhance the performance and extend the service life of unpaved roads. The study consists of comparing the performance and stability of road sections constructed with different materials like, coir geotextile, jute, tyre shreds, coarse aggregates. In field tests, geotextile performed the best of these materials. This is due to the uniform distribution of applied load throughout the geotextile material. The various engineering properties of the soil at the site, with and without the low cost materials, like the grain size distribution, dry density, permeability and shear strength were also studied. From the analysis of stability of slopes, it was found that geotextile is effective in stabilizing the slopes of even 1:1, while the other materials fail to perform well.