सूक्ष्म,लघु और मध्यम उद्यम मंत्रालय, भारत सरकार
MINISTRY OF MICRO, SMALL & MEDIUM ENTERPRISES
GOVERNMENT OF INDIA

कयर बोर्ड
COIR BOARD

India International Coir Fair
IICF
2016

Coir Bhoovastra

Eco friendly, Bio degradable Material for Soil Conservation and Rural Roads

SAVE NATURE..USE COIR

Published on the occasion of the
India International Coir Fair 2016,
Coimbatore

COIR BOARD

सूक्ष्म,लघु और मध्यम उद्यम मंत्रालय, भारत सरकार
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India International Coir Fair

IICF

2016

JULY 15-18

CODISSIA TRADE FAIR COMPLEX

COIMBATORE

Coir Bhoovasthra - an Eco friendly, Bio degradable Material for Soil Conservation and Rural Road

Save Nature
Use Coir

Ministry of Micro, Small and Medium Enterprises,
Government of India

MSME

MICRO, SMALL & MEDIUM ENTERPRISES

कॉयर बोर्ड, भारत सरकार

COIR BOARD, GOVERNMENT OF INDIA

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KALRAJ MISHRA

सूक्ष्म, लघु और मध्यम उद्यम मंत्री
भारत सरकार
नई दिल्ली - 110011

Minister
of
Micro, Small & Medium Enterprises
Government of India
New Delhi-110011

MESSAGE

I am happy to learn that the Coir Board, under the Ministry of MSME is organizing the 4th Edition of the **India International Coir Fair (IICF)** at CODISSIA Trade Fair Complex, Coimbatore from 15-18th July, 2016. Coir Board, during its existence spanning over six decades, has been extending dedicated services for the development of coir industry in our country. I am sure that the IICF 2016 would turn out to be an excellent opportunity to consolidate the gains so far and to equip the industry to face the challenges ahead. I hope that the compilations on coir products like Coir geotextile, coir pith, coir wood and coir floor furnishing material proposed to be released in this event would emerge as treasure of knowledge to information seekers on the industry and as a reference for posterity.

I wish IICF 2016 a grand success.

(KALRAJ MISHRA)

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एम. वेंकैया नायडु
M. VENKAIAH NAIDU

शहरी विकास,
आवास और शहरी गरीबी उपशमन एवं
संसदीय कार्य मंत्री
भारत सरकार
MINISTER OF URBAN DEVELOPMENT,
HOUSING & URBAN POVERTY ALLEVIATION
AND PARLIAMENTARY AFFAIRS
GOVERNMENT OF INDIA

28th June, 2016

MESSAGE

I am very happy to take note that the Coir Board, under the Ministry of Micro, Small and Medium Enterprises, is organizing the 4th edition of the India International Coir Fair (IICF) at CODISSIA Trade Fair Complex, Coimbatore from 15th to 18th July, 2016.

Coir industry in India holds its richest tradition and provides livelihood to lakhs of rural people across coconut producing regions. The industry produces wealth from waste and earns valuable foreign exchange to the exchequer. While lauding the Coir Board for its earnest commitment to promote coir industry, I convey my sincere appreciation to all those who are behind this endeavor.

I trust that the compilation on Coir Geotextiles, Coir pith, Coir Wood and Coir floor furnishing proposed to be released during this event would give complete information on application of these bio-degradable products.

I wish the IICF 2016 a grand success.

(M VENKAIAH NAIDU)

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नितिन गडकरी
NITIN GADKARI

सत्यमेव जयते

मंत्री
सड़क परिवहन, राजमार्ग
एवं पोत परिवहन
भारत सरकार
MINISTER OF ROAD TRANSPORT,
HIGHWAYS AND SHIPPING
GOVERNMENT OF INDIA

MESSAGE

It gives me a great pleasure that the Coir Board, under the Ministry of MSME is organising the fourth edition of the India International Coir Fair at CODISSIA Trade Fair Complex, Coimbatore from 15th to 18th July, 2016.

Coir products, by virtue of its eco-friendly and bio-degradable qualities, have tremendous possibilities for applications to preserve environment and arrest global warming. The organization of these type of activities would lead to all round and sustainable growth of the sector.

I earnestly believe that the publications on Coir Geotextiles, Coir Pith, Coir Wood and coir floor furnishings, to be released coinciding with the event, would help for a detailed understanding on the product and its application.

I wish the IICF 2016 all success.

(Nitin Gadkari)

Date: 4th July, 2016
Place: New Delhi

Transport Bhawan, 1 Sansad Marg, New Delhi-110 001, Tel. : 23711252, 23710121 (O), 23719023 (F)
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सुरेश प्रभु
SURESH PRABHU

सत्यमेव जयते

रेल मंत्री
भारत सरकार, नई दिल्ली
MINISTER OF RAILWAYS
GOVERNMENT OF INDIA
NEW DELHI

30 JUN 2016

MESSAGE

I am happy to learn that the Coir Board is organizing the fourth edition of the India International Coir Fair at Coimbatore from 15th to 18th July, 2016.

As evident from the growing affinity world over and the steady increase in exports, Coir products have proven to be ideal for preserving the mother earth. I believe that the outcome from the event and the publications on various Coir products would be of immense prospects for the future.

I wish the event all success.

(Suresh Prabhu)

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राधा मोहन सिंह
RADHA MOHAN SINGH

सत्यमेव जयते

कृषि एवं किसान कल्याण मंत्री
भारत सरकार
MINISTER OF AGRICULTURE
& FARMERS WELFARE
GOVERNMENT OF INDIA

D.O. No. 1151 /AM.

New Delhi
Dated: 30-6-2016

MESSAGE

I am extremely happy to note that the Coir Board, under the Ministry MSME is organizing the fourth edition of the India International Coir Fair at Coimbatore from 15th to 18th July 2016.

Being an agro based industry, the coir products have got a worldwide acceptance by virtue of its eco-friendly and bio-degradable qualities. Coir products, as I understand, have tremendous possibilities in soil conservation and agri-horti applications. I trust that organization of international events like the instant one are in the right direction to take the coir industry further forward. I have no doubt that the publications on Coir Geotextiles, Coir Pith, Coir Wood and Coir Floor Coverings, proposed to be brought out by Coir Board, would help much for a detailed understanding on the products and their applications.

WISHING THE VERY BEST FOR IICF 2016.

Radha Mohan Singh

RADHA MOHAN SINGH

Office : Room No. 120, Krishi Bhawan, New Delhi-110 001 Tel.: 23383370, 23782691 Fax : 23384129

गिरिराज सिंह
GIRIRAJ SINGH

D.O. No. 09 / MOS (MSME)/2016

राज्य मंत्री
सूक्ष्म, लघु और मध्यम उद्यम
भारत सरकार
नई दिल्ली - 110011
MINISTER OF STATE
FOR
MICRO, SMALL & MEDIUM ENTERPRISES
GOVERNMENT OF INDIA
NEW DELHI-110011

MESSAGE

I am very much delighted to note that the Coir Board under the Ministry of MSME is organizing yet another edition of the India International Coir Fair 2016 at CODISSIA Trade Fair Complex, Coimbatore from 15th to 18th July, 2016. Coir Board has been instrumental in developing and proliferating this industry in different parts of the country. I firmly believe that the fourth edition of this event is going to add another feather to the glittering cap of Coir Board.

I firmly believe that the events would bring in more tangible results to the industry for the longer run and the publication on Coir Geotextiles, Coir, pith, Coir wood and Coir floor furnishing proposed to be released in this context will be of much use to the trade.

WITH BEST WISHES FOR IICF 2016.

(GIRIRAJ SINGH)

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HARIBHAI P. CHAUDHARY
MINISTER OF STATE
GOVERNMENT OF INDIA

भारत सरकार
सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय
उद्योग भवन, नई दिल्ली - 110011
GOVERNMENT OF INDIA
MINISTRY OF
MICRO, SMALL AND MEDIUM ENTERPRISES
UDYOG BHAWAN, NEW DELHI - 110011

MESSAGE

I am extremely happy to note that the Coir Board, under Ministry of MSME, Government of India is all set to organize the India International Coir Fair 2016 at Codissia Trade Fair Complex, Coimbatore from 15th to 18th July, 2016. I understand that the current edition of IICF is the fourth of its kind and organized in one of the major coir producing Statesin our Country.

Coir products, as known to everybody, has got a tremendous product range which can even address the current day issues on global warming etc. The efforts of Coir Board to release the compilation on products like Coir Geotextiles, Coir Pith, Coir Wood and Coir Floor Coverings during this event are definitely laudable.

I wish IICF 2016 the very best and congratulate all the stakeholders of Coir Industry for venturing into this important event.

New Delhi

Dated: 08.07.2016

Haribhai Chaudhary

(Haribhai P. Chaudhary)

कृष्ण कुमार जालान
सचिव
K. K. Jalan
Secretary

भारत सरकार
सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय
उद्योग भवन, रफी मार्ग, नई दिल्ली-110 011
GOVERNMENT OF INDIA
MINISTRY OF MICRO, SMALL AND MEDIUM ENTERPRISES
UDYOG BHAWAN, RAFI MARG, NEW DELHI-110 011

MESSAGE

It is indeed a pleasure to note that the Coir Board under the Ministry of Micro, Small and Medium Enterprises, Government of India, is organising yet another edition of the India International Coir Fair at CODISSIA Trade Fair Complex, Coimbatore, Tamil Nadu.

Coir Industry, as I understand, has tremendous prospects to grow and develop in our country. I am confident that organisation of these type of event, followed by actual field level interventions would bring in incremental benefits to all the stake holders and sustainability to the coir sector for the longer run. I trust that compilations on products like Coir Geotextiles, Coir Pith, Coir Wood and Coir Floor Furnishings, proposed to be brought out during this event, would help to a greater deal in better understanding of the products and its varied end uses.

I wish IICF 2016 all success.

(K. K. Jalan)

New Delhi,
11th July 2016.

169, UDYOG BHAWAN, NEW DELHI-110 011, Tel. : +91-11-23062107 Fax : 2306 3045, E-mail: secretary-msme@nic.in; www.msme.gov.in

FOREWORD

Coir industry has made rapid strides during the last two decades through product innovation and development. Coir Board has made innumerable field demonstrations and case studies in collaboration with different research institutes / Govt. departments in the application of Coir Geo Textiles in geotechnical fields like soil erosion control on embankment of roads, ponds and hill slopes through revegetation. Coir Bhoovastra or Coir Geo Textiles is an eco-friendly, biodegradable and renewable material. Coir Board has been able to formulate four specifications for Coir Geo Textiles and got published by the Bureau of Indian Standards. Concrete efforts from all quarters for inclusion of Coir Bhoovastra in the manual of State PWDs, NHAIs etc. may lead to its popularization and extensive usage for application in village roads, highway slopes etc.

Coir Bhoovastra is a product which is capable of bringing about a revolutionary change in the raw material utilization and consumption of coir in our country and abroad. I fervently believe that under the dynamic leadership of the Central Minister for Surface Transport ably supported by the Minister for MSME and Minister of State for MSME, the Board would be able to get these products included in the schedule of rates of various user organizations in the Government.

This publication containing different products, different qualities and methods of installation of Coir Bhoovastra is intended to benefit the consultants, entrepreneurs and actual end users working on Coir Geo Textiles. I take this opportunity to congratulate all those who have made contributions for making this publication a reality which will pave the way for utilization of the resources of coir industry in a more effective and economic manner.

C.P. Radhakrishnan, Ex. M.P.
Chairman, Coir Board

DIRECTOR'S MESSAGE

The India International Coir Fair 2016 has been organized by Coir Board to demonstrate and disseminate to public the findings of research on coir conducted at Central Coir research Institute (CCRI) and Central Institute of Coir Technology (CICT) and through In –house / collaborative projects with reputed organizations in India. The theme for the IICF-2016 envisages sustainable development of the grass root workers in the Coir Industry and expands to overseas niche markets for coir/coir products through futuristic technologies. We are currently facing dramatic economic and market changes surrounding our business enterprises. In these circumstances, R&D becomes increasingly important in order to overcome this unprecedented transition stage and to succeed in expanding globally. The ability to predict market needs, select and focus on research themes, keep relevant divisions working together as a team, and operate with flexibility and speed is important.

Recently, much emphasis has been given worldwide to the use of eco-friendly fabrics to control soil erosion. Coir fibre has properties like durability, strength and is biodegradable and therefore has an edge over synthetic materials used as geotextiles. Through this book, an effort has been made to provide information about the advantage of using coir geotextiles for environmental applications such as reinforcement of unpaved rural roads and erosion control. Grateful acknowledgements are due to Shri. C.P. Radhakrishnan, Chairman, Coir Board for his continued guidance and valuable support. I hope the information being delivered through this book will be helpful to entrepreneurs, researchers and for all in the coir industry.

Dr. Das Anita Ravindranath
Director, RDTE, CCRI

PREFACE

K.A.Baby

P.K.Ravi

Coir Board in association with the Central Road Research Institute, New Delhi conducted the first case study for arresting erosion of hill slide slopes of Hindustan- Tibet National Highway near Simla in 1972 by using 1/2 inch Coir Bhoovastra for an area of 278.7m^2. Since then the Coir Board has taken up more than 100 field demonstration using different types of Coir Bhoovastra in association with the research institutions and Govt. departments in arresting the soil erosion, stabilisation of rain harvesting ponds and reinforcement of unpaved roads as part of popularisation of the application of Coir Bhoovastra in geotechnical fields.

The Coir Board organized the first "Workshop on Coir Geo grids/ Geo fabrics in Civil Engineering Practice" on 21st September 1988 at Coimbatore with the active participation of Contractors and Engineers from Govt. departments as an effort to make awareness of the potential of coir geo textiles in geotechnical fields. Coir Board continued its effort in this direction by organizing seminars on geo textiles in association with the International Geo textiles Society (India) and Coir Trade Association at various places of India such as New Delhi, Alappuzha, Bangalore, Dehradun, Shilliong, Kohima, etc. These activities have indeed promoted the application of coir geo textiles and a few voluntarily came forward to participate in association with the Coir Board in arranging demonstrations.

Coir Board has established a ASTM laboratory for testing the quality of coir geo textiles which is listed in the ASTM International Directory of Testing Laboratories .It is extending the facilities of testing the quality of coir geo textiles to the users such as break load by wide width method, AOS, thickness, mass per unit area, permeability, and modified direct shear, CBR and puncture resistance.

Coir Board is actively propagating the different uses of Coir Bhoovastra and extending consultancy in laying of Coir Bhoovastra for the geotechnical applications. Recently several road projects in association with College of Engineering, Thiruvanathapuram, NIT,

Trichy, NIT, Calicut, MANIT, Bhopal, CUSAT,Kochi etc were undertaken by Coir Board for achieving Indian Roads Congress accreditation permanently for application of coir geo textiles as a new material/ technique for road construction against the advice of National Rural Roads Development Agency (NRRDA), Govt of India to make use of coir geo textiles in the construction of 50 km rural roads in 9 states in the country.

The NIT'S in various states are State Level Technical Agencies who got the mandate of carrying out research and post construction monitoring of the roads to be constructed under Pradhan Mantri Grama Sadak Yojana (PMGSY) of Bharat Nirman Scheme of Govt of India. With a view to popularize the use of innovative techniques by the use of coir geo textiles for strengthening soft soil sub grade of low volume roads through demonstrations projects, the NIT'S carried out a systematic lab and field level studies to establish the application of coir geo textiles on particular type of soils available in the respective states, field applications of coir geo textiles in the soil and over those construction of rural roads by selecting the particular variety of coir geo textiles most suitable for the soil thus generating concrete research data which will be ultimately incorporated in the PWD manuals by the respective states for the use of coir geo textiles in construction of roads.

The assistance of Dr. Mariamma Joseph and Dr. Sheela Evangeline Y of College of Engineering, Thiruvanathapuram, Dr.Samson Mathew of NIT, Trichy, Dr.M.V.L.R. Anjaneyulu of NIT, Calicut,Dr.P.K.Agarwal of MANIT,Bhopal and Dr.KS.Beena of CUSAT,Kochi is worthy to note for their active participation in making the road projects a success one. This publication on Coir Bhoovastra would definitely benefit the producers and end users in selecting the right type of Coir Bhoovastra for a particular application

On this occasion, we would like to express our sincere gratitude and thanks to Shri.P.R.Ajithkumar, Director (Mkg) and Shri. M. Kumara Raja, Secretary, Coir Board for their keen interest and motivation behind this publication for popularization of the technology from the laboratory to field. The overall guidance of T.A.Rajendra Babu, Joint Director (Res) and Dr.Anita Das Raveendranath, Director RDTE are gratefully acknowledged.

Last but not the least we acknowledge the co-operation received from all and the painstaking secretarial assistance in compiling this publication by providing data and photographs of each demonstration.

CONTENTS

Coir Bhoovasthra, an Eco friendly and Biodegradable Material for Soil Conservation and Rural Roads

1. Introduction

India has one of the largest road networks in the world, aggregating to about 33 lakh km at present. However many of the existing roads are becoming structurally inadequate because of the rapid growth in traffic volume and axle loading. At locations with adequate sub grade bearing capacity/CBR value, a layer of suitable granular material can improve the bearing capacity to carry the expected traffic load. But at sites with CBR less than 2%, problems of shear failure and excessive rutting are often encountered. The ground improvement alternatives such as excavation and replacement of unsuitable material, deep compaction, chemical stabilization, pre loading and polymeric geo synthetics etc are often used at such sites. The cost of these processes as well as virgin material involved is usually high and as such they are yet to be commonly used in developing nations like India. In this context natural fiber products hold promise for rural road construction over soft clay.

Geo textiles are proving to be cost effective alternative to traditional road construction method. Studies have indicated that the biodegradability of coir can be used to advantage and the coir based geo textiles have the potential of being used for rural road construction over soft clay. In paved and unpaved road construction, geo synthetics reinforcement has been applied to improve their overall strength and service life. The stabilization of pavements on soft ground with geo textiles is primarily attributed to the basic functions of separation of base course layer from sub grade soil, reinforcement of composite system etc. But these synthetic products are non biodegradable and cause environment problems, whereas natural geo textiles like coir is biodegradable.

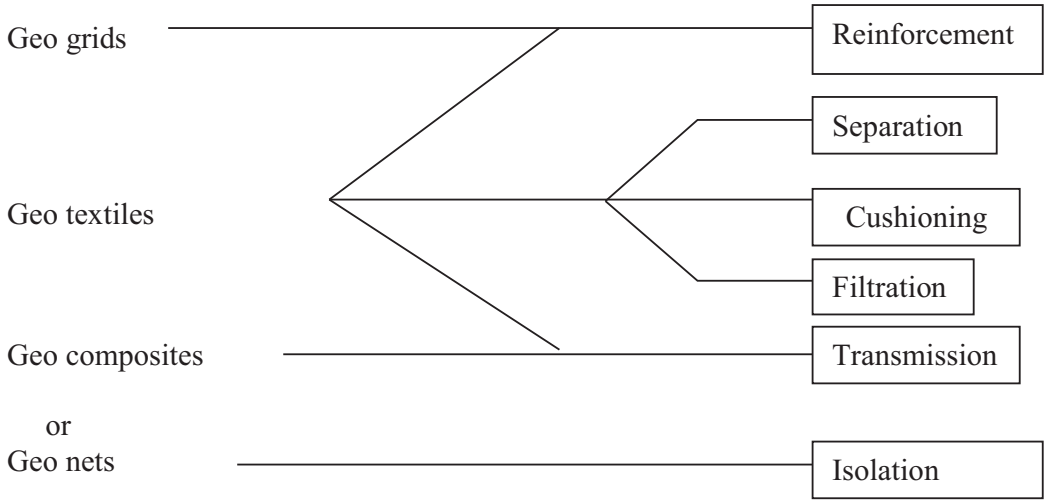
2. Geo synthetics

Geo synthetics are synthesized polymeric or natural materials used to solve engineering problem. The problem of rural roads on soft soil can be solved to some extent using geo synthetics. Polymeric materials are polypropylene, polyethylene, nylon, polyester etc. Natural geo synthetics are produced from natural materials like coir, jute, sisal etc.

A geo synthetic is affected by its surroundings or environment. Environmental factors that contribute to the degradation of geo synthetics include UV radiation (sunlight), mechanical/ physical wear, long duration loads and temperature. For instance, a polypropylene textile or grid will creep when exposed to tensile loads. Creep is also enhanced by an increase in

temperature and additionally, UV radiation in sunlight can cause serious degradation and weakening of polymer bonds.

Geo textiles, Geo grids, Geo membranes and Geo composites (Geo nets) belong to the family of geo synthetics.



Geo synthetic highway applications can be split into two areas, which are unpaved and paved roads .In paved and unpaved road construction, geo synthetic reinforcement has been applied to improve their overall strength and service life. The stabilization of pavements on soft ground with geo textiles or geo grid is primarily attributed to basic functions of separation of base course layer from sub grade soil, reinforcement of composite system etc.

3. Geo textiles

The geo textiles derive its name from two words “geo” and “textiles” and therefore it means the fabric in use in relation with “earth”. The term geo textiles or geo fabric represent woven / non woven, knitted / composite / blanket cells of natural or synthetic origin, used as a permeable textile fabrics in geo technical engineering to prevent the soil from migrating while maintaining the water flow (soil erosion). Geo textiles come in thickness ranging from 0.2 mm to 10 mm in roll lengths up to 100 metre and width up to 10 metres with permeability comparably ranged from coarse gravel to fine sand.

The geo textiles role is to protect and promote vegetarian cover during its formative period after which it degrades over a period of time and mixes with the soil providing for valuable nutrients.

4. Soil Erosion

It is the gradual removal of the topsoil of earth's crust over an extended period of time. This leads to

1. Depletion of nutrients from the topsoil.
2. Reduction in productivity.
3. Disturbance in the wild life habitat.
4. Topographical alteration in the landmass.
5. Exorbitant costs of repairing erosion damaged sites.

Erosion consists of the loosening and transportation of soil particles, a heavy thunder storm will throw into the air up to 250 tons per hectare of top soil and the flowing water which can no longer be absorbed by the soil causes rills and gullies. Deforestation, mining and construction, vegetation disturbance etc. creates conditions for accelerated erosion. Rainfall, agricultural and forestry disturbance cause India to lose 6000 million tones of precious top soil annually.

5. History of Application of Geo textiles

The first use of a synthetic fabric as geo textiles was in the late 1950's when a permeable woven fabric made of a synthetic fabric was placed beneath concrete pavements for erosion control in Florida. Woven geo textiles found wide uses throughout the US during the 1960's in erosion control applications. In Europe, geo textiles materials were used in the Netherlands around 1960 in combination

with reed mat fascines for erosion protection in coastal works, Non woven geo textiles were first used by Giroud as early as 1969 in earthen dam as a filter under erosion protection on the upstream pace. In the same time, Wager started using both woven and non-woven geo textiles in erosion protection in Sweden. Since then, plastic and steel nets and grids, used automobile tyre casings, steel landing mats, Columbus fascine mats, reinforced plastic, rubber membrane, wood, jute, coir and saw dust have also been used in reinforced soil structures.

The application of geo textiles to geo technical projects gained its momentum in 1970's. One of the earliest applications of geo textiles were in transportation engineering and in pavement rehabilitation. It is estimated that 1400 million sq.metres of geo textiles are being used in the world annually. Europe and North America markets each account for 40 % with the remaining 20 % attributed mainly to Japan. Natural fibre geo textiles (coir, jute, sisal, hemp, straw etc.) account for less than 1 %.

5.1. The application vs. percentage of different major application areas for geo textiles is furnished below.

Application area	Percentage (%)
1. Reinforcement	4
2. Silt fences	6
3. Erosion control	7
4. Linings	8
5. Drainage	16
6. Asphalt overlay	17
7. Separation / stabilization	42

5.2. Features and benefits of Geo textiles

Surface soil erosion on slopes occurs by dislodgement of soil particles and their transportation down slope as a series of events that may be repeated several times by a single particle before final deposition.

Erosion control is the process of restraining the initial movement of soil particles by wind and water (rain). The selection and installation of an effective erosion control material will reduce the impact of rain drops on the soil and impede overland water flow by reducing the impact of rain drops, fewer soil particles become dislodged during rainfall.

Features of Geo textiles	Benefits derived
Shield soil-against wind jet efflux and rain	Prevent soil loss and controls erosion
Protects seeds/plants – against wind, rain & birds	Increases germination rate of seeds
Retains moisture-by capillary storage of water and shading	Promotes vigorous growth of vegetation
Fertilizes soil-increase humus content of soil as natural organic constituents degrade	Enhances soil fertility and permeability
Reinforces Turf – against general wear and tear.	Greater turf durability and stability of soil surface
Insulates soil & roots – against extremes of temperature	Provides optimum conditions for seeds early growth of vegetation
Mulching – prevents moisture loss from soil	Extended period of growth per season results in lower plant loss
Weed control-totally opaque	Environmental friendly and suppresses weed growth
Temperature Moderation-the matrix/blankets moderates temperature changes	More roots survive to give stronger plant growth
Increased fertility – as the matrix degrades it adds to the humus in the soil	Improves long term condition for plant growth
The economics-easily man handleable, in roll form, no special labour, very easy to install, takes the contour of the soil, provides for long term weed control, mulching etc.	Reduces laying time, site labour utilised, cost spread over several financial years, eco friendly & biodegradable.

The soil erosion can be avoided with soil surface protection using a vegetation cover of relatively shallow, fibrous root structure whereby the roots creep along the ground. Native plants that occur naturally in a particular region, ecosystem and habitat without direct or indirect human actions can achieve the vegetative cover. The vegetation plays an extremely important role in controlling rainfall erosion by

1. Interception: Foliage and plant residues absorb rainfall energy and prevent soil detachment by raindrop splash.
2. Restraint: Root systems physically bind or restrain soil particles while above ground portion filter sediment out of run off.
3. Retardation: Stem and foliage increase surface roughness and slow velocity of run off.
4. Infiltration: Plants and their residues help to maintain porosity and permeability thereby delaying onset of run off.

5.3. Rolled Erosion Control Products (RECP)

They are expected to serve mitigation of erosion both in the short term as well as long term through the establishment and maintenance of vegetation cover.

The Rolled Erosion Control Products can be classified as

1. Erosion Control Nettings (ECN)
2. Erosion Control Meshes (ECM)
3. Erosion Control Blankets (ECM)
4. Turf Reinforcement Mats (TRM)

6. Functions of Geo textiles

Geo textiles usually fulfill one or more of the following functions

1. Drainage (Fluid Transmission).
2. Filtration.
3. Separation.
4. Reinforcement (Protection).

6.1. Drainage

Geo textiles can collect a liquid or gas and convey it along its own plane thus providing fluid transmission

6.2. Filtration

Geo textiles acts as filter when it allows liquid to pass normal to its own plane, while preventing most soil particles from being carried away by the liquid current. It is one of the most widely used geo textiles functions. A geo textile provides filtration function, which serves the same role in soil structures, as were the various gradations off aggregates conventionally used.

6.3. Separation

The separation function refers to the separation of two dissimilar materials. The primary geo textile responsibility is to prevent intermixing of the two different soil layers or dissimilar materials, throughout the design life of the structure. Normally geo textiles provided for separation in road pavement prevent intrusion/pumping of soil particles into the base/ sub base course. Geo textiles are commonly used for this function when pavements are constructed over soft soils. Roadway pavements are basically structures for taking the high contact pressure from the vehicle tyres and reducing that pressure through the depth of the pavement to a level, which can be handled by the underlying soil. Pressure dissipation occurs down through the various layers of materials within the pavement. Over a period of time, especially in presence of water, repeated vehicle load applications cause sub grade soils to migrate into the aggregate base of the pavement section. Contamination of the aggregate base by the sub grade results in the reduction of the effective base thickness to a value, which is less than what, was the design

value. Reduction of the base thickness results in a decrease in the load carrying capability of the aggregate base and leads to a reduction in the pavement life. Geo textiles prevent the sub grade materials from migrating into the aggregate base, while maintaining the desired strength over a much longer period and as a consequence the quality and the life of the pavement is increased substantially.

6.4. Protection

Geo textiles protect a material when it alleviates or distributes stresses and strains transmitted to the protected material. This can be

1. Surface protection, as in erosion control
2 For interface protection i.e. alleviation of reflection cracking
3. As tensioned membranes when placed between two materials with different pressures (bridging of gaps, stress reductions)
4. As tensile member in a reinforced soil structure to provide tensile modulus and strength through interface friction.

In many applications, geo textiles may perform more than the function envisaged.

7. Coir Bhoovastra (Coir Geo textiles)

Coir geo textiles (Coir Bhoovastra) are permeable fabrics capable to control soil erosion. It protects the earth and promotes vegetation retaining precious top soil. It is available in woven and non-woven forms.

Coir Bhoovastra is

- Made from natural fibre
- 100% organic and renewable
- Good durability
- Biodegradable
- Naturally resistant to rot, moulds and moisture
- Needs no chemical treatment
- High tensile strength and modulus
- Good dimensional stability
- Anti-slip nature

- Available in India in abundance at low price
- Found to last for 4-6 years within the soil environment
- eco friendly and bio degradable
- Serves the purposes of Reinforcement, Separation, Filtration and Drainage – in road construction
- Low extensibility
- Stiffness
- Long hairs protruded from the yarn surface fibre shedding and processibility
- High biodegradability to last for 4-6 years within the soil environment

Coir Bhoovastra (Coir Geo textiles) is a net fabric from coir fibre. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1" square. The netting (mesh) gives the grass plenty of room to grow at the same time provides large number of "Check Dams" per square meter of soil media. The nettings are normally produced on Coir handlooms out of 2-ply coir yarn, i.e., 1-meter wide rolls of 50-meter length.

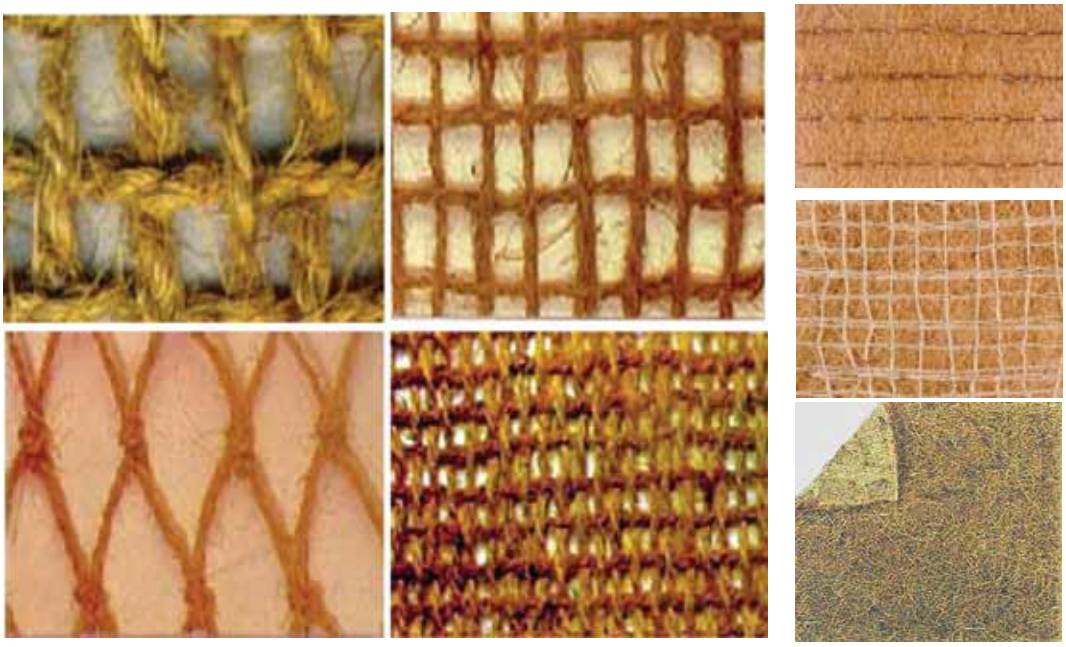
Coir Bhoovastra are permeable fabrics made from coir fibre extracted from coconut husk either by natural retting or by mechanical process. Coir geo textiles are used for stabilisation of soil through vegetation against erosion of landscape and soil slopes as well as protection of banks of river, canal and lakes, road and railway embankment and reinforcement of mud wall of stream, bunds, farm and fishponds against erosion and other applications involving separation and filtration.

Compared to other natural fibres like cotton, jute etc, coir fibres of larger diameter and curvature, possess rigidity to bending which helps to bridge gaps in soil materials in the case of filters and separation functions. Also in the case of reclamations, coir fabrics require less support than other fabrics

Coir geo textiles control the soil erosion by acting as a ground cover or mulch .The term mulch refers to any material which would be decomposed fully or partially over a period of time and serving as nutrient to the vegetation that is being nurtured. The mulch has a short-term role to play and not a long-term role in stabilisation. As a ground cover, it reduces the flow velocity of runoff water by forming check dams with the help of net structured strands of coir geo textiles in firm contact with the soil, which absorb the impact of water flow and resist washing down keeping the soil intact. Coir geo textiles provide support to the seeds sown and seedling which could be otherwise easily washed away by water. The strands of the net reduce the wind velocity at the soil surface thereby trap soil particles from being blown away. As a mulch, coir geo textiles provide ideal environment for the seeds to germinate and healthy grow of

seedling by regulation of soil humidity, temperature and manure and controlling weeds, by protection from direct sunlight and rain.

8. Types of Coir Bhoovastra



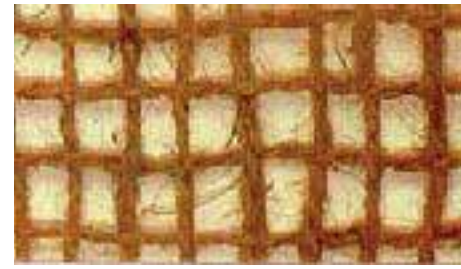
8.1. Open Weave Coir Bhoovastra

Open Weave Coir Bhoovastra is a net fabric woven from coir yarn. Open Weave Coir Bhoovastra is a good insulant, resistant to dampness and moths, biodegradable, absorb moisture equal to its own weight and conserved moisture in soil which is sufficient for the growth of vegetation. When the Open Weave Coir Bhoovastra eventually disintegrates, it leaves only humus. There is no need for post-installation work.

Open Weave Coir Bhoovastra have been found to be an ideal geo textile for situations where land is sloppy which may lead to riling and gulling. In such slopes, heavy rainfall causes loss of soil. In the areas of scanty rainfall where soil is non- cohesive and prone to wind blowing, Open Weave Coir Bhoovastra provides adequate protection .Coir bhoovastra finds applications in erosion of cut slopes of railways, road, approaches of bridges, canal and drainage bank, bank of river, ponds, lakes, hill slopes and terraces requiring surface stabilisation, reclamation of mine spoil heaps and sand dune stabilisation.

The Open Weave Coir Bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds of better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, Open Weave Coir Bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.

In areas prone to soil erosion like slopes and drainage areas open weave Coir Bhoovastra, holds seed and soil intact even during heavy rainstorms. It stays on the earth against the ravages of quick flowing water, wind or wild vegetative growth. The openings between the strands give the grass or vegetation plenty of growing room.



8.1.1. Quality Parameters of Coir Geotextiles as per IS12503 (Part 2) 1988 Coir Mattings, Mourzouks and Carpets

A matting of two-treadle weave in construction with the difference that the warp and weft strands are positioned at a distance to get mesh effect.

Designation	Type of warp yarn	Approximate scorage of warp yarn	Ends per dm	Type of weft yarn	Picks per dm	Mass, kg/ m2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hand loom matting						
H2M1 (MMA1)	Anjengo	14	9	Vycome	8	0.650
H2M2 (MMB1)	Beach	9	8	Beach	7	0.700
H2M3 (MMR1)	Aratory	15	14	Aratory	14	0.875
H2M4 (MMA2)	Anjengo	12	19	Aratory	11	1.400
H2M5 (MMV1)	Vycome	13	9	Vycome	8	0.740
H2M6 (MMV2)	Vycome	12	4.6	Vycome	4	0.400
H2M7(MMY1)	Beypore	-	4	Beypore	6	1.250
H2M8(MMA3)	Anjengo	12	11	Aratory	7	0.700
H2M9 (MMA4)	Anjengo	11	13	Aratory	7	0.900
H2M10 (MMA5)	Anjengo	11	18	Anjengo	9	1.300

Permissible tolerances

Sl.No.	Parameters	Tolerance Permissible
1	Scorage of yarn	1
2	Dimension Length Width up to 180 cm Width above 180 cm	 + 1 % ± 13mm ± 25 mm
3	Ends	± 2 strands per dm
4	Picks Width up to 275 cm Width over 275 cm	 - 5% - 2 per dm
5	Mass	+7.5% -5%

Note:

MMA2 (H2M4) In this matting the warp threads are arranged in-group of three strands.

MMR1 (H2M3) In this matting, the warp and weft threads are arranged is pairs, each warp strands are woven alternately with the adjacent strands.

MMA5 (H2M10) In this matting the warp strands are arranged in-group of 6 strands leaving a gap of 1 cm between each group. After 6 such groups 4 jute strands are provided to protect the warp after cutting. A gap of 1.5 cm is provided after the jute strands of facilitate cutting of matting in strips of 20 cm width.

MMB1 (H2M2) In this matting extra warp strands are allowed to reinforce over a width of 2" at both sides, when the width of matting is 36" and less. Above 36" width a reinforcement of 4" width at the centre and sides of the matting is allowed.

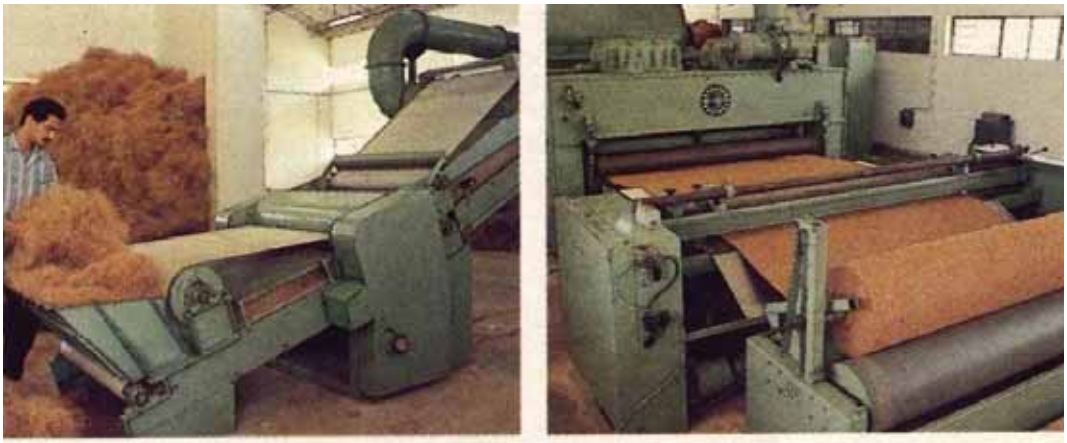
8.2. Geo rolls and Vegetation Fascines

These are mainly used for the stabilisation and revegetation of sites marked by steepness or high exposure to waves and currents causing instability. Geo rolls or vegetation fascines are construction modules characterised by a compact roll of coir web covered by exterior

coir mesh netting making it strong and flexible. Their configuration and density help them to maintain form without losing material and promote plant growth as well as microbial activity. In areas where there is a constant flow of water, they facilitate new channel alignment. In standing water they initiate sedimentation, facilitate vegetation and dissipate induced wave energy. Geo rolls collect and hold mineral and organic particles, provide a physically stable substrate for root growth and gradually bio-degrade to leave a self sustaining erosion control system. The interior of the geo rolls consist of 100% coir fibre webs cross-lapped or air laid, followed by needle punching or stitch bonding. The fibre density is greater than or equal to 1000 gsm and the width of 220 mm to 600 mm. The substrate is then rolled into desired diameters.

8.3. Non-woven Coir needled Felts.

Coir needled felt is a non woven fabric of various densities made from needle punching of decorticated coir fibre. The coir non-woven blankets are composed of 100% coir fibre randomly needle punched to the desired degree of compaction. In the manufacturing process, well cleaned coir fibres of good staple length pass through the cleaning machines by pneumatic suction and punched by the needle loom on one side to manufacture felts of



Needled felt manufacturing machinery

different density depending upon punching intensity, needle penetration and thickness. The fibre is mechanically bonded (interlocked) to form a continuous length of sheet. No bonding material is used in the manufacture. It can be manufactured in thickness from 10 mm to 20 mm with a density varying from 500 to 1500 g/sq.m. Coir needled felts are available in blanket forms backed with nets made of jute, polypropylene and polythene also.

The felts have excellent moisture absorption and retention characteristics and form an ideal medium for plant growth.

8.4. Cocologs

Cocologs are made from coir fibre bunches under pressed condition in tubular enclosures of knotted coir yarn. They are having a shape similar to a wooden log.They vary in diameter, length and weight. The diameter varies from 30 cm to 50 cm, weight from 60 kg to 180 kg, usually produced with a length of 6 metre.

Charcoal is also used intermittently for filling the logs as additional manure for faster growth of plants. Cocologs are mainly used for vulnerable streams, rivers or lake bank to protect scour. The rolls are attached at the edges of the bank and secured by wooden stakes/ pegs. The pegs may be used on alternate sides of the log.

For high embankment areas with variable water level, several Cocolog can be applied as a stack.

8.5. Coir Fibre Beds (Cocobeds)

Cocobeds are made from coir fibre and coir geo textiles. Coir fibre is sandwiched between two coir geo textiles and stitched together to form a bed or pouch. Cocobeds are produced in different thickness, width and lengths. The thickness varies from 5 cm to 15 cm, width from 60 to 100 cm and length 125 cm to 600 cm.

Relatively steep stream banks can be covered with pre planted Cocobeds. Sediments will be collected and held in Cocobeds, which helps in plant growth and purifies water to a certain extent.

8.6. Coir Loop Fabric

Coir loop fabric is a product made with loop construction usually manufactured in rolls for use as geo fabric for soil erosion control and soil stabilization.

8.6.1. Constructional Details of Coir Loop Fabrics

Quality Number	Tight chain	Binding chain	Loop chain	Weft	Tig-ht	Bin-ding	Lo-op	Picks/ dm	Weight gm/m^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SPL L7	Vycome	Vycome	Vycome	Vycome	5	10	5	8	1300
SPL L8	Vycome	Vycome	Quilandy	Vycome	4	8	4	8	1600
SPL L9	Beach	Beach	Beach	Beach	5	5	5	9	1200

8.7. Coir Cell Geo Textiles

India is a mineral-rich country, with more than 20,000 mineral deposits. The country produces about 90 minerals, which include four fuels, 10 metallic and 50 non-metallic, three atomic and 23 minor minerals. Most of the country's mining activities are concentrated in the 11 statesviz. Gujarat, Andhra Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Karnataka, Odisha, Tamil Nadu, Maharashtra, Chhattisgarh and West Bengal which accounts 92 per cent of the mines. 2,628 mines were reported in India during 2010-11.

8.7.1. Major Mineral Mines in India

- Asbestos Mines
- Bauxite Mines
- Chromate Mines
- Coal Mines
- Copper Mines
- Diamond Mines
- Dolomite Mines
- Feldspar Mines
- Gold Mines
- Granite Mines
- Iron Mines
- Iron Ore Mines
- Lime Stone Mines
- Metallic Minerals
- Non Metallic Minerals

8.7.2. Impacts of mining

Almost all of India's minerals are located in regions that also hold most of its forests, tribal population and major river systems. Forest land has constantly been getting diverted for the purpose of mining and for other developmental projects. During 1980-2005, about 1,00,000 ha of land was diverted across India to make way for 1,200 mines. This diversion has destroyed ecosystems as well as livelihoods.

Like the majority of human activities, mining operations produce waste materials. The soil and rock which is removed to gain access to buried ore and the material (water, solids, and gases) left behind after the ore has been processed to remove the valuable commodities, are considered to be waste materials. The large volumes of waste produced during mining operations are expensive to manage and are frequently cited as an obstacle in the environmental sustainability of mining.

The type, amount and properties of mine waste produced at different mines vary depending on the resource being mined, process technology used and geology at the mine site. While many mine wastes are benign, mining companies manage their waste in order to deal with the large volumes of waste produced and to prevent the release of contaminates into the environment. Waste management plans are developed as part of the mine approval process and consist of waste storage area selection and design, strategies to address problematic waste and long term stabilization of waste as part of mine closure. Understanding and addressing potential impacts at many of these sites are often complex involving multiple environmental media spread over large areas.

Since climate is basically an average of the weather over a long period of time, vegetation is important to climate. Plants also use carbon dioxide during photosynthesis, which slightly offsets the amount of greenhouse gas being released in the atmosphere through the burning of fossil fuels. Vegetation is necessary for normal weather and climate.

Soil is the mixture of minerals, organic matter, gases, liquids and myriad organisms that together support plant life. Two general classes are topsoil and subsoil. Soil is a natural body that performs four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of the atmosphere of Earth; and it is a habitat for organisms all of which modify the soil.

Soil is considered to be the “skin of the earth” with interfaces between the lithosphere, hydrosphere, atmosphere of Earth, and biosphere. Soil consists of a solid phase (minerals and organic matter) as well as a porous phase that holds gases and water. Accordingly, soils are often treated as a three state system.

As soil resources serve as a basis for food security, the international community advocates for its sustainable and responsible use through different types of Soil Governance.

Soil formation is the combined effect of physical, chemical, biological and anthropogenic processes working on soil parent material. Soil is said to be formed when organic matter has accumulated and colloids are washed downward, leaving deposits of clay, humus, iron oxide, carbonate and gypsum producing a distinct layer called the B horizon.

8.7.3. Application of Coir Cell Geo Textiles in the Waste Dumping Yards of Mines

The type, amount and properties of mine waste produced at different mines vary depending on the resource and dumping sites hence the technology for the application of coir geo textiles also varies. The application of coir geo textiles for the development of vegetation in the other sites has top soil available. For the vegetation in the mines, it is essential to provide top soil or

the conditions for the germination of seedlings. Due to deep slope dumping and varying sizes of waste, use of normal coir geo textiles cannot control the retention of the added top soil till effective germination.

The Coir Cell Geo Textiles is a new innovation for the application of Coir Bhoovastra. Coir Cell Geo Textile is normal coir geo textiles provided with woven pockets for the insertion of seed embedded manure blocks/ coir felt etc. The plant species are selected on the basis of suitability to the climatic conditions of the site. The pockets are woven so as to insert the seed implanted blocks or coir felt at the desired places in the coir geo Textiles. Pockets of variant size and dense per area can be made in the Coir Geo Cell textiles. The blocks or felt can be inserted at the time of weaving or at the site before application. Size and number of pockets to be provided depends on suitable factors for local natural well growing vegetation. Based on the suitability for thick vegetation the coir pith/ manure /soil etc are mixed and embedded with seeds to make the blocks of coir felt. The Coir Cell Geo Textiles can be effectively applied on rocky patches and mainly in the wasting dumping yards of the mines.

9. Bioremediation using Coir geo textiles

The potential of natural geo textiles lies in areas of short to medium term applications, with high performance and a life span of 1.5 to 2 year. Coir fibre is coarse, rigid, and strong and degrades slowly. The slow rate of degradation is attributed to the high lignin content of the coir fibre. The high content of lignin in coir fibre, bestows the strength to the coir geo textiles, which remains undisturbed and embedded in the soil till root fixation and establishment of the vegetation.

Biodegradation of coir geo textiles is very slow process in comparison to the other natural geo textiles like jute and sisal. The acidic phenolic materials leached out from the coir prevent the indigenous micro flora from attacking it. Over the passage of time, biodegradation sets with the enrichment of the phenolic precursors leached out into the soil environment. The development of a consortia of micro organisms (bacteria, yeast, fungi and protozoa) lead to the biodegradation of the coir geo textiles and adds to the nutrient status of the soil with a marginal increase in nitrogen / potassium and phosphorous content of the soil.

According to the tests conducted by German Bundesamt for Material Testing on natural fibres over a prolonged period of time in highly fertile soil maintained at high humidity (90%) and

30^0C temperature revealed that coir retained 20% of its strength after 1 year whereas cotton degrades totally in 6 weeks, and jute in 8 weeks, coir has retained 2 % strength even after one year, and it takes 15 times longer than cotton and 7 times longer than jute to degrade. It is reported that under the conditions of flooding water, it was found that coir was undamaged even after 4000 hours while jute and cotton expanded in diameter like floating paper and then broke apart. The above results showed that the coir has got a very stable physical structure in comparison to other natural fibres. The life expectancy of the natural geo textiles depends on the soil structure & composition; climate conditions, UV radiation aspects, rainfall at site, temperatures and type of applications.

10. Qualities of Good Coir Bhoovastra

It should possess high modulus of elasticity, low elongation, satisfactory punching strength, high absorption qualities, resistance to ultra violet, surface compatible with the needs and it should be economical.

11. Major Application Areas of Coir Bhoovastra

Coir Bhoovastra is an excellent medium for bio engineering applications in many parts of the world in the form of meshes, netting, needle felt and pads, erosion control blankets, geo rolls, vegetation fascines, geo cushions, geo beds, anti weeds blankets and so on. Coir Bhoovastra is the answer to many of the environmental problems that man faces today

i) Shoreline stabilisation.
ii) Beautification of lakes and ponds.
iii) Plant and tree protection systems.
iv) Landscaping and Golf courses.
v) Sand dune stabilization.
vi) Ski slope and high altitude vegetation.
vii) Protection and re vegetation of waste dumps.
viii) Wasteland development.
ix) Reinforced soil retaining structures.
x) Road / Railway / River embankment.
xi) Mine site reclamation.
xii) Dams.
xiii) Bearing capacity improvement for high capacity traffic areas.
xiv) Cuttings and hill slide slopes.
xv) Irrigation works.
xvi) Dam wicks / Table drain outlets.

xvii) Farm and Forestry application.

xviii) Watercourse protection including stream bank protection.

xix) Storm water channels.

xx) Roof top greening.

xxi) Agricultural and horticultural application like mulching, anti weed, vegetative seeding etc.

xxii) Protection from wind erosion.

xxiii) Mud wall reinforcement.

xxiv) Separation application in rural roads, railways, parking and storage areas.

xxv) Reinforcement of rural unpaved roads, temporary walls.

xxvi) Providing sub base layer in road pavement.

xxvii) Filtration in road drains and land reclamation.

xxviii) Containment of soil and concrete as temporary shuttering.

xxix) Concrete column curing

xxx) Fly ash dump waste protection and greening

xxxi) Control of shallow mass waste and gully erosion..

xxxii) Wetland environments.

xxxiii) Plant and tree protective systems.

xxxiv) Agri and Horti engineering industry.

xxxv) Soil stabilisation

12. Choice & Selection of Coir Bhoovastra Depends on

i) Type and degree of improvement required.

ii) Type of soil, geological structure and seepage conditions.

iii) Cost.

iv) Availability of material and quality of work required.

v) Construction time available.

vi) Possible damage during construction.

vii) Durability of material in the environment as related to the expected life of the structure for the given environmental and stress conditions.

13. Advantages of Coir Bhoovastra

a. The high tensile strength of coir fibre protects steep surfaces from heavy flows and debris movement. It can withstand considerable pedestrian movement and vehicular traffic without deterioration.

b. Easy to install and hugs contour of the soil surface due to its heavy weight and ability to absorb water.

c. Totally bio degradable, 100% natural and provided nutrients.

d. Water absorbent, thus acts as mulch on the surface and as a wick in the soil mantle.

e. Environmentally friendly and aesthetically pleasing and non polluting.

f. Provides excellent microclimate for plant establishment and healthy growth.

g. The thick and protruding fibres from the yarn render an extra protection against soil erosion and provide roughness to the surface floor and hold the soil particles in place.

h. The intersecting strands move independently of one another in the coir geo textiles thereby allaying fear of wild life entrapment.

i. The coir geo textiles give the grass plenty of room to grow and at the same time provides large number of “Check Dams” per square meter of soil media. Due to high resistance to salt water action, the coir geo textiles remain virtually unaffected when used against wave lap erosion.

j. During the manufacturing process of coir yarn, no chemicals are used.

k. Presence of pesticide residue in Coir Bhoovastra is below the toxicity limits of food items.

l. Holds the seeds and saplings in place.

m. Allows sunlight to pass through.

14. Demerits of Geo textiles from synthetic materials

1. Recalcitrant, i.e., not bio-degradable.

2. Synthetics originate from hydrocarbons, which are obtained from non-renewable sources such as petroleum and natural gas. These are fast depleting and need to be used sparingly.

3. Synthetics need 100% shielding from the ultra violet rays to prevent release of toxic gases into the environment leading to environmental pollution. The chemicals applied for shielding are toxic and pollute the environment.

4. Application of synthetics prevents the percolation of water into the underground water table.

5. Non hygroscopic, they alter the microclimate around the plants thus discouraging healthy vegetation.
6. Undergo slow attack of acid rain and UV light to produce poisonous chemicals.
7. Being a non-conductor of heat, increase the temperature of soil creating unfriendly atmosphere for the vegetation to grow.
8. Incineration or recycling also creates pollution due to release of harmful chemicals and gases.

15. Looms for Manufacturing Coir geo textiles

15.1. Coir Wooden Handloom

With the aid of loom, the process of weaving manufactures coir products. A coir handloom consists of different parts such as chain beam, chain rest beam, heddle frame, pulley, sley, reed, waist beam (front rest), tension beam (cloth beam), treadles, lamprod, shuttle, etc.

The chain beam is a wooden roller upon which the warp yarns are wound. Chain rest beam guide the warp yarn from the chain beam in a parallel sheet form to the heddle, reed etc of the loom. Separate chain beams are provided for tight and slack chains. Heddle frame is a wooden rectangular frame in which the heddles are arranged by two iron rods (heddle staves) at top and bottom. The number of heddle frames for a loom depends upon the design and type of the fabric to be woven. The heddles are made from 18 gauge G.I wire twisted to form a heddle eye at the centre, having two holes, one each at the top and bottom for the insertion of heddles through the heddle staves.

Pulley is meant for up and down movement of the heddle frames. The sley is used to bring the weft to the fell of the cloth. The process of bringing the weft to the fell of cloth is called beating.

The reed determines the width of the fabric woven in the loom. Reed helps the uniform distribution of warp yarns from heddles and positioning of the weft at appropriate places during weaving. The space between the two iron strips is known as dent and the number of dents determines the quality and density of the woven fabric. The dents should be uniform in

a reed. Two dents will be taken in excess for getting proper selvedge in the course of weaving. For matting, 100's reed means that 100 dents per yard (3 feet) and mats, 30's reed denotes 30 dents per foot. Waist beam is a support for woven fabric and guides the fabric to the tension beam. Tension beam is used for maintaining the tension of the tight warp. The warp ends are tied to apron rod, which is connected to the tension beam by means of pieces of rope.

Treadles are meant for lowering and raising the heddle frames according to the design to be woven. The process of tying the heddle frames to the treadle is known as "tie-up". The shuttle is the carrier of the weft. It is a boat shaped device made of wood having arrangement to hold the quill inside it.

For perfect working of the heddle frames, the heddle frames are first tied to the lamprod and then to the treadle.

15.2. Anugraha

Central Coir Research Institute, the research centre of Coir Board has developed a metallic handloom named "ANUGRAHA" for weaving all varieties of coir geo textiles.

The operation of wooden coir handlooms requires exertion of a large force and therefore can be operated mainly by males having sound physique. Anugraha loom has been so designed that it can weave a coir fabric with a close weave of 6 mm to a fabric having a mesh size of 25 mm. A layman can operate and produce standard quality products without any drudgery. As there is no power required to operate this loom, it can be installed in the remote village where women can easily operate it as it has a simple pedal for treadling. The treadling and beating is very easy in Anugraha loom and is operated by a 3 mm wire rope (motor cycle cable) and beating simplified providing a bush bearing.

Anugraha is light weight, easy to shift from one place to another as it needs no foundation. It needs less maintenance and occupies less space. It is easy to operate compared to

wooden handloom. Anugraha loom is a big success in the coir industry and there is a tremendous scope for the generation of women employment. It is a boon to the industry and hence named “Anugraha” which means blessing especially to the rural poor women folk.

Fabrication of wooden handloom requires one cubic meter of wood such as Sal, Thembavu, Maruth etc. A tree of height 15 meters and diameter 0.5 meter can produce 2.25 cubic meters of planks. Therefore two wooden handlooms necessitate cutting of a tree. The metallic Anugraha handloom could save trees, which are very essential for maintenance of ecology.

Sl.No.	Wooden handloom	Mild steel Anugraha handloom
1	Fabrication cost is ₹ 45,000	Fabrication cost ₹ 30,000
2	One handloom requires one cubic meter of special quality wood viz., sal, maruthi, thembavu etc. A pair of handloom requires cutting of a tree of 15 meter height and 0.5 meter diametre.	Requires around 120 kg mild steel
3	Produces irregular number of wefts per unit length as the gap is controlled manually	Produces fixed number of wefts per unit length which can be predetermined by a ratchet mechanism provided in the machine
4	Winding is to be done by stopping the weaving operation, as it is done manually	Winding is carried out without stopping the weaving operation by the ratchet mechanism
5	The release of yarn from the chain beam is done manually, stopping the weaving operation	The yarn is released automatically due to providing of a brake mechanism which releases warp yarn continuously from the chain beam
6	Requires operation by two healthy persons	It can be operated by only one woman worker
7	For changing the heddle frame, a force of minimum 30 kg is required to treadle by foot	For changing the heddle frame the force required is only 1kg to treadle by foot, which is easily done by women workers
8	Space required is 2metre x 3metre	The space required is 1metre x 2metre
9	It cannot be shifted without dismantling, due to its enormously heavy structure	Due to its light weight, it can be easily shifted from one place to another
10	Production is 60 meters/day per 8 hours by two persons	Production is 80 meters/day per 8 hours by one woman

The Anugraha loom is designed with a cover to protect the women during weaving. Women get expertise to operate Anugraha Loom in 4 hours training. Panama matting, Ribbed Matting, rod mat, rod inlaid mat and carpet mat can also be manufactured using Anugraha Loom with minor arrangements.

Comparison of wooden handloom and Anugraha handloom

15.3. Jacquard Loom

It is the most improved type of mechanism that exists in the weaving. The mechanism facilitates control of warp threads individually and provides a very large scope for producing complicated designs. In ordinary and dobby looms, only a group of warp threads drawn through the heddle frames depending upon the number of heddle frames used can be either raised or lowered for every picks, whereas in Jacquard shedding mechanism each and every warp threads can be individually controlled according to the will and pleasure of the weaver as per the design.

The design making capacity of the Jacquard machine is expressed in terms of the number of hooks in the machine. In coir industry, the machine having 100-400 hooks is in practice. A single treadle operates the machine.

The design to be woven is first drawn on a graph paper and is punched on pattern cards. The size of the card depends upon the capacity of the Jacquard machine. In the Jacquard design, draw the design in the ratio 2:1 for warp and weft for getting a square design and take a ratio of 1:1 for producing a rectangle in the matting.

16. Application of Geo textiles

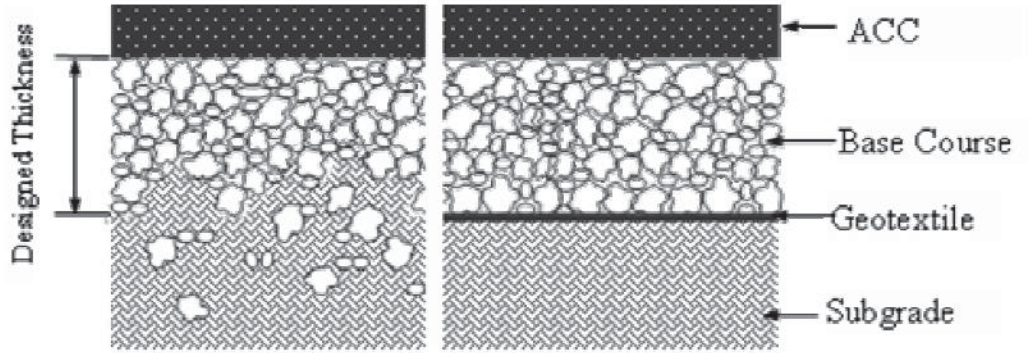
16.1. Present Status

- Lack of knowledge or know-how for adopting the new materials and techniques.
- Absence of scientific literature with regard to the long term performance of pavements constructed with coir geo textiles.
- Fear of possible pre-mature failures.
- Non-availability of experienced or skilled workers familiar with such alternate methods.
- Non-availability of contractors who are willing to take up such works.
- Lack of self-confidence in trying new techniques.

16.2. Separation

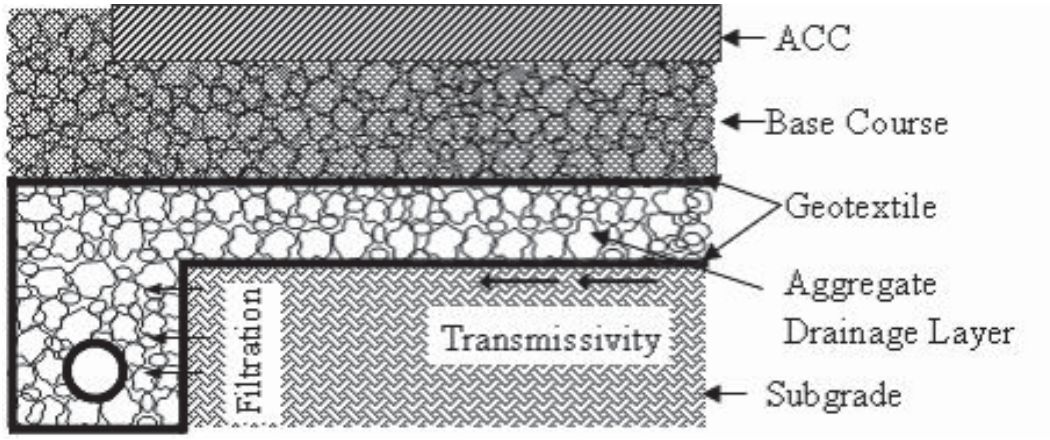
- Prevent the intermixing of two adjacent soils

- Eg. separating fine sub grade soil from the aggregates of the base course, the geo textiles preserves the drainage and the strength characteristics of the aggregate material



16.3. Filtration

- Defined as "the equilibrium geo textile-to-soil system that allows for adequate liquid flow with limited soil loss
- To perform this function the geo textile needs to satisfy two conflicting requirements: the filter's pore size must be small enough to retain fine soil particles while the geo textile should permit relatively unimpeded flow of water into the drainage media.



16.4. Drainage (Transmissivity)

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

16.5. Reinforcement

This is the synergistic improvement in the total system strength created by the introduction of a geo textile into a soil and developed primarily through the following three mechanisms:

1. Lateral restraint through interfacial friction between geo textile and soil/aggregate.
2. Forcing the potential bearing surface failure plane to develop at alternate higher shear strength surface.
3. Membrane type of support of the wheel loads.

17. Guidelines for Installation and Laying of Coir Geo textiles

17.1. For Soil Erosion Control

17.1.1. Site Assessment

The first step in the application of Coir Bhoovastra is to make a detailed study of the site like: Slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of Coir Bhoovastra as well as the seed or saplings for the vegetation cover.

17.1.2. Site Preparation

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps, rivulets, and gullies, crusting and caking, etc.

Slope application: Soil type assessment/slope assessment /slope blanket selection/slope vegetation selection/slope stabilization procedure.

Channel application: Channel assessment/channel liner selection/channel vegetation selection/proposed vegetation assessment/ channel stabilization procedure.

Shoreline application: Shoreline assessment/Shoreline blanket selection/Shoreline vegetation selection/Shoreline stabilization.

17.1.3. Vegetation & Seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

Quick germinating, sod forming/ grass species to be used whenever possible. The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the Coir Bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

17.1.4. Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20cm. The overlapping edges are fixed on the ground with the help of either 15 cm long U-shaped nails or 22 cm long J shaped hooks made of 3 mm iron or steel wire.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. The U shaped nails or J shaped hooks should be driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. Wooden bamboo pegs may also be used for fixing the coir geo textiles. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric.

17.1.5. Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The Coir Bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the Coir Bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The Coir Bhoovastra is pegged using U/J shaped or wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the Coir Bhoovastra is in place. Finally, the Coir Bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between Coir Bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the Coir Bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Care must be taken to protect the treated site from trampling by human and cattle till vegetation comes up fully.

17.1.6. Monitoring

Close monitoring should be carried out for at least two-season cycle. Displacement of Coir Bhoovastra, if any, is to be noted and watched without disturbing it initially. Fresh Coir Bhoovastra pieces duly stapled on all sides should be applied to overlap torn portions.

17.2. Reinforcement of Paved Roads

The other application is the paved road that also encompasses the unpaved application since during construction of a paved road relatively few repetitions of trucks heavily loaded with construction materials traverse the partially completed (unpaved) highway grade. This often

leads the road to critical stage. Then, construction is completed with placement of an asphalt surface course, thus the highway is paved and open to the public. The opened highway is exposed to many repetitions from loaded truck traffic; however the intensity of sub grade load is considerably less due to the greater stiffness of the surface course. Benefits of an underlying geo synthetic during construction are apparent, but as time and greater numbers of load cycles pass, the benefits are not as clear for the paved road (Barksdale et al. 1989).

Geo grids and geo textiles are the two types of geo synthetics most widely used in pavement systems at aggregate sub grade interface to reinforce or stabilize pavements. Field evidences suggest that both geo grid and geo textile could improve the performance of pavement sections constructed on weak soil.

Several investigators have reported significant effects of pavement stabilization using geo textiles reinforcement to improve the bearing capacity of sub grade soil. Steve et al. (2005) conducted a field demonstration to study how the performance of highway pavements is improved with geo textiles. In his research a field demonstration was conducted using a 21-m section along a Wisconsin highway (USH 45) near Antigo, Wisconsin, that incorporated three test sub-sections. Three different geo synthetics including woven geo textiles and two different types of geo grids had been used for stabilization. Observations made during and after construction indicate that all sections provided adequate support for the construction equipment and that no distress seems to be evident in any part of the highway. Large-scale experiments conducted on working platforms of crushed rock (breaker run stone or Grade 2 gravel) overlying a simulated soft sub grade. The tests were intended to simulate conditions during highway construction on soft sub grades where the working platform is used to limit total deflections due to repetitive loads applied by construction traffic. Tests were conducted with and without geo synthetics reinforcement to evaluate how the required thickness of the working platform is affected by the presence of reinforcement. Working platforms reinforced by geo synthetics accumulated deformation at a slower rate than unreinforced working platforms, and in most cases deformation of the geo synthetics reinforced working platforms nearly ceased after 200 loading cycles. As a result, total deflections were always smaller (about a factor of two) for reinforced working platforms relative to unreinforced working platforms.

Hans and Andrew (2001) investigated the reinforcement function of geo synthetics for a typical Minnesota low volume roadways. From the study it was observed that the addition of a geo synthetics does provide reinforcement to the roadway as long as the geo synthetics is stiffer than the sub grade material. The service life of a roadway may also be increased with the addition of geo synthetics reinforcement. It was also observed that the deflection response of roadway is governed by the Young's modulus of the geo synthetics used. Since the deflections were controlled by the Young's modulus of the geo synthetics; the largest modulus geo synthetics produced the largest increase in service life.

Schriver et al. (2002) conducted experimental study on geo grid reinforced lightweight aggregate beds to determine their sub grade modulus and increase in the bearing capacity ratio. From the study it was observed that the geo grid reinforcement placed at sub base/ aggregate interface effectively increases the service life of paved roads. Geo grid reinforcement provides a more uniform load distribution and a deduction in maximum settlement more at the asphalt aggregate and aggregate sub grade interface.

Ranadive (2003) investigated the performance of geo textiles reinforcement in soil other than sand. In this study, model strip footing load tests were conducted on soil with and without single and multi-layers of geo textiles at different depths below the footing. Testing was carried out on Universal Testing Machine. From the study it was observed that bearing capacity improved considerably for reinforced soil over unreinforced soil. It was observed that for a single layer system, BCR (Bearing Capacity Ratio) for depth of layer below footing equal to 0.25B is maximum where B is the width of the footing and BCR decreases as the depth of layer increases and for multilayer system, BCR for a constant d/B ratio and S/B ratio, (where d is the depth of single reinforcing layer below footing and S is spacing between subsequent geo textiles reinforcing layers when depth of top layer below footing was kept constant equal to 0.25B). The BCR is maximum for N=4 but the percentage increase in BCR for N=4 over BCR for N=3 is very low. Thus N=3 is recommended as optimum value.

Gitty and Ajitha (2008) conducted plate load test to study the variation of load carrying capacity for both reinforced and unreinforced pavements. It was observed that the bearing capacity improved by providing coir geo textiles as reinforcement and reported an increase in bearing capacity by 1.83 times for reinforced pavement compared to unreinforced pavement.

Venkatappa and Dutta (2005) conducted monotonic and cyclic load test on Kaolinite with geo textiles placed at the interface of the two soils. It was found bearing pressure of the soil improved by about 33% when reinforced with coir geo textiles.

Indian Roads Congress also suggested in its Rural Road Manual (IRC: SP: 59-2002) the use of coir geo textiles but no design methodology, construction guidelines and product specifications are mentioned.

Open weave CBV is an ideal fabric for reinforcement of paved roads.

The surfaces of the roads are made dust free, hot bitumen is sprayed on the cleaned surface before laying the chipping carpet. Open Weave CBV of ½ inch mesh is spread on the carpet over which hot bitumen is applied. The roller is moved over the surface. The seal coat (bitumen carpet chips) is applied with 6

mm metal to 1 inch thickness over the bitumen coated Open Weave CBV and the surface rolled for consolidation.

The condition of Coir Bhoovastra should be assessed for any constructional / installation damages before covering. Torn / damaged portions may be covered by pieces of coir geo textiles and the extent of overlap will be such as to cover the damaged / torn portion fully plus at least 75 mm beyond, on all sides.

Selection of PMGSY road

Collection of coir geo textiles

Stacking of coir geo textile

Before laying coir geo textiles

Finished Sub base Ready for Coir Geo textiles laying

Field density testing

Stiffness &modulus of elasticity determination using Geogauge

Keep the rolls adjacent and find out the overlap that can be given

Roll out first roll with one of edges as reference

Roll out second& third rolls while maintaining required overlap

Laying of coir geo textiles


Laying of coir geo textiles


Fix the roll to the subgrade by using clamps with one metre spacing


Fixing of coir geo textiles


Coir geo textile ready for sub base

Laying of sub base over coir geo textiles

Placing of soil above geo textiles

Compacting sub base with Road Roller

LAYING OF GSB

COMPACTION OF GSB

LAYING AND ROLLING OF AGGREGATE


LAYING AND ROLLING OF AGGREGATE




SPREADING, WATERING AND ROLLING OF GRAVEL, LAYING OF PMC

Surfacing of road

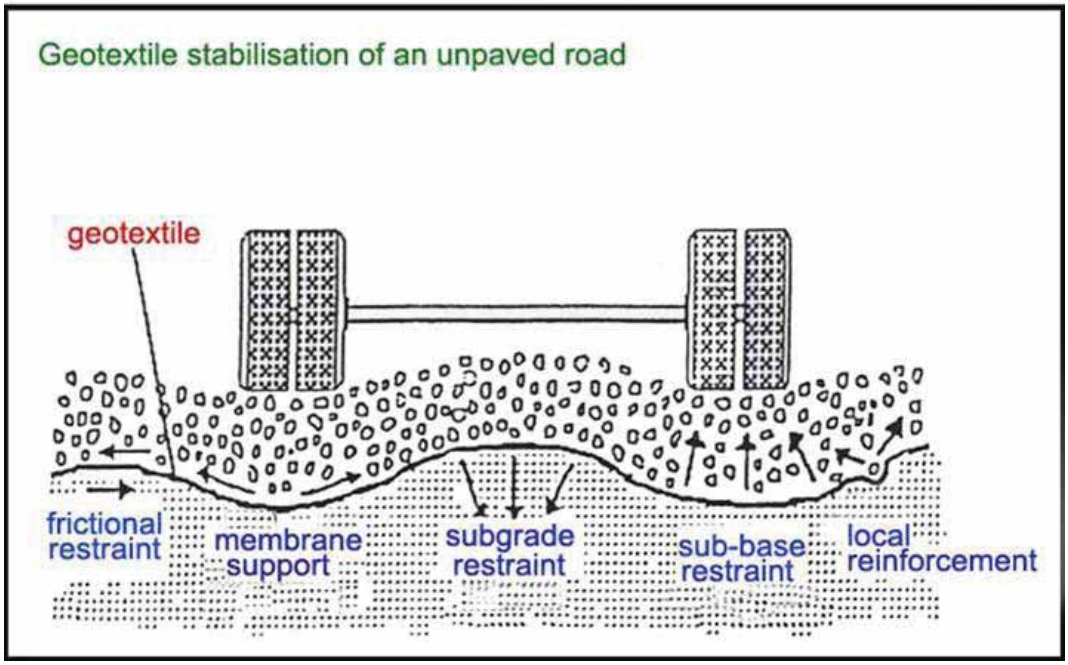
17.3. Cost Estimate for Reinforcement of Paved Roads 1 Km Long and 4 M Wide with Coir Geo textiles

Sl.No.	Particulars	Cost (in Rs.)
1.	Earthwork filling with conveners own gravelly earth cut and conveyed with all leads and lifts including consolidation of 20 cm thick 1000x4x.2x 12322/10 cum	9,85,760
2.	Cost of geo textiles(H2M6) for 4 m wide 1 km long road (considering overlapping in both directions and side wrapping)- 1100x5@ Rs 33 per sq meter	1,81,500
3.	Cost of Bamboo holding-5x6x1000 (Rs 5 per piece, 6 Numbers per meter length)	30,000
4.	Labour charges for preparation and laying- Rs 500x50	25,000
5.	Supplying and stacking 60mm graded metal (proportion of 7:3 of 60mm and 36mm by volume) in standard heaps for measurement 1000x4x0.1x1654/cum	6,61,600
6.	Supplying and stacking 36mm hard granite broken in standard heaps for measurement 1000x4x0.1x1748/cum	6,99,200
7.	Supplying and stacking of gravely earth for subbase in standard heaps 140 cum@ 1073/cum	1, 50,220
8.	Metalling the roadway 100 mm thickness compacted to 75 mm using metal and gravel, dry to compaction from sides to centre until the fines creams up and fill the voids of the stone, then take off the roller and allow to set to harden for 24 hours and rerolling the next day, and maintaining the surface free of ruts for 15 days 1000x4x@ 736/10 sq mt	2,94,400
9.	Metalling the roadway 100 mm thickness compacted to 75 mm as second subbase wbm layer 1000x4x@ 736/10 sq mt(2^{nd} layer)	2,94,400
10.	Supplying and stacking 12 mm hard blue granite broken stone in standard heaps for measurement 1000x4x.02@2170/cum	1,73,600
11.	Supplying and stacking 6 mm hard blue granite broken stone in standard heaps for measurement 1000x4x.01@1874/cum	74,960
12.	Providing 20 mm chipping carpet over the wbm surface with broken stone after thoroughly cleaning the base , applying a priming coat of 7.5kg of bitumen/10 Sq.mt and spreading the hot premix ,rolling to dense surface spreading the seal coat (0.09cum of 6mm metal and bitumen ,again rolling including the cost of bitumen, oils, and hire of brass brooms, etc complete applying priming coat 1000x4 @1760/10 sq mt	3,04,000
	Total	38,74,640

17.4. As Sub -base layer (Under lays) in Village / Rural Unpaved Roads.

An unpaved road haul loads across undeveloped terrain. Typically, such grades are crossed with a minimum amount of preparation that allows for an efficient movement of relatively few, but heavy, load repetitions. Rutting in the wheel paths is allowed but typically desired to be four inches or less in depth. Regrading or leveling of the ruts can be performed but is not typically, considered for an initial design of a layer of select granular material, which is placed upon the sub grade as a surface course. The purpose of this surface course is to transfer the surface load to the sub grade while spreading out the load to the sub grade, which effectively reduces the intensity of pressure on the sub grade (Steward et al. 1977).

Ways in which a geotextile helps stabilise an unpaved road (John 1987)



A geo synthetic placed properly does improve an unpaved road. The most effective location of the geo synthetic is below the select granular material and on the sub grade surface (Das et al. 1998). In this location the geo synthetic provides separation, lateral restraint of the upper granular course and a tensioned membrane effect when strained extensively. Geo textiles separate a granular course from a fine-grained sub grade, due to its relatively small apertures or apparent opening size (AOS). However, a geo grid also provides separation due to its less than 100 percent open area and better lateral restraint of upper granular particles. Due to interface friction and interlock with many individual ribs,

a geo grid provides superior lateral restraint of the upper granular course, whereas the geo textiles rely exclusively on interface friction for lateral restraint (Steward et al. 1977). The tensioned membrane effect requires that the geo synthetic be extensively strained (i.e., deeply rutted) for this mechanism to contribute a significant benefit.

The Coir Bhoovastra of low mesh can effectively be used for soil stabilization techniques in road construction. The use of coir geo textiles varieties of 700g (H2M5, H2M2 & H2M8) and 900g (H2M9) with 1/2 inch mesh as an interface between the sub grade and the sub base increases the strength of the pavement and prevents intermingling of the soil and the granular sub base which improves drainage.

The rural unpaved roads are leveled, clearing of all foreign materials including uprooting of any vegetation if present. The area is leveled with earth and rolled for compaction to set the optimum moisture content. To facilitate easy unrolling on the surface of the sub-grade to be treated, the Coir Bhoovastra, in rolls of 1 to 2m width, is spread directly over the leveled sub grade, ensuring that it should touch the sub grade surface at all points.

The edge of the Coir Bhoovastra should be folded back. The Coir Bhoovastra should be folded back or cut and overlapped in the direction of the turn on application in curve. The granular material is spread over Coir Bhoovastra (15 cm thick) to prevent puncture / damage due to rolling of the upper sub base/ base layer and rolled with a light or medium roller. The second layer of Coir Bhoovastra is laid again and sand is applied up to a thickness of 15cm thick and rolled. In the case of clay sub-grades, a cushion layer of 10 cm thick sand is laid before spreading the Coir Bhoovastra or Coir Bhoovastra layers can be increased to 3 or 4 depending on condition of the soil.

Under the weight of the base layer and the compactive effect, the sub-grade loses water draining through the Coir Bhoovastra and gains in strength. Due to the inherent tensile strength, the Coir Bhoovastra acts as a support membrane and reduces localized distress on the road surface by redistributing traffic loads over a wider area of the road surface.

Once the Coir Bhoovastra is placed on the weak sub grade, the sub grade stiffens and becomes stronger on consolidation within in a year or so under the action of the granular sub base surcharge, self-weight of pavement, construction rolling and traffic loads. The Coir Bhoovastra immensely helps in this rapid sub grade strengthening process in combination with the drainage layer above it. With time, the sub grade becomes less and less dependent on the fabric for its stability and therefore, the long-term durability aspect of coir should not deter its use as geo textiles for various applications in road construction.

The condition of Coir Bhoovastra should be assessed for any constructional / installation damages before covering. Torn / damaged portions may be covered by pieces of coir geo textiles and the extent of overlap will be such as to cover the damaged / torn portion fully plus at least 75 mm beyond, on all sides.

Selection of PMGSY road

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Before laying coir geo textiles

Finished sub base ready for coir geo textiles laying

Field Density Testing

Stiffness & Modulus of Elasticity Determination using Geogauge

Keep the rolls adjacent and find out the overlap that can be given

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Roll out second& third rolls while maintaining required overlap


Laying of coir geo textiles


Laying of coir geo textiles


Fix the roll to the subgrade by using clamps with one metre spacing


Fixing of coir geo textiles

Coir geo textile ready for sub base

Laying of Sub base over coir geo textiles

Placing of soil above geo textiles

Compacting sub base with Road Roller

17.5.Reinforcement of Village Roads using Coir Geo textiles under PMGSY

The Coir Board entered in to collaboration with the College of Engineering, Thiruvanathapuram, NIT, Trichy, NIT Calicut and MANIT,Bhopal as part of achieving Indian Roads Congress accreditation permanently for application of coir geo textiles, a rural product generated from rural waste providing employment to the rural people, as a new material/ technique for road construction. The National Rural Roads Development Agency (NRRDA), Govt of India advised 9 states in the country to make use of coir geotextiles in the construction of 50 km rural roads. With a view to popularize the use of innovative techniques by the use of coir geotextiles for strengthening soft soil sub grade of low volume roads through demonstration projects, the NRRDA advised that the NIT'S in various states are State Level Technical Agencies who got the mandate of carrying out research and post construction monitoring of the roads to be constructed under Pradhan Mantri Grama Sadak Yojana (PMGSY) of Bharat Nirman Scheme of Govt of India. Being Central Govt funded institutes, the Coir Board contacted NIT'S who undertook research projects to carry out studies not only for construction of roads rather than to carry out a systematic lab and field level studies to establish the use of coir geotextiles for the first time in their states to generate concrete data.

The Coir Board supplied and met the cost of coir geo textiles. The collaborating institutes conducted lab studies on application of coir geo textiles on particular type of soils available in their respective states, field applications of coir geo textiles in the soil and over those construction of rural roads by selecting and using the particular variety of coir geo textile most suitable for the soil thus generating research data which will be ultimately incorporated in the PWD manuals by the respective states.

The NIT, Trichy constructed 40.931 km(18 roads) of rural roads in 7 districts of Tamil Nadu, a length of 13.80 km roads (6 roads) in 5 districts of Madhya Pradesh by MANIT, Bhopal, a distance of 5 km roads(5 roads) in 2 districts by NIT, Calicut and a distance of 6.30 km roads (6 roads) in 5 districts by College of Engineering, Thiruvanathapuram in the road projects at a cost of Rs.354 lakhs using 1,79,200 m^2 H_2M_5 , 1,05 ,500 m^2 H_2M_6 and 61,300 m^2 H_2M_9 coir geo textiles for a total length of 59.941km roads.

The cost of laying coir geo textiles($H_2M_{6)}$ for 4 meter wide road as per the IRC Guidelines IRC SP 72:2007 was Rs 1.815 lakhs in the year 2009 as per the details furnished in the table below.

Table: Cost of construction of rural roads of 1km length

Sl.No.	Particulars	Cost (in Rs.)
1.	Cost of coir geo textiles, H_2M_6	26m/^{2}
2.	Cost of H_2M_6 for 8m wide 1 km long road (Considering overlapping in both directions and side wrapping)- 1100x10x26	2,86,000
3.	Cost of bamboo holding-3.5x12x1000 (Rs 3.5 per piece, 12 Numbers per meter length)	42,000
4.	Labour charges for preparation and laying-Rs 350x100	35,000
	Total	3,63,000

Cost of laying of coir geo textiles geo textiles for 4m wide road would come to Rs 1.815 lakh

18. Performance Evaluation

Performance evaluation of pavement can be classified as functional performance and structural performance.

18.1. Functional Performance

Functional performance can be evaluated by visual examination, Merlin test and bump indicator.

Visual examination is done for Alligator Cracking, Block Cracking, Transverse Cracking, Joint Reflection Cracking, Patching, Potholes, Corrugation and Shoving, Depression, Rutting/ Permanent deformation, Stripping, Raveling and raveling. The details of visual examination are explained in table below.

Table: Visual Evaluation

Sl. No.	Distress Type	Identification and Problems
1.	Alligator Cracking	Series of interconnected cracks caused by fatigue failure of the surface under repeated traffic loading. Indicator of structural failure, cracks allow moisture infiltration, roughness, may further deteriorate to a pothole.
2.	Block Cracking	Interconnected rectangular cracks. Larger blocks are generally classified as longitudinal and transverse cracking. Block cracking normally occurs over a large portion of pavement area but sometimes will occur only in non-traffic areas.
3.	Transverse Cracking	Cracks occur in perpendicular to the pavement's centerline or lay down direction. It allows moisture infiltration.

4.	Joint Reflection Cracking	Cracks in a flexible overlay of a rigid pavement. Allows moisture infiltration.
5.	Patching	An area of pavement that has been replaced with new material to repair the existing pavement.
6.	Potholes	Small, bowl shaped depressions in the pavement surface. It causes serious vehicular damage and moisture infiltration
7.	Corrugation and Shoving	A form of plastic movement typified by ripples or an abrupt wave across the pavement surface.
8.	Depression	Depressions are small localized areas. Noticeable after a rain. It cause vehicle hydroplaning.
9.	Rutting/ Permanent deformation	Surface depression along the wheel path. Ruts filled with water can cause vehicle hydroplaning, can be hazardous because ruts tend to pull a vehicle towards the rut path as it is steered across the rut.
10.	Stripping	The loss of bond between aggregates & asphalt binder. It causes decrease in structural support, rutting, shoving/corrugations raveling or cracking.
11.	Raveling	The progressive disintegration of an layer from the surface downward as a result of the dislodgement of aggregate particles. It causes loose debris on the pavement, roughness, water collecting in the raveled locations resulting in vehicle hydroplaning, loss of skid resistance.

18.2. Pavement Performance Evaluations

Pavement performance evaluation consists of collection of road data related to surface distress (crack area, raveled area, and pothole area), rut depth, roughness, deflection, bearing strength etc.

The type and extent of distress developed at the surface were observed, based on visual condition survey. The following parameters were taken for the study.

18.2.1. Rutting

Rutting is the longitudinal depression of the pavement along the wheel paths of the traffic. Rut depth was measured in middle portion of each 25m subsection by placing 1.5m straight edge across the rut.

18.2.2. Raveling

Raveling is the loss of aggregate particles from the surface. Percentage of raveled surface was assessed visually.

18.2.3. Pothole

A pothole is a bowl-shaped hole through one or more layers of the flexible pavement structure. The severity levels of potholes are given in the table below.

Table: Severity Levels of Potholes

Severity Levels	Depth of pothole
Low	Less than 25mm deep
Medium	25mm to 50mm deep
High	More than 50mm deep

18.2.4. Cracking

The following table gives the severity levels of cracking based on their width and nature.

Table: Severity Levels of Cracks

Severity Levels	Description
Low	Individual cracks not interconnected. Small crack width(< 10mm)
Medium	Interconnected cracks with small crack width <10mm OR individual cracks with larger crack width(> 10mm)
High	Interconnected wide(> 10mm) cracks

18.2.5. Edge Drop

Edge drop is the difference between the levels of pavement surface at edge and the shoulder. This was measured by using a scale held vertically and a bar held horizontally along the pavement surface.

18.2.6. Merlin Test for Roughness Measurement

Road surface roughness is an important measure of road condition. The Merlin road roughness measurement machine was developed by the Transport Research Laboratory for use in developing countries. Schematic sketch and photograph of Merlin are shown in figures (a) and (b) below.

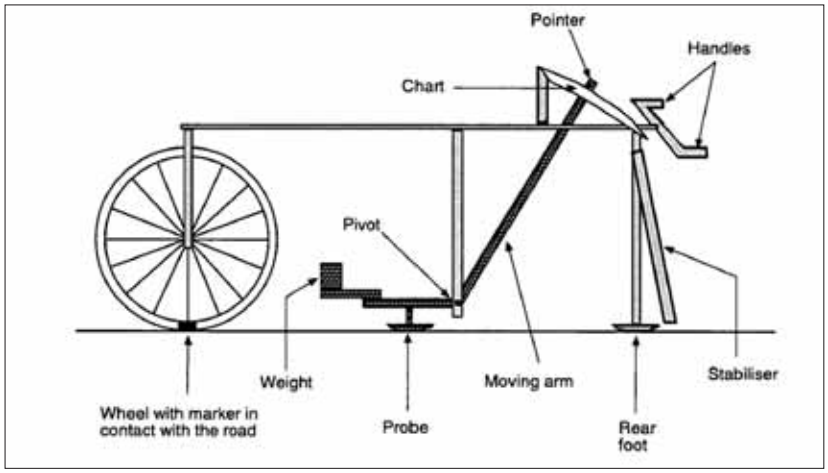


Fig. (a) Schematic sketch of Merlin test apparatus

Fig. (b) Photograph of Merlin test apparatus

The Merlin consists of a metal frame with a wheel at front and handles and a foot at the rear. The distance between the rear foot and the bottom of the wheel is 1.8 m. Attached to the frame is a pivoted moveable arm which has a probe at one end which rests on the road surface half way between the wheel and the rear foot. At the other end of the arm is a pointer which moves over a prepared chart. The arm is pivoted close to the probe so that

a vertical displacement of the probe of 1 mm will produce a displacement of the pointer of 1 cm.

The Merlin is used to measure the roughness of a stretch of road by taking repeated measurements at the intervals along the road. For each measurement the machine is made to rest on the road with the wheel, the rear foot and probe in contact with the road surface. The position of the pointer on the chart is recorded with a cross. Each new measurement is taken by moving the Merlin forward to a new position on the road and recording the corresponding new position of the pointer on the chart so that a histogram distribution of crosses is gradually built up. Once two hundred measurements have been made the position between the tenth and eleventh crosses, counting in from one end of the distribution, is marked. The procedure is repeated for the other end of the distribution and the spacing between the two marks, D is measured in millimeters.

For most road surface the road roughness can be determined using the equation,

$$IRI = 0.593 + 0.0471D$$

$$(2.4 < IRI < 15.9)$$

Where IRI is the roughness in terms of the International Roughness Index (in m/km) and D is measured from the Merlin chart (in mm).

Allowable IRI values for different types of pavements as per Sayers et al., 1986 are presented in Fig. (c) below.

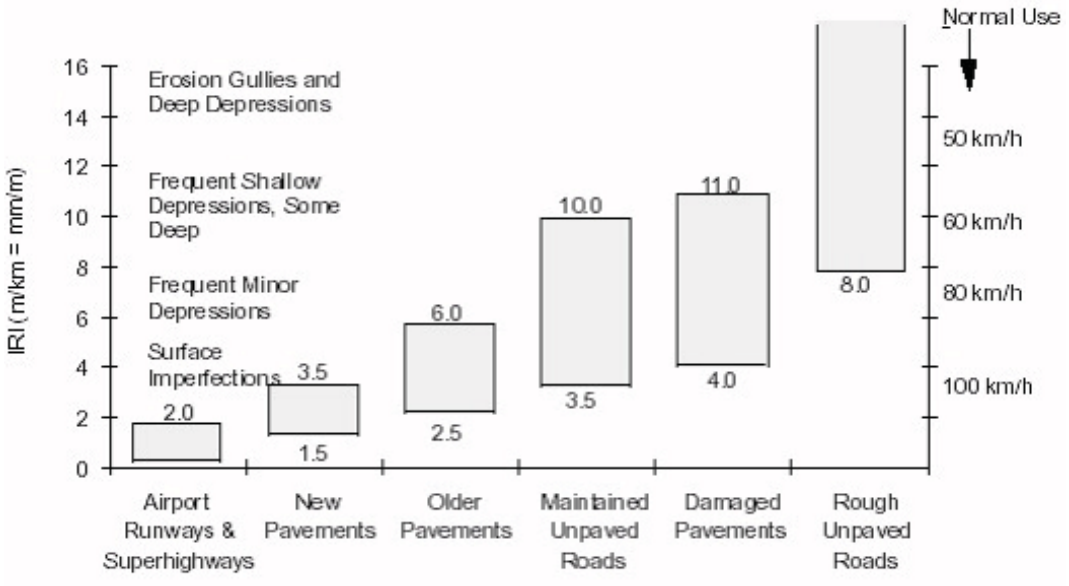


Fig. (c) Allowable IRI Values for different types of pavements

ROUGHNESS BY MERLIN

Fig. Merlin test in progress

18.2.7. Skid Resistance

Skid resistance is the frictional force developed at the tyre pavement interface when a tyre on being prevented from rotating skid along the pavement surface. Adequate skidding resistance is essential for safe operation of vehicles from the point of acceleration, deceleration, cornering and abrupt stopping. Functional performance/quality of any pavement is affected in two ways. Reduction in surface evenness (roughness), Reduction in skid resistance of the pavement with the passage of time and traffic (dependent on climatic and environmental factors).

Skid resistance found out using British Portable Skid Resistance Tester (Portable Pendulum Tester is shown in Fig. (d). This apparatus gives the frictional resistance between a rubber slider (mounted on the end of a pendulum arm) and the road surface.

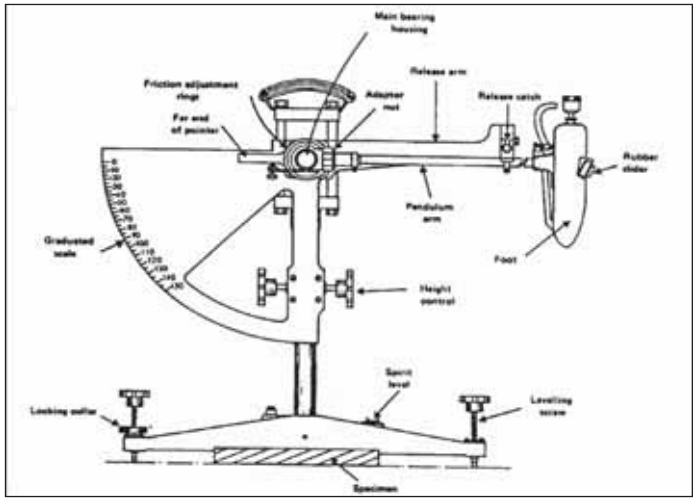


Fig (d) The British Pendulum Tester

Allowable Skid Resistance values of different conditions as per (IRC: SP: 83–2008) are

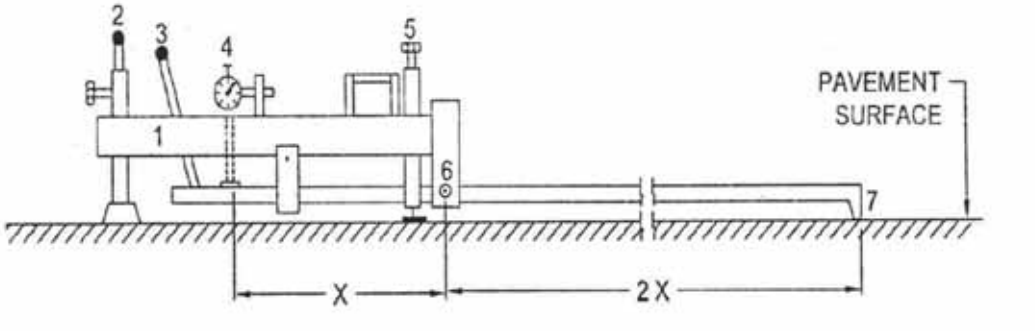
1. Values between 45 to 55 indicates satisfactory surface in only favorable weather and vehicle condition.

2. Value of 55 or greater indicates generally acceptable skid resistance in all conditions. 3Value of 65 and above indicates good to excellent skid resistance in all conditions.

18.3. Structural Performance

18.3.1. Benkelman Beam Test

Structural performances were determined using Benkelman Beam. Benkelman beam is a device which can be conveniently used to measure the rebound deflection of a pavement due to a dual wheel load assembly or the design wheel load. The equipment consists of a slender beam of length 3.66m which is pivoted to a datum frame at a distance of 2.44m from the probe end. The datum frame rests on a pair of front levelling legs and a rear leg with adjustable height. The probe end of the beam is inserted between the dual rear wheels of truck and rests on the pavement surface at the centre of the loaded area of the dual wheel load assembly. A dial gauge is fixed on the datum frame with its spindle in contact with the other end of the beam in such a way that the distance between the probe end and the fulcrum of the beam is twice the distance between the fulcrum and the dial gauge spindle. Thus the rebound deflection reading measured at the dial gauge is to be multiplied by two to get the actual movement of the probe end due to the rebound deflection of the pavement surface when the dual wheel load is moved forward.

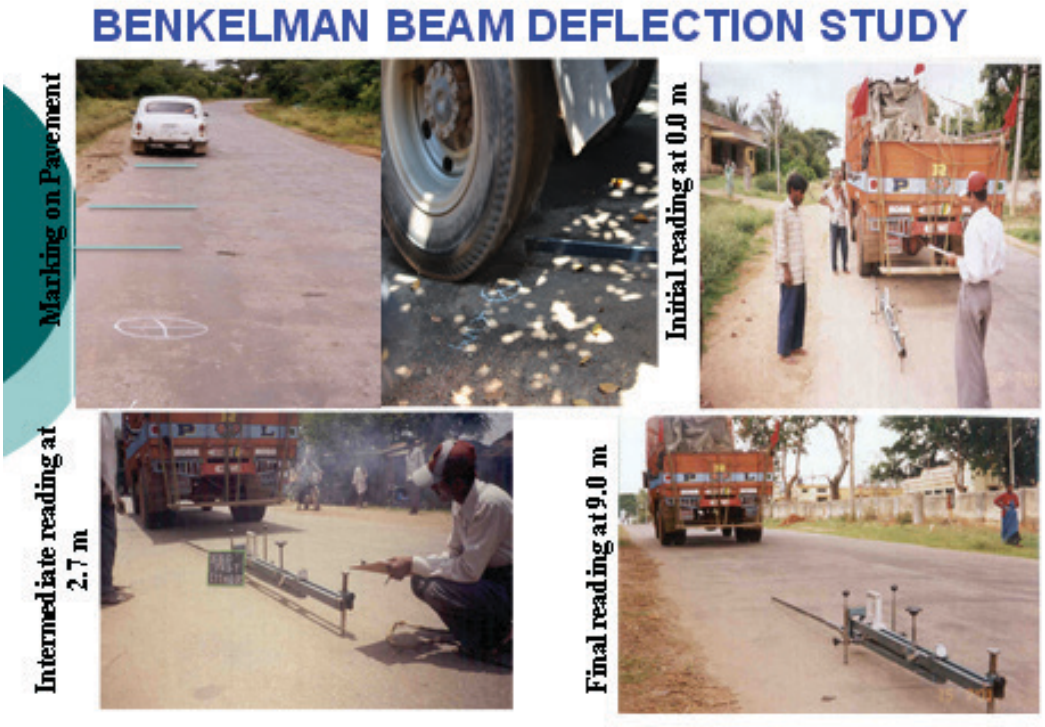


Benkelman beam

Schematic sketch of Benkelman Beam is shown in fig.

Truck loaded with 12 tonne such that the rear axle load is 8170 kg equally distributed over the two sets of dual wheels; the spacing between the tyre walls should be 30-40 mm; the tyres is 10x20 ply inflated to a pressure of 5.60 kg/sq. cm. Schematic sketch of Benkelman beam is shown in fig.

The rebound deflection value D at any point is given by D = 2(Do-Df) + 2K (Di-Df) . Where Do is the Initial Dial gauge reading under and in between the gap of the back dual wheel of Truck normally it is adjusted to zero. Di = Intermediate Dial gauge reading at a distance 2.7m after running of Truck. Df = Final Dial gauge reading at a distance 9m after running of Truck. Moisture correction, Temperature correction and Leg correction are to be made to the deflection.



The allowable limit of deflection having no need of any improvement works in the pavement as per IRC 81 – 1997 is 0.45mm. There is no need of any upgradation when the deflection is below 0.45mm as per overlay thickness design curve. Allowable limit of deflection without any improvement works for different cumulative numbers of standard axial loads is presented table below.

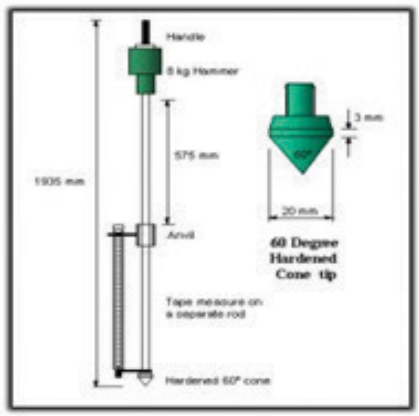
Table: Allowable limit of deflection without any improvement works for different cumulative numbers of standard axial loads is presented

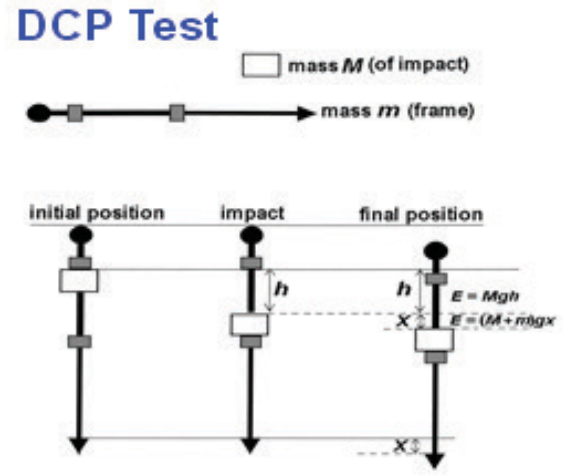
Deflection in mm	3	2	1.65	1.4	1.05	1	0.8	0.45
Million standard axial load	0.1	0.5	1	2	5	10	20	100

The bearing capacity of soil improves when reinforced with geo textiles and better improvement is seen when two layers of geo textiles are provided at top and half the depth from top of the sub grade

18.3.2. Dynamic Penetration Test

The strength of in situ (sub grade) soil was measured by using Dynamic Cone Penetrometer. The DCP test is intended to measure the resistance offered by compacted granular/soil layer due to penetration of a standard 20mm diameter cone driven by a 8kg hammer dropped freely from a height of 575mm.The average penetration of the cone per blow is reported as an index value and can be represented in many ways viz., DCP, DCP index (DCPI), penetration index (PI), penetration rate (PR) etc. The DCP test was conducted on each subsection of the roads.





The Laboratory studies and field studies indicated the followings.

Laboratory study

1. The CBR value of soil is found to increase with the inclusion of geo textiles.
2. The CBR value for reinforced soil under soaked condition is found to be lower than the unreinforced soil for very soft soil.

3. There is considerable increase in the CBR value when the geo textiles is anchored to the soil. There is an increase of more than 100% for geo textiles placed at the surface and more than 25% increase when the geo textiles is placed at the mid height of the sub grade to that of unreinforced soil.

4. The CBR value of soil with anchored geo textiles is observed to vary from 17% to 100% for unsoaked condition and 4% to 75% for soaked condition with respect to that without anchorage.

Field Study

1. By visual examination the coir geo textiles reinforced roads are better in performance compared to unreinforced roads.
2. Potholes as well as cracking seem to be more in unreinforced road sections.
3. IRI values as well as skid resistance seem to reduce with time but they are all within the allowable limits.
4. Benkelman deflection of reinforced roads is less compared to unreinforced roads.
5. Initially the variation in Benkelman Beam deflection between reinforced and unreinforced road is high and with time the variation reduces in both the roads.

It was reported that the coir geo textiles reinforced roads are structurally strong compared to unreinforced roads and it remains stable.

19. Cost & Performance Benefits

- reduce the intensity of stress on the sub grade
- prevent the base aggregate from penetrating into the sub grade, prevent sub grade fines from pumping or otherwise migrating up into the base
- prevent contamination of the base
- reduce the depth of excavation required for the removal of unsuitable sub grade materials
- reduce the thickness of aggregate required to stabilize the subgrade
- reduce disturbance of the sub grade during construction
- allow an increase in sub grade strength over time
- reduce the differential settlement of the roadway
- maintain pavement integrity and uniformity
- reduce maintenance extend the service life of the pavement

19.1. Cost of Laying with Single Layer of Coir Geo textiles for 1 Km Long and 8 M Wide Unpaved Road

Sl.No.	Particulars	Cost (in Rs.)
A. H2M6		
1.	Cost of H_2M_6 coir geo textiles	33/ m^2
2.	Cost of H_2M_6 for 8 m wide 1 km long road (Considering overlapping in both directions and side wrapping)- 1100x10x33	3,63,000
3.	Cost of Bamboo holding-5x12x1000 (Rs 5 per piece, 12 Numbers per meter length)	60,000
4.	Labour charges for preparation and laying-Rs 500x100	50,000
	Total	4,73,000
Cost of laying 1km road and 4 m width with H2M6		2,36,500
B.H2M5/H2M2		
1.	Cost of H2M5/H2M2 coir geo textiles	52/ m^2
2.	Cost of H_2M_5 for 8m wide 1 km long road(Considering overlapping in both directions and side wrapping)- 1100x10x52	5,72,000
3.	Cost of Bamboo holding-5x12x1000 (Rs 5 per piece, 12 Numbers per meter length)	60,000
4.	Labour charges for preparation and laying-Rs 500x100	50,000
	Total	6,82,000
Cost of laying 1km road and 4 m width with H2M5/H2M2		3,41,000
C. H_2M_8		
1.	Cost of coir geo textiles	55/m^2
2.	Cost of H_2M_8 for 8m wide 1 km long road(Considering overlapping in both directions and side wrapping)- 1100x10x55	6,05,000
3.	Cost of Bamboo holding-5x12x1000 (Rs 5 per piece, 12 Numbers per meter length)	60,000
4.	Labour charges for preparation and laying-Rs 500x100	50,000
	Total	7,15,000
Cost of laying 1km road and 4 m width with H_2M_8		3, 57,500

19.2. Cost Estimate for Reinforcement of Unpaved Roads 1 Km Long and 4 M Wide with Single Layer of Coir Geo textiles and Two Layer of Earthwork Filling

Sl.No.	Particulars	Cost (in Rs.)
1.	Earthwork filling with conveners own gravelly earth cut and conveyed with all leads and lifts including consolidation of 20 cm thick 1000x4x0.2x 12322/10 cum	9,85,760
2.	Cost of geo textiles (H2M6) for 4 m wide 1 km long road (considering overlapping in both directions and side wrapping)- 1100x5@ Rs 33 per sq meter	1,81,500
3.	Cost of Bamboo holding-5x6x1000 (Rs 5 per piece, 6 Numbers per meter length)	30,000
4.	Labour charges for preparation and laying- Rs 500x50	25,000
5..	Second layer of earthwork filling with conveners own gravelly earth cut and conveyed with all leads and lifts including consolidation of 10 cm thick 1000x4x0.1x 12322/10 cum	4,92,880
	Total	17,15,140

20. Standards for Testing Quality Parameters of Geo textiles

Sl.No.	Parameter	Standards
1.	Thickness	IS: 13162 Part 3 1992 / ASTM D 1717: 96
2.	Mass per unit area	ASTM D 3776-85 / IS 14716: 1999
3.	Apparent opening size	ASTM D 4751 99 / IS: 14294 – 1995 / IS 14294: 1995
4.	Wide width tensile strength in dry / wet conditions & Tensile elongation	ASTM D 4595 86 / IS: 13162 (Part 5) 1992
5.	Grab test	ASTM D 4632 – 91
6.	Trapezoid tearing strength	ASTM D 4553-91 / IS: 14293-1995
7.	Puncture resistance by falling cone method	IS: 13162 (Part 4) 1992
8.	Tensile strength after keeping in xenotest for 0 hrs – 500 hrs	ASTM D 4355 – 99 / IS: 13162 (Part 2) 1991
9.	Permeability (Permittivity)	ASTM D 4491-99 / IS: 14324 – 1995
10.	Pore size	IS: 14294 – 1995 / ASTM D 6767 – 02
11.	Index puncture resistance	IS: 13162/ASTM D4833-00e
12.	CBR Puncture resistance	ASTM D 1883
13.	Abrasion resistance	IS: 14714-1999/ASTM D 4158-01 (Abrasion resistance of Textile Fabrics)

21.Indian Standards for Coir Bhoovastra

1. IS 158 68 2008- Natural fibre Geo textiles (Jute Geo textile and Coir Bhoovastra) - Methods

   Part I-Determination of Mass per unit Area

   Part 2- Determination of Thickness

   Part 3- Determination of percentage of Swell

   Part 4- Determination of water Absorption Capacity

   Part 5-Determination of Smoldering Resistance

   Part 6- Determination of Mesh size of Coir Geo textile by Overhead Projector Method

2. IS 15869:2008 Textiles-Open Weave Coir Bhoovastra -Specifications

3. IS 15871:2009 Use of Coir Geo textiles (Coir Bhoovastra) in Unpaved Roads-Guidelines

4. IS 15872:2009: Guidelines for Application of Coir Geo textiles (Coir Woven Bhoovastra) for Rain Water Erosion Control in Roads, Railway Embankments and Hill Slopes

5. IS 12503(Part 2) 1988 Coir Matting, Mourzarks and Carpets

21.1. IS 15868 (Part 1 to 6): 2008: Methods of Test for Natural Fiber Geo textiles (Jute Geo textiles & Coir Bhoovastra)

The use of natural fiber geo textiles has been recognized in erosion control in embankment construction for roads and railways, dam engineering, canals etc and in road pavements. Their increasing importance is due to their versatility based on their specific properties.

For applications, it is desired that the geo textiles maintain integrity during the course of its life and do not tear, split and deteriorate under constructional or post- constructional stresses.

21.1.1. Part 1 Determination of Mass per unit area

Scope

This standard (Part 1) explains a method to determine the mass per unit area of all natural fiber geo textiles for identification purposes and for use in technical data sheets.

Principle

The mass per unit area is calculated by weighing small square or circular specimens

of known dimensions. The mass per unit area of an ECB is determined by weighing test specimens of known dimensions cut from various locations over the full width of the laboratory sample.

The measured weight is then used to calculate the mass per unit area of the specimen, and these values are averaged to obtain the mean mass per unit area of the laboratory sample

21.1.2. Part 2 Determination of Thickness

Scope

This standard (Part 2) prescribes a method for the determination of the thickness of geo textiles at specified pressures and defines at which pressure the normal thickness is determined.

Thickness (of geo textiles)

The distance between a reference plate on which the specimen rests and a parallel presser-foot applying the given pressure to the specimen is defined as the thickness of the geo textiles.

Nominal Thickness (of geo textiles)

The thickness determined when applying a pressure of 2±0.01 kPa to the specimen

Principle

The thickness of a number of specimens of geo textiles are measured as the distance between the reference plate on which the specimen rests and a parallel circular presser-foot exerting pressure on an area of defined size within a larger area of geo textiles. The result of the test is given as the average of the results obtained at each specified pressure.

21.1.3. Part 3 Determination of Percentage of swell

Scope

This standard (part 3) prescribes method for determination of the percentage of swell in water of geo textiles.

Principle

This test is used to calculate the percentage of swell of all natural fiber geo textiles in water. This method determines the percentage swell in thickness of the sample after it has been immersed in water for 24 hours.

21.1.4. Part 4 Determination of Water Absorption Capacity

Scope

This standard (part 4) prescribes the method for determination of the water absorption capacity of geo textiles

Principle

This test is used to calculate the water absorption capacity of all natural fiber geo textiles.

21.1.5. Part 5 Determination of Smoldering Resistance

Scope

This standard (part 5) details a procedure for the determination of the smouldering resistance of degradable rolled erosion control products.

Principle

The distance between an extinguished cigarette and maximum smoulder travel is measured to determine the smoldering resistance of the specimen.

Significance and use

This is of great concern since degradable erosion control materials are susceptible to flammability caused by cigarettes. This test method serves to provide an index reading of relative smoulder resistance.

21.1.6. Part 6 Determination of Mesh size of coir geo textiles by overhead projector method.

Scope

This standard (Part 6) specifies method to determine the mesh size by projecting the geo textiles through an overhead projector (OHP).This method is suitable for mesh having large opening sizes.

Principle

A sample of known dimension (20cmx 20cm) is placed on the OHP. The dimension of the projected meshes in both directions is also noted. The projected mesh size is measured in both directions .By the ratio proportion method the mesh size of the sample can be determined.

21.2. IS 15869:2008- Textiles-Open Weave Coir Bhoovastra -Specifications

Quality parameters for Open Weave Coir Bhoovastra

Sl.No	Characteristics	Grade			Method of test
1	Mass/unit area, g/m^2 Min	400	700	900	IS 15868(Part 1 to 6)
2	Width, cm, Min	100 or as required	100 or as required	100 or as required	IS 12503(Part 1 to 6)
3	Length, m	50 or as required	50 or as required	50 or as required	IS 12503 (Part 1 to 6)
4	Thickness at 20 kPa, mm, Min	6.5	6.5	6.5	IS 15868 (Part 1 to 6)
5	Ends (warp),runnage	180	150	210	IS 12503 (Part 1 to 6)
6	Picks (weft),runnage	160	160	250	
7	Break Load, Dry Condition (kN/m), Min a) Machine Direction b) Cross Machine Direction	 7.0 4.0	 8.5 8.0	 15.0 8.0	IS 13162 (Part5)
8	Break Load, Wet Condition (kN/m), Min a) Machine Direction b) Cross Machine Direction	3.0 2.0	7.0 4.5	12.5 5.0	IS 13162 (Part5)
9	Peak Load, Dry Condition (kN/m), Min a) Machine Direction b) Cross Machine Direction	7.5 4.0	9.0 8.0	18.0 9.0	IS 13162 (Part5)
10	Peak Load, Wet Condition (kN/m), Min a) Machine Direction b) Cross Machine Direction	3.0 2.0	8.5 5.5	15.0 6.0	IS 13162 (Part5)
11	Trapezoidal tearing strength (kN) at 25 mm gauge length, Min a) Machine Direction b) Cross Machine Direction	0.18 0.15	0.35 0.30	0.50 0.35	
12	Mesh size, mm, Min	20.0x16.75	7.50x7.30	4.2x5.1	IS 15868 (Part 1 to 6)

Plants and Grass for Soil Conservation using Coir Geo textiles

Sl.No	Name	Suited for
1.	Avicennia Officinalis	Shrub suitable for marshy places
2.	Rhizophora Mucrunata	Shrub suitable for marshy places
3.	Cyperus Exaltatus	Grass suitable for highway slopes

4.	Acrostichum Aureum	Shrub suitable for dam sites
5.	Adiantum spices	Shrub suitable for dam sites
6.	Cyanodon dactylon	For light sandy soils
7.	Cenehurs ciliaries	For most types of soil
8.	Eragrostis curuvla	For protecting terraces and channels
9.	Dianthum annulatum	For light soil
10.	Pennisetum pedicellatum	Sandy loam soil
11.	Both rochola glabra	For red semi arid soil
12.	Stylosanthis gracilis	For light soils with low moisture
13.	Stylosamthis gusineusis	For light and medium soil with low moisture
14	Pucraria hirsuta	Cover crop suited to alluvial soil
15.	Pennisetum purpureum	For hill slopes
16.	Peuraria hirsta	Cover crop suited to alluvial soil
17.	Pennisetum purpureum	For hill slopes
18.	Peuraria hirsuta	For hills in humid climate.

Marking

Unless otherwise agreed to between the buyer and the seller, the rolls shall be marked with an indelible ink with the following information.

a) Roll No

b) Grade

c) Length, in m

d) Indication of the source of manufacture

e) Month and year of packing

f) Gross mass

g) No of pieces packed in the package; and

h) Any other information as required by the law in force

21.3. IS 15871: 2009: Guidelines for Use of Coir Geo textiles (Coir Bhoovastra) in unpaved Roads)

Scope

This standard prescribes the guidelines of coir woven bhoovastra suitable for application in unpaved roads including the selection of coir woven bhoovastra and installation methods.

Coir Woven Bhoovastra

Open structure coir woven bhoovastra made out of coir threads in which each warp thread gets interlaced alternatively over and under by successive weft thread.

Application

In order to perform beneficially in road stabilisation applications the coir woven bhoovastra must not only be properly designed, it must be properly installed and must be cleared of sharp objects, which could puncture the geo textiles. Coir bhoovastra damaged during placement or installed in a highly wrinkled condition will not perform. Coir woven bhoovastra shall maintain integrity during the course of its life. The aggregate overlay must be placed to its full design depth and it must be applied in a manner that will not cause damage to the coir woven bhoovastra from the movement of construction equipment.

Functions

The main functions of the coir bhoovastra in unpaved road application are separation, filtration, drainage and reinforcement.

Separation

This is the principle function of coir woven bhoovastra when placed beneath the aggregate layer of an unpaved road. The coir woven bhoovastra prevents intermixing of aggregate and underlying sub grade soil. In the absence of geo textiles there is loss of aggregate thickness and intermixing of finer grained material reduces load bearing capacity. A stone is forced down by compaction or the passage of construction, the coir woven bhoovastra act to spread the load and tends to cause the whole layer to act together in the manner of a flexible beam. This separation and confinement plus additional strength gained by frictional interlock between the aggregate and coir woven bhoovastra, helps to maintain the reduced stress on the sub grade, thereby increasing load bearing capacity of structural section.

Filtration/ Drainage

The coir woven bhoovastra may also function as a filtration and drainage capacity in the presence of wet or saturated soils. Under dynamic high load pore pressure create soil slurry that pumps upward against the fabric. The coir woven bhoovastra acts as a filter, screens out fines from contaminating the aggregate layer, while allowing water to drain freely through the aggregate or through the plain of the coir woven bhoovastra.

Reinforcement

The two principal mechanisms of the coir woven bhoovastra is to confine and restrain

movements of the granular, structural layer and the so called membrane effect whereby a fabric that develops high tensile strength under load can induce a vertical stress upward. This aids the granular layer to support vehicular loading while reducing the magnitude of stress imposed upon sub grade. Coir woven bhoovastra will ensure that no intermixing takes place at this level and the effective depth of the pavement remains intact. The coir woven bhoovastra is useful for soft sub grades with CBR<3.

Installation

The three basic steps involved in installation of coir woven bhoovastra are

a) Sub grade preparation

b) Geo textiles placement

c) Aggregate application and compaction.

The area over which the coir woven bhoovastra is to be placed must be cleared of sharp objects, tree stamps or large stones that could puncture the coir woven bhoovastra. The area should be excavated, stripping away soft soil or unsuitable base materials then compacted to design grade.

The coir woven bhoovastra is unrolled on to the prepared sub grade in the direction that aggregate will be placed. The coir woven bhoovastra sections must be overlapped side to side and end to end around 0.5 m. The edges of coir woven bhoovastra should slope towards drainage ditches or other drain systems that parallel the roadway. Granular material can now be back dumped on the coir woven bhoovastra beginning on firm ground just in front of the coir woven bhoovastra edge.

The aggregate is then spread to a thickness sufficient to allow subsequent compaction. Initial compaction can be accomplished and then fully compacted. Aggregate should not be graded down rather they should be filled with additional aggregate and compacted.

Selection of Coir Bhoovastra

The choice of the coir woven bhoovastra basically depends on the type of pavement to be protected.

21.4. IS 15872:2009 : Guidelines for Application of Coir Geo textiles (Coir Woven Bhoovastra) for Rain Water Erosion Control in Roads, Railway Embankments and Hill Slopes

Scope

This standard prescribes the code for the guidelines for woven coir bhoovastra suitable

for application in slopes of road and railway embankments and also in hill slopes including the selection of woven coir bhoovastra and installation methods.

Materials

Coir Woven Bhoovastra

The open structure coir woven bhoovastra made out of coir threads in which each warp thread gets interlaced alternatively over and under by successive weft thread.

Mechanism of Soil erosion

The exposed soil surface road and railway embankments and hill slopes by impact of rain drops and surface wind which cause surface run off particles. These impacts detach the soil particles and carry away by the surface runoff. These articles carry seeds and soil nutrients. Natural growth of vegetation on slope is thus hindered.

Role of Coir woven bhoovastra in surface erosion control

Coir woven hoovastra are permeable coir fabrics made from coir fibre extracted from natural coir fibre. Coir woven bhoovastra control the soil erosion by acting as a ground cover. As a ground cover, it reduces the flow velocity of runoff water by forming check dams with the help of net structured strands of Coir woven bhoovastra in firm contact with the soil, which absorb the impact of water flow and resist washing down keeping the soil intact.

Selection of coir woven bhoovastra

The choices of coir woven bhoovastra basically depend on the type of soil to be protected. It requires to be ensured primarily that the slope to be protected from rain water erosion is geo technically stable. It also required considering the extreme rainfall in limited time span at that location as the intensity of rainfall is more important than the average rainfall. It is recommended that the choice of coir woven bhoovastra shall be 400/700 where intensity of rainfall is severe irrespective of type of soil and slope is <1:1.

Installation Method

The stages of laying of woven coir woven bhoovastra on slopes for rain water erosion control are as under.

The slope shall be made free from undulations, soil slurry, mud and sharp projections and compacted with additional earth where necessary.

Anchoring trenches shall be excavated at the top and toe of the slope along the slope downward, caring to see that it touches the soil surface at all points.

The selected coir woven bhoovastra shall be unrolled across the top trench and along the slope downward caring to see that it touches the soil surface at all points.

Overlap shall be minimum 150 mm at sides and ends. The coir woven bhoovastra at the higher level on the slope shall be placed over level. Side overlaps of a coir woven bhoovastra piece shall be placed over its next piece on one side and under the next piece on the other.

The coir bhoovastra shall be fixed in position with the help of steel staples of 220 mm length (usually of 11gauges) or by split bamboo pegs. Stapling shall b e done normally at an interval of 500-750 mm both in longitudinal and transverse directions. Special care shall be taken to staple the coir woven bhoovastra within the anchoring trenches (300 mm depth and 150 mm width) both at the bottom and at the sides.

The anchoring trenches shall b e filled up with brick/bats/ soil for preventing displacement of the coir woven bhoovastra. Special care shall be taken that the overlaps are not displaced during installation.

Care should be taken to prevent any damage of geo textiles due to puncture/tear and other operational stresses.

Seeds of vegetations (grass/legumes etc) shall be spread or saplings are then planted at suitable intervals through the opening of the coir woven bhoovastra.In special circumstances, a second dose of seeds may be spread with dibbling of locally available grass.

Installation shall be completed preferably before the monsoon to take advantage of the rains for quick germination of seeds.

Monitoring

Close monitoring should be carried out for at least one season cycle.

The treated area shall be kept out of bounds for cattle and other grazing animals till the time of maturity of vegetation.

The damage and displacement of coir woven bhoovastra shall be noted for corrective action. Torn portions of the coir woven bhoovastra shall be covered with new pieces of coir woven bhoovastra of identical specifications duly stapled at all sides.

Watering/ maintenance of identical specifications duly stapled at all sides.

Advice shall be sought from specialist to find out cause of unsatisfactory growth of

vegetation. Withered plants shall be replaced. Species of vegetation needs to be selected carefully considering the local soil and climatic conditions.

22. Equipments and Procedure for Measuring Quality Parameters of Geo textiles

22.1. Bursting strength test apparatus

- Measure the resistance bursting strength of geo textiles to bursting i.e. the bursting strength.
- The geo textiles are subjected to a gradual upward pressure using a hydraulic 48 mm diaphragm, moulded from synthetic rubber.
- The load at rupture is measured as the bursting strength.
- It gives the geo textiles resistance to rupture by applying load.
- It simulates an in situ situation such as the load applied in sub base while overlying geo textiles on soft ground.

22.2. Dry sieve test apparatus

DRY SIEVE TEST APPARATUS

- Determine the AOS (Apparent Opening Size) of geo textiles by sieving glass beads through it. .
- AOS is a means of correlating geo textiles pore structure to an equivalent screen mesh size.
- It is the measure of the largest effective opening available in geo textiles for soil to pass through when placed in pavements, embankments etc.
- The AOS is the diameter of the glass beads, which is, retained 95 % by the geo textiles after sieving and gives indication of the ability of the geo textiles to retain the soil.
- AOS data is important for filtering and drainage applications.
- This test is widely used for relative comparison among the geo textiles and using geo textiles as a medium to retain soil particles necessitates compatibility between it and the adjacent soil.

22.3. Cone drop test apparatus

CONE DROP TEST APPARATUS

- To assess the impact stress or the puncture penetration resistance of geo textiles.
- Used to evaluate the resistance of geo textiles to damage during installation due to dropping of sharp edged/pointed stone on geo textiles directly.
- It gives the ability of geo textiles to resist sudden impact.
- The amount of cone penetration indicates the resistance.
- The penetration or hole is measured with the help of a graduated cone.
- The smaller the hole, greater is the resistance of the geo textiles to damage.

22.4. Modified direct shear test apparatus


DIRECT SHEAR APPARATUS

- To determine the coefficient of interface friction between soil and geo textiles.
- The shear stress is measured by subjecting the geo textiles, which is placed between two soil layers to a constant normal load and an increasing horizontal force.
- Soil reinforcement is used widely in earth retaining structures, slope stability, landside protection works, pavements, etc.
- It gives a correct assessment of soil/ reinforcement frictional relationship while transferring load and forces via soil to the reinforcement.
- It helps in designing of sub structure, in determining bearing capacity of soils and in stability calculations of earth slopes
- The force, which causes a shear failure along the junction, is the shear load. The coefficient of internal friction is also calculated

22.5. CBR push through test apparatus

- To measure the force required to puncture geo textiles.
- CBR gives the resistance of the geo textiles to withstand localised pressure, which is particularly noticed in pavement systems.
- The plunger is pushed centrally through the fabric at a specified rate.
- The load at failure read directly from the dial gauge gives the resistance of the geo textiles to withstand localised pressure.

22.6. Hydrodynamic sieve test apparatus

HYDRO DYNAMIC SIEVE TEST APPARATUS

- To determine the AOS in wet condition, sieving is done in an aqueous medium.
- The AOS is taken as the diameter of the glass beads, which is, retained 95 % by the geo textiles after sieving.

22.7. Geo textiles permeometer

GEOTEXTILES PERMEOMETER

- Specifically designed to calculate the permeability of geo textiles.
- Water is allowed to pass through the geo textiles over a specified head for a specified time interval and the outlet water is collected and measured.
- It is related to filtration.
- The water flows through the geo textiles into crushed stones, pipes or some other drainage system.
- It is important that the fabric allows for this flow to occur without any obstruction.
- The hydraulic permittivity at constant head is calculated using the equation

Permittivity, φ= (QRt)/ HAT

Q =Quantity of water passing through the geo textiles

Rt = Temp correction factor

H = head

A = area of cross section

T =Time of flow

22.8. Cross plane permeability test apparatus (hydraulic permittivitty test apparatus)

- To determine the Permittivity of a geo textiles which is a measure of volumetric rate of flow per unit area of geotextile and unit hydraulic head?
- Water is allowed to flow through the geo textiles under varying normal compressive stresses.
- It is related to filtration.
- The water flows through the geotextile into crushed stones, pipes or some other drainage system.
- It is important that the fabric allows for this flow to occur without any obstruction.
- Covers determination of the water permittivity of geo textiles under varying normal compressive stresses.

The hydraulic permittivity at **constant head** is calculated as follows

$= Q/\Delta HA$ where

=permittivity of the geo textiles

Q=rate of flow

ΔH = head loss

A = area of the geo textiles

The hydraulic permittivity for **varying head** is calculated as follows

$= 2.3a/ (A. \Delta t) \log_{10}(h_0/hf)$ where

h_0= initial head

hf = final head

Δt = time required for the head change

A = cross sectional area of specimen

A = cross sectional area of standpipe above sample

22.9. In-plane permeability test apparatus (hydraulic transmissivitty test apparatus)

- The ability of geo textiles to transmit water across a plane is termed as transmissivity.
- It is defined as the volumetric rate of flow per unit width of geo textiles and unit hydraulic head in the radial direction.
- It covers the determination of the water transmissivity behavior of geo textiles under varying normal compressive stresses.
- It is related to filtration.
- The water flows through the geo textiles into crushed stones, pipes or some other drainage system.
- It is important that the fabric allows for this flow to occur without any obstruction.

The hydraulic transmissivity is calculated as follows

$\Theta = R_t QL/WH$ where

Θ = hydraulic transmissivity

R_t = Temperature correction factor

Q = Quantity of water in unit time

L = Length of the specimen

W = Width of the Specimen

H = Difference in head

22.10. Wide width tensile test by Universal Tensile Testing Machine

- To determine tensile properties of geo textiles including tensile strength and elongation.
- Tensile strength of geo textiles is the maximum resistance to deformation when subjected to tension by an external force.

- It provides design parameters for reinforcement type applications like design of reinforced embankments over soft sub grades, reinforced soil retaining walls, reinforcements of slopes, etc.
- Specimen size is 100 cm x 200 cm.
- Tensile properties of geo textiles in machine direction and cross machine direction in wet and dry conditions are determined.
- In this test the width is greater than the length of the specimen.
- In geo textiles applications there are a tendency to contract (neck down) under a force in the gauge length area.

UTM - WIDE WIDTH GRIP

- The greater width of the specimen specified in wide width test method minimizes the contraction effect and provides a close relationship to expected geo textiles behaviour in the field and a standard comparison can be arrived.

22.11. Trapezoidal tearing strength

To measure the tearing strength of geo textiles.

It is the value for estimating the relative tear resistance of different geo textiles or different directions of the same fabric.

- Geo textiles can be cut or punctured during field installations, which can create a possible condition by which strength is controlled by tearing resistance.

22.12. Grab tensile strength

- It measures the ability of the geotextiles to distribute concentrated loading.
- Specimen size is 200 x 100 mm.
- It is widely used by manufacturers as a quality control tool.
- It can be used for relative comparison between geo textiles of the same type.

22.13. Long term flow permeability test apparatus (filtration test)

- To evaluate the clogging resistance of geo textiles.
- In addition to the opening size and permeability of the geo textiles, the hydraulic behaviour of combined soil-geo textiles influence the filtration ability of geo textiles in the long-term flow situation.
- Measures long term flow rates

- Evaluates the long-term filtration behaviour and clogging potential of soil-geo textiles system
- This is to ensure long-term filtration process and the flow rate of soil geo textiles system is measured at a constant head.
- The tests for permittivity and transmissivity help in comparing one-geo textiles to another.
- The flow rate of the soil-geo textiles system decreases as the pores of the geo textiles get clogged.
- Soil-geo textiles permeability test is suggested to determine the long-term flow capability of geo textiles.
- The clogging is highly soil dependent for which two types of testing viz. filtration test and gradient ratio test are employed.

22.14. Long term flow permeability test apparatus (gradient ratio test)

- It gives a direct measure of geo textiles clogging potential.
- The gradient ratio is defined as the ratio of hydraulic gradient through the geo textiles plus 25.4 mm of the soil to that of the hydraulic gradient through the adjacent 50.8 mm of the soil.
- It is determined after 24 hours of flow of water.

$$\text{Gradient Ratio} = \frac{H2 - H_1}{(H_3 - H_2)/2}$$

Where H_1, H_2, H_3 are the piezometric heads corresponding to piezometers1, 2 and 3

22.15. Thickness gauge

- Measures the thickness of geo textiles.
- Thickness is one of the basic physical properties used to control the quality of many geo textiles.
- It is an important parameter for the measurement of permeability, tensile stress etc.

23. Tested Quality Parameters of Coir Matting

Parameter		Types of Coir Matting				
		Saloon	Panama (2x2)	2 Shaft (2x2)	Herring Bone Matting	Ribbed
Mass/unit area (gm/m^2)		1797.3	1844.96	1583.5	1906.4	2312.66
Thickness at 2 kPa (mm)		11.03	11.93	9.88	10.98	13.70
Puncture Resistance (mm)		2	2.4	3.6	2	2.8
CBR Push Through Resistance (kN)		4.35	3.91	2.77	4.18	2.45
AOS (mm)		1.42	2.05	2.25	1.84	0.9
Wide Width Tensile Test Dry (kN/m)	Warp	34.16	35.33	43.44	52.77	11.61
	Weft	25.72	23.50	17.11	21.27	22.50
Wide Width Tensile Test Wet (kN/m)	Warp	31.33	27.61	32.77	41.88	10.16
	Weft	20.22	13.38	13.11	15.38	15.16
Shear Stress (kg/cm^2)	0.5	0.485	0.654	0.475	0.644	0.579
	1	0.803	0.981	0.710	1.177	1.009
	1.5	1.224	1.298	1.009	1.504	1.260
	2	1.607	1.523	1.298	1.803	1.560
Bursting Strength (kPa)		5480	4510	3843	5250	3453
Permeability (l/m^3/min)		9484.41	9951.19	10184.5	8470.18	8004
Warp		27 (Aratory)	26 (Aratory)	28 (Anjengo)	28 (Anjengo)	Slack 20 (Anjengo) Tight 10 (Anjengo)
Weft		16 (Vycome)	16 (Vycome)	10 (Vycome)	14 (Vycome)	24 (Vycome)
Scorage of matting		12.15	11.70	12.60	12.60	13.5

24. Tested Quality Parameters of Latex coated Coir Needled Felt backed with plastic film

Parameters		Light weight Non-woven coir geo textiles composite		Medium weight Non-woven coir geo textiles composite		Heavy weight Non-woven coir geo textiles composite	
Mass /unit area(gm/m^2)		660		970		1240	
Thickness at 2kPa(mm)		9.80		14.77		13.40	
Puncture Resistance (mm)		8.8		2.33		2.66	
AOS (mm)		0.75		0.57		0.46	
Puncture Resistance (kgf)		54.4		87		81.6	
Shear Stress (kg/cm^2)	0.5 kg/cm^2	0.476		0.420		0.336	
	1 kg/cm^2	0.663		0.476		0.448	
	1.5 kg/cm^2	0.822		0.803		0.596	
	2 kg/cm^2	1.317		1.439		1.18	
Wide Width Tensile Test (Dry)	Direction	Break Load (kN/m)	Break Strain (%)	Break Load (kN/m)	Break Strain (%)	Break Load (kN/m)	Break Strain (%)
	warp	1.61	15	2.13	22	2.27	38
	weft	0.64	23.32	1.13	28	1.72	22.64
Wide Width Tensile Test (Wet)	warp	1.38	39.08	1.0	36	0.97	32
	weft	0.917	19.32	1.22	22	0.86	18.67

25. Tested Quality Parameters of Coir Needled Felt backed with plastic film

Parameters		Light weight Non-woven coir geo textiles fabric	Medium weight Non-woven coir geo textiles fabric	Heavy weight Non-woven coir geo textiles fabric
Mass/unit area(gm/m^2)		480	630	950
Thickness at 2kPa(mm)		6.8	8.44	14.57
Puncture Resistance (mm)		15.66	16	_
AOS (mm)		1.15	0.65	1.18
Puncture Resistance (kgf)		27	21.7	59.8
Shear stress,kg/cm^2	0.5 kg/cm^2	0.467	0.476	0.523
	1 kg/cm^2	0.644	0.775	0.766
	1.5 kg/cm^2	1.037	0.999	0.953
	2 kg/cm^2	1.36	1.22	1.261

Wide width tensile test (Dry)	Direction	Break Load (kN/m)	Break Strain (%)	Break Load (kN/m)	Break Strain (%)	Break Load (kN/m)	Break Strain (%)
	warp	0.5	32	0.61	37.06	0.72	36.93
	weft	0.38	14.6	0.416	14.26	0.50	21.86
Wide width tensile test (Wet)	warp	0.42	37	0.48	20	0.55	23.33
	weft	0.30	8.2	0.33	14.6	0.44	13.33

26. Tested Quality Parameters of Coir Bhoovastra (Coir geo textiles)

Parameter		Types of Coir Bhoovastra (Coir geo textiles)					
		H2M6 (400 gm/ $m^{2)}$	H2M2 (700 gm/ $m^{2)}$	H2M5 (740 $gm/m^{2)}$	H2M8 (700 gm/ $m^{2)}$	H2M8 (Green Husk fibre)	H2M9 (900 $gm/m^{2)}$
Mass/unit area (gm/m^2)		454.48	717.52	772	746.3	645.8	972
Thickness at 20 kPa (mm)		6.55	6.77	6.61	6.45	6.36	6.51
Puncture Resistance (mm)		0	26	23.60	23.22	16.88	11.93
CBR Push Through Resistance (kN)		0.71	1.47	1.90	1.14	1.58	1.84
AOS (mm)		20.07 x16.87	8.71 x 7.27	7.57 x 8.04	4.92 x 9.96	7.95x 9.04	5.00 x 8.05
Wide Width Tensile Test Dry (kN/m)	Warp	8.00	8.76	10.70	15.65	11.50	17.74
	Weft	5.62	9.84	10.24	10.24	8.40	10.42
Wide Width Tensile Test Wet (kN/m)	Warp	4.23	7.66	8.52	12.90	9.00	16.56
	Weft	3.36	8.18	8.74	4.94	4.94	7.29
Trapezoidal Tearing Strength (kN)	Warp	0.25	0.45	0.44	0.62	0.33	0.69
	Weft	0.23	0.47	0.47	0.44	0.43	0.43
Shear Stress (kg/cm^2)	0.5	0.38	0.32	0.44	0.45	0.36	0.39
	1	0.73	0.55	0.71	0.77	0.49	0.62
	1.5	0.93	0.81	0.95	0.85	0.82	0.89
	2	1.33	1.10	1.30	1.18	0.88	1.16
Bursting Strength (Kpa)		0	2146	2660	2373	1455	2532
Permeability ($lit/m^3/min$)		12798	11940	11520	10440	10920	10384
Scorage	Warp	10	10	9	11	13	11
	Weft	9	10	8	12	12	12
Runnage (m/kg)	Warp	177	163	147	213	251	208

Runnage (m/kg)	Weft	166	156	163	326	306	233
Ends/dm		4	8	9	10	9	13
Picks/dm		4	7	8	8	8	9
Peak load Dry (kN/m)	Warp	8.89	12.57	12.55	19.0	12.70	20.38
	Weft	6.02	11.14	11.14	11.45	8.65	9.70
Peak load Wet (kN/m)	Warp	4.44	9.43	9.19	16.80	11.10	16.85
	Weft	3.50	9.45	9.95	5.71	6.95	6.52

27. Tested Quality Parameters of Coir Loop

Parameters		Coir Loop
Mass/unit area (gm/m^2)		1096
Thickness (mm)		13.31
Puncture Resistance (mm)		18.40
CBR Push Through Resistance (kN)		1.36
Wide Width Tensile Test Dry (kN/m)	Warp	11.75
	Weft	7.2
Wide Width Tensile Test Wet (kN/m)	Warp	9.66
	Weft	4.81
Shear Stress (kg/cm$^{2)}$	.5	0.32
	1	0.49
	1.5	0.97
	2	1.32
Bursting Strength (kg/psi)		17.70
Permeability (litres/m^3/min)		11060.00
Scorage	Warp	11
	Weft	12
Runnage (m/kg)	Warp	250
	Weft	281
Ends/dm		9
Picks/dm		7

28. Tested Quality Parameters of Knotted Coir Net

Parameters		Coir Net
Mass/unit area (gms/m^2)		1722.9
Thickness (mm)		17.28
Puncture Resistance (mm)		-
CBR Push Through Resistance (kN)		.3
Wide Width Tensile Test Dry (kN/m)		10
Wide Width Tensile Test Wet (kN/m)		9.06
Trapezoid Tearing Strength (kN)		0.76
Shear Stress (kg/cm^2)	.5	0.51
	1	0.84
	1.5	1.07
	2	1.64
Bursting Strength (kg/psi)		21.52
Permeability (lit/m^3/min)		12730

29. Tested Quality Parameters of Coir Needled Felt With Hessian and HDPE Backing

Parameters		Coir Needled Felt		Coir Needled Felt-Hessian Backing		Coir Needled Felt-HDPE Backing	
Mass /unit area (gm/m^2)		850.0		1031.67		879.10	
Thickness at 2kPa(mm)		11.54		12.28		11.49	
Puncture Resistance (mm)		-		4.66		2.33	
AOS (mm)		2.35		0.78		0.43	
Bursting Strength (kg/cm^2)		26.08		28.74		26.36	
Puncture Resistance (kgf)		10.80		76.10		65.20	
Shear Stress (kg/cm^2)	0.5 kg/cm^2	0.31		0.20		0.20	
	1 kg/cm^2	0.44		0.43		0.38	
	1.5 kg/cm^2	0.77		1.04		0.68	
	2 kg/cm^2	1.03		1.49		0.93	
Permeability (lit/m^3/min)		10388.28		9335.87		6670.90	
Wide Width Tensile Test (Dry)-kN/m	Direction	Peak Load	Break Load	Peak Load	Break Load	Peak Load	Break Load
	Warp	0.52	0.25	4.96	4.82	1.95	0.25
	Weft	-	-	3.23	2.84	2.53	0.26
Wide Width Tensile Test (Wet)-kN/m	Warp	-	-	4.74	4.37	3.13	0.26
	Weft	-	-	2.97	2.31	2.27	0.26
Trapezoidal Tearing Strength, kN	Warp	0.19	0.05	0.58	0.56	0.46	0.37
	Weft	0.13	0.05	0.30	0.30	0.36	0.28

30. Tested Quality Parameters of Coir Needled Felt

Parameters		Mass (gm/m^2)		
		800 gm/m^2	900 gm/m^2	1000 gm/m^2
Mass /unit area (gm/m^2)		816	835	987
Thickness at 2kPa(mm)		10.12	10.29	12.69
Puncture Resistance (mm)		0	0	0
AOS (mm)		3.70	-	1.65
Bursting Strength (kg/cm^2)		18.60	20.86	21.43
Puncture Resistance (kgf)		8.10	3.0	5.0
Shear Stress (kg/cm^2)	0.5 kg/cm^2	0.29	0.47	0.50
	1 kg/cm^2	0.43	0.67	0.72
	1.5 kg/cm^2	0.66	0.85	0.94
	2 kg/cm^2	0.91	1.05	1.21
Permeability ($lit/m^3/min$)		10080	9480	8640

31. Patents Granted for Application and Manufacture of Coir Geo textiles

Sl. No.	Name of Technology for Patent	Patent Application No. & Date	Patent No.
1.	An Erosion Control Blanket (Case A) by Christy Fernandez and U.S. Sarma	588/MAS/2000 dated 28th July 2000	208689
2.	An Erosion Control Blanket from Coir Fibres (Case F) by Christy Fernandez and U. S. Sarma	842/MAS/2000 dated 5th October 2000	
3.	An Erosion Control Blanket (Case G) by Christy Fernandez and U. S. Sarma	843/MAS/2000 dated 5th October 2000	223500
4.	A Readymade Lawn by Christy Fernandez, U. S. Sarma and K. P. Somanathan Nair	664/MAS/2001 dated 13th August, 2001	223515
5.	An improved mild steel handloom, T. A. Rajendra Babu and U. S. Sarma	548/CHE/2003 dated 2nd July 2003	222486

The Indian Roads Congress, New Delhi granted accreditation to usage of coir geo textiles in erosion control of soil from roads and highways embankments/railway embankment/ canal embankment/reinforcement of roads and mudwall under new materials and techniques in the year 2011.

32. EXPORT OF COIR GEO TEXTILES FROM INDIA

YEAR	QUANTITY (in MT)	VALUE (Rs.in Lakhs)
1994-95	442	151.35
1995-96	474	167.80
1996-97	361	149.46
1997-98	739	313.31
1998-99	1208	546.91
1999-2000	1711	808.41
2000-01	1402.29	625.38
2001-02	1752.05	780.13
2002-03	2140.69	985.23
2003-04	2599.54	1184.74
2004-05	2323.20	1049.75
2005-06	2512.32	1140.56
2006-07	3044.51	1335.22
2007-08	3364.72	1444.65
2008-09	3251.52	1591.05
2009-10	3754.44	2023.77
2010-11	3266.63	1823.05
2011-12	3680.91	2433.12
2012-13	3597.30	2628.74
2013-14	4468.27	3503.78
2014-15	4236.00	3270.28
2015-16		

Note: The export of coir geo textiles before 1994-95 was included in the export of handloom mattings.

33. Protection of road embankment using coir geo textiles

Eroded embankment of road

road embankment of

Leveling of eroded

Coir geo textiles laid road embankment

Stabilised road embankment

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir

geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of either 15 cm long U-shaped nails or 22 cm long J shaped hooks made of 3 mm iron or steel wire.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. The U shaped nails or J shaped hooks should be driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. Wooden pegs may also be used for fixing the coir geo textiles. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric.

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per

sq.metre after the coir Bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides. Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately. First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

Monitoring

Close monitoring should be carried out for at least two-season cycle. Displacement of Coir Bhoovastra, if any, is to be noted and watched without disturbing it initially. Fresh Coir Bhoovastra pieces duly stapled on all sides should be applied to overlap torn portions. Care must be taken to protect the treated site from trampling by human and cattle till vegetation comes up fully.

34. Reinforcement of rain water harvesting pond and stream embankment using coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth


Reinforcement of rainwater harvesting pond at Thozhuthur, Kumbakonam, Tamil Nadu

and promotes vegetation retaining precious topsoil. Coir boovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface. The nettings are normally produced on coir handlooms out of 2-ply coir yarn, with a width 1-2meter and 50-meter length.

It is an ideal geo textile for situations where land is sloppy which may lead to rilling and gulling. In such slopes, heavy rainfall causes loss of soil. In the areas of scanty rainfall where soil is non cohesive and prone to wind blowing, open weave coir bhoovastra provides adequate protection. There is no need for post installation work.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.


Reinforcement of stream embankment, Vellamathara, Kuttanadu

35.Protection of hills slope embankment using coir geo textiles

Laying of coir geo textiles

Laying of coir geo textiles in trench

Planting of grass sapling

Hill slope protection

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir Bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface. The nettings are normally produced on coir handlooms out of 2-ply coir yarn, with a width 1-2meter and 50-meter length.

It is ideal geo textiles for situations where land is sloppy which may lead to rilling and gulling. In such slopes, heavy rainfall causes loss of soil. In the areas of scanty rainfall where soil is non cohesive and prone to wind blowing, open weave coir bhoovastra provides adequate protection. There is no need for post installation work.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of either 15 cm long U-shaped nails or 22 cm long J shaped hooks made of 3 mm iron or steel wire.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. The U shaped nails or J shaped hooks should be driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. Wooden pegs may also be used for fixing the coir geo textiles. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric.

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

36. Protection of canal embankment using coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1".

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for

Protection of canal embankment,Arattupuzha

better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along

sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately. First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

37. Protection of chromites mine fields using coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1".

The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of “Check Dams” per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During

the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

38. Protection of irrigation canal embankment using coir geo textiles

Protection of irrigation canal embankment,Muvattupuzha and Kabini canal embankment, Mysore

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir Bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

39. Stabilization of landslide using coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir

Stabilization of landslide Khandikhal, Uttarkhand

fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres.

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

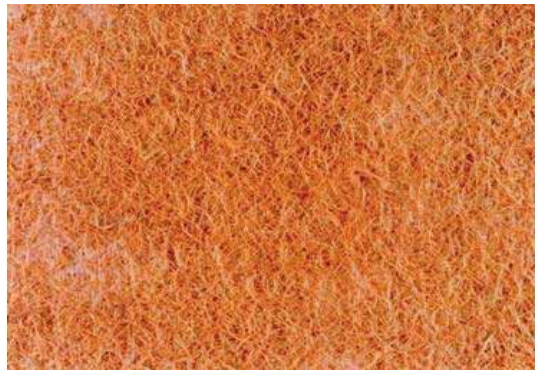
The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

Trees may be planted through the open spaces between the strands of coir geo First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and textiles after laying. Surface is leveled again by compacting the loose soil.

40. Protection of clay embankment using coir needled felt

Laying of coir needled felt and Stabilized clay embankment, NH Byepass, Kozhikode

Coir needled felt



Coir needled felt is a non woven fabric of various densities made from needle punching of coir fibre. In the manufacturing process, well cleaned coir fibres of good staple length pass through the cleaning machines by pneumatic suction and punched by the needle loom on one side to manufacture felts of different density depending upon punching intensity, needle penetration and thickness. The fibre is mechanically bonded (interlocked) to form a continuous length of sheet. No bonding material is used in the manufacture. It can be manufactured in thickness from 10 mm to 20 mm with a density varying from 500 to 1500 g/sq.m. The felts have excellent moisture absorption and retention characteristics and form an ideal medium for plant growth.

Coir needled felts are available in blanket forms backed with nets made of jute, polypropylene and polythene also. The coir non woven blankets are composed of 100% coir fibre randomly needle punched to the desired degree of compaction.

The coir bhoovastra of low mesh can effectively be used for soil stabilization techniques in road construction. The use of coir geo textiles varieties of 700g (H_2M_5, H_2M_2 & H_2M_8) and 900g ($H_2M_{9)}$ with 1/2 inch mesh as an interface between the sub grade and the sub base increases the strength of the pavement and prevents intermingling of the soil and the granular sub base which improves drainage. The soil condition and its structure may be assessed before laying of coir geo textiles for better result.

The rural unpaved roads are leveled, clearing of all foreign materials including uprooting of any vegetation if present. The area is leveled with earth and rolled for compaction to set the optimum moisture content. To facilitate easy unrolling on the surface of the sub grade to be treated, the coir bhoovastra, in rolls of 1 to 2m width, is spread directly over the leveled sub grade, ensuring that it should touch the sub grade surface at all points.

The edge of the coir bhoovastra should be folded back. The coir bhoovastra should be

folded back or cut and overlapped in the direction of the turn on application in curve. The granular material is spread over coir bhoovastra (15 cm thick) to prevent puncture / damage due to rolling of the upper sub base/ base layer and rolled with a light or medium roller. The second layer of coir bhoovastra is layed again and sand is applied up to a thickness of 15cm thick and rolled.Under the weight of the base layer and the compactive effect, the sub grade loses water draining through the coir bhoovastra and gains in strength. Due to the inherent tensile strength, the coir bhoovastra acts as a support membrane and reduces localized distress on the road surface by redistributing traffic loads over a wider area of the road surface.

Once the coir bhoovastra is placed on the weak sub grade, the sub grade stiffens and becomes stronger on consolidation within in a year or so under the action of the granular sub base surcharge, self-weight of pavement, construction rolling and traffic loads. The Coir Bhoovastra immensely helps in this rapid sub grade strengthening process in combination with the drainage layer above it. With time, the sub grade becomes less and less dependent on the fabric for its stability and therefore, the long-term durability aspect of coir should not deter its use as geo textiles for various applications in road construction.

The condition of coir bhoovastra should be assessed for any constructional / installation damages before covering. Torn / damaged portions may be covered by pieces of coir geo textiles and the extent of overlap will be such as to cover the damaged / torn portion fully plus at least 75 mm beyond, on all sides.

In the case of clay sub grades, a cushion layer of 10 cm thick sand is laid before spreading. The coir bhoovastra or coir bhoovastra layers can be increased to 3 or 4 depending on condition of the soil.

41. Stabilisation of eroded slopes of railway embankment by coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. coir choovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment,

Protection of railway embankment, Konkan railway

open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The Coir Bhoovastra is pegged using wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

42.Appliction of coir geotextiles for reinforcement of mudwall for protecting canals

Reinforcement of mudwall,Monkompu,Kuttanadu

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden

pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The coir bhoovastra is pegged using wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

43.Creation of greenery over rocky patches using coir geotextiles

Laying of CGT over exposed rocky patches

Spreading of coir pith over CGT

Regeneration of exposed of rocky patches

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment,

open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The coir bhoovastra is pegged using wooden pegs driven at intervals of 50-

75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

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44. Protection of dam against siltation using coir geotextiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir Bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp

Eroded bank and Geo textiles laid on leveled bank of reservoir, Kakkayam

Protection of Kakkayam reservoir bank

and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The coir bhoovastra is pegged using wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

45. Protection of river embankment using coir geotextiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir


Laying of coir geo textiles and planting of grass on laid coir geo textiles on Periyar river bank

Protection of Periyar river bank

fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The Coir bhoovastra is pegged using wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure

that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

46. Prevention of soil erosion due to runoff on the banks of river using cocolog

Cocolog laid on the banks of Pampa river for preventing soil erosion

Cocologs are made from coir fibre bunches under pressed condition in tubular enclosures of knotted coir yarn. They are having a shape similar to a wooden log. They vary in diameter, length and weight. The diameter varies from 30 cm to 50 cm, weight from 60 kg to 180 kg, usually produced with a length of 6 metre. Charcoal is also used intermittently for filling the logs as additional manure for faster growth of plants. Cocologs are mainly used for vulnerable rivers to protect scour. The rolls are attached at the edges of the bank and secured by wooden stakes/ pegs. The pegs may be used on alternate sides of the log.

For high embankment areas with variable water level, several cocolog can be applied as a stack. Relatively steep stream banks can be covered with pre planted cocobeds. Sediments will be collected and held in cocobeds, which helps in plant growth and purifies water to a certain extent.

47. Erosion control of soil and water conservation for vegetable crop on steep slope laid with coir geo textiles

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process.

Leveled steep slope

Leveled slope laid with coir geo textiles

Leveled slope with brinjal at Konni

It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: slope assessment, nature and consistency of the soil cover, the extent of damage, rainfall patterns etc., and thereby choose the right kind of coir bhoovastra as well as the seed or saplings for the vegetation cover.

Site preparation:

The slope area is demarcated. The surface is leveled. The slope is prepared and the soil is tamped to the desired shape by rounding of the tips ensuring uniform contact of the coir geo textiles with soil over the entire area to guide the run off to flow over the net. The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the prepared slope needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs.

The sides, top and bottom of coir geo textiles are anchored into the trenches of 30 cm deep and 15 cm width, free from mud / soil slurry at the sides and the bottom. Wooden pegs may be used for fixing the coir geo textiles driven at intervals of 50 – 75 cm; along sides and overlapping sections at a distance of 30-50 cm. The hooks must be at the same

level with the ground for smooth water flow over the joint to the next fabric

Laying

The erosion control blanket is to be laid in a direction of the water flow starting from the top to the bottom. The rolls are to be rolled down the slope and are cut at the end .The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together.

The top and bottom ends of the coir bhoovastra are fixed into slots about 30cm deep, dug into the slope. The slots are filled with soil and tamped to pick up even with the soil surface. The coir bhoovastra is pegged using wooden pegs driven at intervals of 50-75cm, along sides and overlapping sections at a distance of 30-50 cm.

Second seeding of grass is done 10g per sq.metre after the coir bhoovastra is in place. Finally, the coir bhoovastra is flushed with the soil surface. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy germination of the seeds. The treated slope is irrigated as required to promote the growth of vegetation. When fully laid, the coir bhoovastra will protect the slope against soil erosion and create permanent greenery on the surface.

Vegetation & seeding.

The plant species are selected on the basis of suitability to the climatic conditions of the site. If the slopes are entirely raw and infertile and if the soil happens to be slightly acidic, calcium ammonium nitrate is applied @50 kg per 1000 sq.metre in solution.

The seeds after germination should take up deep rooting system. After preparing the soil surface, the seeds have to be applied on the surface by hand broadcasting or by hydraulic means and the coir bhoovastra to be laid over the seeds almost immediately.

First seeding of grass is done at 10g per sq.metre or alternative planting such as root slips may also be done. For quick coverage, rooted slips of grasses and cuttings of shrubs and trees may be planted through the open spaces between the strands of coir geo textiles after laying. Surface is leveled again by compacting the loose soil.

48. Coir geo-rolls for high velocity stream bank protection

Cocologs are made from coir fibre bunches under pressed condition in tubular enclosures of knotted coir yarn. They are having a shape similar to a wooden log. They vary in diameter, length and weight. The diameter varies from 30 cm to 50 cm, weight from 60 kg to 180 kg, usually produced with a length of 6 metre. Charcoal is also used intermittently for filling the logs as additional manure for faster growth of plants. Cocologs are mainly used for vulnerable streams or lake bank to protect scour. The rolls are attached at the edges of the bank and secured by wooden stakes/ pegs. The pegs may be used on alternate sides of the log. Relatively steep stream banks can be covered with pre planted cocobeds. Sediments will be collected and held in cocobeds, which helps in plant growth and purifies water to a certain extent.

Planting of grass on laid geo roll

Stream bank protected with geo rolls

49.Weed control & mulching using coir geo textiles

Template planting (pineapple) and as a mulch

Coir needled felt

Coir needled felt is a non woven fabric of various densities made from needle punching of coir fibre. In the manufacturing process, well cleaned coir fibres of good staple length pass through the cleaning machines by pneumatic suction and punched by the needle loom on one side to manufacture felts of different density depending upon punching intensity, needle penetration and thickness. The fibre is mechanically bonded (interlocked) to form a continuous length of sheet. No bonding material is used in the manufacture. It can be manufactured in thickness from 10 mm to 20 mm with a density varying from 500 to 1500 g/sq.m. The felts have excellent moisture absorption and retention characteristics and form an ideal medium for plant growth.

Coir needled felts are available in blanket forms backed with nets made of jute, polypropylene and polythene also. The coir non-woven blankets are composed of 100% coir fibre randomly needle punched to the desired degree of compaction.

Coir netting

Coir geo textiles are permeable fabric capable to control soil erosion. It protects the earth and promotes vegetation retaining precious topsoil. Coir bhoovastra is made from coir fibre/yarn extracted from coconut husk either by natural retting or by mechanical process. It is a woven fabric of two treadle in construction made from coir yarn in which the warp and weft strands are positioned at a distance to get a mesh (net) effect of ¼", ½" and 1". The netting (mesh) gives the grass plenty of room to grow, at the same time it provides large number of "Check Dams" per square meter of soil surface.

The open weave coir bhoovastra initially holds the ground for seeds and seedling and provides a mechanical support against water erosion helps the germination of seeds for better and growth of the plants conserving moisture and adds organic matter to the soil after degradation. In areas where vegetation is poor or takes longer time for establishment, open weave coir bhoovastra can hold the soil together for a longer period of time in comparison to other natural fibres

Guidelines for installation of coir geo textiles

Site assessment

The first step in the application of coir bhoovastra is to make a detailed study of the site like: nature and consistency of the soil cover, the extent of damage, rainfall patterns etc

The ground has to be made free of protruding stones, earth masses etc, but natural budges can be left as it is. Before applying any seedling, the site needs to be relatively free of weeds, stones, root stumps and gullies etc.

Fixation

The open mesh coir geo textiles are laid side by side by overlapping of 15 cm while end to end overlapping of two coir geo textiles is 20 cm. The overlapping edges are fixed on the ground with the help of 15cm wooden pegs driven at intervals of 50 – 75 cm. The hooks must be at the same level with the ground for smooth water flow over the joint to the next fabric

Laying

The coir bhoovastra should be laid loosely and evenly without stitch. Adjoining coir geo textiles should overlap 15cm or be stitched together. Care should be taken to ensure that no aggregate stays between coir bhoovastra and the base soil either at the bottom sides.

Once or twice sprinkling of water is recommended if the weather is hot and dry. During the first few days, the moisture levels are to be properly monitored to facilitate easy growth of the plants.

भारतीय सड़क कांग्रेस
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No.IRC:24(12)/2016/Coir Geo Textiles

Dated: 08.07.2016

M/s Coir Board,
Central Coir Research Institute,
Kalavoor,
P.O. Alleppey District,
Pin-688522
E-mail:ccrikalavoor@gmail.com

Sub: **Renewal** of Certificate of Accreditation of New/Alternative materials/techniques technologies/equipment for adoption in the Highway Sector namely **"Coir Geo Textiles"**

Sir,

I am directed to state that the presentation was made to the Accreditation Committee of IRC on 14th May, 2016 by the Director, M/s Coir Board for renewal of validity of Accreditation for the product stated in the subject which was first renewed on 11.12.2013 vide letter No.IRC: 24(12)/2010(ACC-61). It was presented that the proposed new material is a naturally occurring 100% organic fiber obtained from coconut husk abundantly available resistant to rot, moulds and moisture and needs no chemical treatment and serves the purposes of Reinforcement, Separation,Filtration and Drainage – in road construction. The Committee taking into cognizance the perpetuity of accreditation of the product has recommended to renew its validity with the request to submit the performance reports. It is, therefore, decided to renew the validity of accreditation w.e.f. 11.12.2015 for the new material under the trade name **"Coir Geo Textiles"** promoted by M/s Coir Board to be deemed accredited ***on trial basis*** for adoption in the Highway Sector subject to the following:

(i) The Accreditation certificate shall remain valid for a period of **two years** from the date of issue of this Certificate for Accreditation or **till the date the licensee (manufacturer/distributor/vendor etc) enjoys the legal marketing right entrusted passed on him by the Patent Company /Sole Proprietor of material /technology in accordance to the agreed terms, whichever is earliest.**

(ii) The developer/promoter shall to strive to furnish the performance reports of the accredited material/technique from the client/user agency (State PWD/NHAI/BRO/NHIDCL/Rural Road Agencies/Corporate Bodies etc.) evaluated over a period of time (preferably half yearly cycle) to establish their suitability for adoption and formulation of guidelines and codes of practice for their future usage in the Highway Sector.

(iii) The promoter/developer of the accredited material/technique shall be required to bear the extra cost involved in the field trials.

(iv) The developers/promoters shall strive to establish permanent base in India and show long term commitment to the goal of innovative infrastructure development in India.

Yours faithfully,

(Sunil Ishrawat)
Tech. Asstt.

References:

1. "Retted (white) Coir Fibre Nettings-the Ideal Choice as Geo textiles for Soil Erosion Control by K.George Joseph and U.S.Sarma, paper presented and published in the proceedings ofthe IECA's 28th Annual Conference, Tennesee, USA held on 25-28,February ,1997 pg. 67-76.

2. "Application of Eco-friendly Coir Geo textiles for Canal/River Bank Protection"A.C.Jose, U.S.Sarma, K.R.Anil and M.Kumaraswamy Pillai, Poster presentation in the Annual Conference of International Erosion Control Associations, 2006 at California, Feb 21- 24

3. "Versatile Coir Geo textiles"' A.C.Jose and U.S.Sarma, Poster presentation in the Annual Conference of International E rosion Control Association, 2007 at Reno, Nevada.

4. "Application of a Coir Geo textile Reinforced Mud wall in an Area below Sea level at Kuttanad, Kerala"'U.S.Sarma and A.C.Jose, accepted for presentation in the Annual Conference of International Erosion Control Association, 2008 at Orlando, Fluoridate 18-22.

5. "Coir Geo textiles and its Applications", by U.S.Sarma, paper in the 2nd International Workshop on Geo textiles Organized by the Committee for International Geo textiles Society (India) held at New Delhi on 11-12 January, 1994.

6. "Manifold Potentials of Coir Geo textiles"' by U.S.Sarma and M.Kumararaja, paper presented at the Seminar on Coir Geo textiles" held at Alleppey *and* published in the Coir News, Vol.26, No.4, April20, 1997, P.27-30.

7. "Eco-friendly&VersatileCoirGeotextiles"'byU.S.Sarma,GeosyntheticAsia'97,Vol.I,26-29 Nov.1997 ,Bangalore,India,Eds,C.V.J.Varma,G.V.Rao and A.R.G.Rao,Publishers,Oxford and IBH publishing Co. Pvt .Ltd,New Delhi, SessionVI,P.49,1997.

8. "Coir Bhoovastra for Soil Bio-engineering Applications"' by U.S.Sarma ,presented at the National Seminar on Coir Bhoovastra organized by Coir Board at New Delhi, on 21 March 2003.

9. "Versatile Coir Geo textiles", paper presented at the International Seminar on "Geo synthetics in India-Present and future"' by U.S.Sarma at New Delhi from 8th to 10th November 2006.

10. "Applications of Geo synthetics –Use on Roads Sub grades"' by U.S.Sarma, paper presented at the Workshop on Applications of Geo synthetics-Present and Future ",at Ahmedabad from 20-21st September 2007.

11. "Use of Coir Bhoovastra in Civil Engineering Applications", by G.V.Rao, paper presented at the National Seminar on Coir Bhoovastra organized by Coir Board at New Delhi, on

21March 2003.

12. "Application of Coir Bhoovastra in Watershed Management", by J.P.Juyal, paper presented at the National Seminar on Coir Bhoovastra organized by Coir Board at New Delhi, on 21March 2003.

13. "An Overview of Projects using Coir Bhoovastra undertaken by Coir Board", by M.Kumaraswamy Pillai, paper presented at the National Seminar on Coir Bhoovastra organized by Coir Board at New Delhi, on 21March 2003.

14. "Erosion Control with Coir Geo textiles "by Dr.K.Balan, paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

15. "Potential Use of Indian Coir Geo textiles " by Shri.C.R.Devarajan , paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

16. "Coir geo textiles for Twenty first Century " by Shri.Manavalan , paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

17. "An Overview of the Prospects of Coir Geo textiles " by M.Kumaraswamy Pillai, paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

18. "Application and Trends of Geo synthetics in Civil Engineering " by Shri.J.N.Mandal, paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

19. "Strength of Coir Geo-textiles & its Potentials " by Shri.S.K.Kuppuswamy, paper presented in the Seminar on Coir Geo textiles organized by Coir Board at Alleppey ,on 28 January 1997

20. "Coir Netting for Erosion Treatment and Sacrificial Landslide Correction" by Shri T.K.Natarajan,Shri.P.J.Rao and A.V.S.R.Murthy , paper presented in the Workshop on Geo grids and Geo fabrics in Civil Engineering Practice organized by Coir Board at Coimbatore ,on 21st September 1988.

21. "A Role for Coir fibre Geo fabrics in Soil Stabilization and Erosion Control" by Shri. Cammack, paper presented in the Workshop on Geo grids and Geo fabrics in Civil Engineering Practice organized by Coir Board at Coimbatore ,on 21st September 1988.

22. "Coir Netting Technique for Controlling Erosion of Soils in Hillside Slopes of Nilgiris" by A.Venkatarangaraju, R.Narayanan, N.Venkatarama and S.Ambethkar, paper presented in the Workshop on Geo grids and Geo fabrics in Civil Engineering Practice organized by Coir Board at Coimabtore, on 21st September 1988.

23. “Utilization Potential for Coir Fabrics as Geo textile Material” by Shri.Henner Schurholz, paper presented in the Workshop on Geo grids and Geo fabrics in Civil Engineering Practice” organized by Coir Board at Coimbatore ,on 21st September 1988.

24. “Coir based Products in Civil and Soil Biotechnical Engineering –Development Imperatives” by G.Venkatappa Rao

25. “Testing and Application of Coir based Geo textiles” by G.V.Rao and R.K.Dutta

26. “Testing of Geo textiles for Weathering” by Dr.Mangala Joshi

27. “Coir Geo textiles: Emerging Trends”by G.Venkattappa Rao and K.Balan

28. ”Comprehnsive Reference Book on Coir Geo textiles “, Edited by.T.S.Ramanatha Iyer, C.G.Ramachandarn Nair and N.Balakrishnan Nair and published by Center for Development of Coir technology

29. IS 158 68 2008(Part 1-6) - Natural fibre Geo textiles (Jute Geo textile and Coir Bhoovastra) – Methods

30. IS 15869:2008 Textiles-Open Weave Coir Bhoovastra -Specifications

31. IS 15871:2009 Use of Coir Geo textiles (Coir Bhoovastra) in Unpaved Roads-Guidelines

32. IS 12503(Part 2) 1988 Coir Matting, Mourzarks and Carpets

33. ”Indian Coir a reference book”’ Edited by P.K.Ravi and published by Coir Board

34. Ajitha, B., Jayadeep, T., 1997. . “Interfacial frictional properties of geo textiles and biomats”,in: Proceedings of Indian Geotechnical Conference, Vadodara, India, Vol.1, pp. 287-290.

35. Anderson, P., Killeavy, M., 1989. “Geo textiles and geo grids-cost effective alternate materials for pavement design and construction” In: Geosynthetics’89, San Diego,USA, vol. 2, 353-364

36. Babu, K.K., Beena, K.S., Raji, A.K., 2008.”Design of Coir Geo textiles reinforced Road using IRC method”. Highway Research Journal, Special Issue

37. Cancelli, A., Montanelli, F., 1999. “In-ground test for geo synthetic reinforced flexible paved roads”. Proceedings of Geo synthetics ’99, Vol. 2, Boston, USA, pp. 863-879.

38. Chauhan, M.S., Mittal, S., Mohanty, B., 2008. Performance evaluation of silty sand sub grade reinforced with fly ash and fibre, Geo textiles and Geo membranes 26 (5), 429-435.

39. Datye. K. R, Gore. V. N., (1994) "Application of natural geo textiles and related products" Geo textiles and Geo membrane 13,371-388

40. Fannin, R.J., Sigurdsson, O., 1996 "Field observations on stabilization of unpaved roads with geo textiles" Journal of Geotechnical Engineering, ASCE. 26(7): 544-553.

41. Giroud, J.P, Noiray, L, 1981. "Geo textile reinforced unpaved road design" Journal of Geotechnical Engineering ASCE 107 (9), 1233–1254.

42. IRC: 81-1997 Guidelines for Strengthening of Flexible Road Pavements using Benkelman Beam Deflection technique.

43. IRC: SP 72 – 2007 Guidelines for the design of flexible pavements for Low volume Rural Roads.

44. IS: 2720(Part 16) – 1979, Methods of Test for Soils: Determination of California Bearing Ratio.

45. IS 2720 (Part 5)-1985, Methods of Test for Soils: Determination of Atterberg Limits.

46. IS 2720 (Part 8)- 1983, Methods of Test for Soils: Determination of Water Content – Dry Density Relation using Heavy Compaction.

47. IS: 15868 (Parts 1 to 6) – 2010. Methods of test natural fibre geo textiles (Jute geo textile and Coir bhoovastra)

48. Khanna,S.K, Justo. C.E.G, "Highway Engineering", published by New Chand and Bros., Roorkee, Eighth Edition, 2009.

49. M.V.L.R..Anjaneyulu, "Evaluation of Pavement Performance"

50. Perkins, S.W., 1999a. Geo synthetic reinforcement of flexible pavements: laboratory based pavement test sections.Final Report FHWA/MT-99-001/8138, State of Montana Department of Transportation, MT, USA, 140 p.

51. Perkins, S.W., 1999b. Mechanical response of geo synthetic-reinforced flexible pavements, Geo synthetics International 6 (5), 347-382

52. Rao. G. V, Balan. K, (2000) "Coir Geo textiles Emerging trends". The Kerala State Coir Corporation LTD (publishers) Alappuzha, Kerala.

53. Rawal, A., Anandjiwala, R., 2007. Comparative study between needle punched nonwoven geo textile structures made from flax and polyester fibres, Geo textiles and Geo membranes 25 (1), 61-65.

54. Sankariah, B., Narahari, R., 1988." Bearing capacity of reinforced sand beds" In:Proc.

on First Indian Geo textiles Conference on Reinforced soil and geo textiles,Bombay, India, pp. C11-C13.

55. Sarsby, R.W., 2007. Use of 'Limited Life Geo textiles' (LLGs) for basal reinforcement of embankments built on soft clay. Geo textiles and Geo membranes 25 (4-5), 302-310.

56. Senthil, K.P., Pandiammal, D.S., 2011. Effect of needle punched nonwoven coir and jute geo textiles on CBR strength of soft sub grade, ARPN Journal of Engineering and Applied Sciences, Vol. 6, no. 11, November 2011.

57. Som, N., Sahu, R.B., 1999. Bearing capacity of a geo textile-reinforced unpaved road as a function of deformation - a model study. Geo synthetics International 6 (1), 1-17.

58. Subaida, E.A., Chandrakaran, S., Sankar, N., 2008. "Experimental investigations on tensile and pullout behaviour of woven coir geo textiles". Geo textiles and Geomembranes27, pp.

59. Constructional Details of Coir and Coir Products, published by the Coir Board.

60. Souvenir published by the Coir Board as part of IICF 2001

61. Evaluation of coir matting as a barricade material for stowing in mines- a feasibility study, published by the Coir Board.

62. Papers of Intensive Training on Application of Coir Bhoovastra at CCRI on 12-18 Feb 2001

63. Proceedings of the Workshop on Coir Geo textiles and geo fabrics in Civil Engineering Practice.

64. Quality Year, Coir 1993-94 – Colloquium on quality for coir exports 4th January 1994

65. Proceeding of the Seminar on Coir Geo textiles at Dehradun on 22nd May 1996

66. Proceedings of the Seminar on Coir Geo textiles held at Alappuzha on 28th January 1997

67. Study on Coir Geo textiles, Mar Athanasius College of Engineering, Kothamangalam

68. Proceedings of Seminar on Coir Geo textiles held at Coimbatore.

69. Geo synthetics – An introduction by G.Venkettappa Rao.

70. Modern Geo technical engineering by Dr.Alamsingh

71. Designing with geo by Robert M Koerner

72. ASTM Standards by ASTM International.

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Case Studies on application of Coir Bhoovastra in India by Coir Board

Sl.No	Type of Application	Coir Bhoovastra Applied Site	Year	Type of Coir Bhoovastra used & Area Laid
1.	Erosion control on hill slides through revegetaion	Hill slide slopes of Hindustan-Tibet National Highway – down hill near Idgah grounds in Simla. (Coir Board & CRRI, New Delhi)	1972	½ inch coir netting & 278.7 m^2
2.	Erosion control on railway embankments through revegetation	Railway embankment slopes near bridge No.154 Pathankot to Jammu Railway Link, 70 km from Pathankot. (Coir Board & CRRI, New Delhi)	1973	½ inch coir netting & 1200m^2
3	Erosion control of Road embankment through revegetation	Dolman - Nainital – Almora Road, U.P. (Coir Board & CRRI, New Delhi)	1987	1 inch coir netting & 500 m^2
4	Erosion control of soil slopes of highways through revegetation	Coonoor – Kundha Road (Nilgiris Hills), Tamil Nadu. (Coir Board & Highways Research Station, Chennai)	1988	1 inch coir netting & 3300 m^2
5.	Erosion control of soil slopes of highways through revegetation	Nagapatinam – Gudallore – Mysore Road, (Nilgiris), Tamil Nadu)	1988	1 inch coir netting & 630 m^2
6.	Erosion control of Road embankment through revegetation	Meerapur – Davel Road, Muzaffar Nagar UP (Coir Board & CRRI, New Delhi)	1988	1 inch coir netting & 750 m^2
7.	Erosion control of Road embankment through revegetation	Lambidhar Mines, Dehradun Dist., U.P (Coir Board & CRRI, New Delhi)	1988	1 inch coir netting & 1500 m^2
8.	Erosion control of Canal embankment through revegetation	Muvattupuzha Valley Irrigation Canal Project, Kerala. (Coir Board)	1994	H_2M_6 & 1000 m^2
9.	Erosion control of Canal embankment through revegetation	Kabani Canal, Mysore (Coir Board & Irrigation Department Karnataka)	1994	H_2M_6 & 22/90th mile to 23/90th mile
10.	Stabilization of road	NH-17 Byepass Coir Board & Sree Dhanya Construction Co.Thiruvananthapuram	1994	Non woven coir blanket (1000gsm) & Ch. 20870 to 28127
11.	Erosion control of Road slopes through re vegetation	Elite Gardenia, Muthuvara, Trichur, Kerala. (Coir Board)	1995	H_2M_5 & 640 m^2
12.	Erosion control of Road embankment through revegetation	Muvattupuzha, Kerala (Coir Board)	1995	H_2M_5 & 800 m^2

13.	Erosion control on Hill slides through revegetation	Upputhodu, Idukki, Kerala, (Coir Board)	1996	H_2M_6 & 500 m^2
14.	Erosion control of Eroded land slopes through revegetation	Cheruthoni, Idukki, Kerala (Coir Board)	1997	H_2M_5 & 1240 m^2
15.	Stabilisation of Mud wall of bunds	Rice Research Station, Moncompu, Kerala (Coir Board & KAU)	1998	M_2BR_3 & 150 m^2
16.	Erosion control on Hill slides through revegetaion	Itanagar, Arunachal Pradesh (Coir Board & BRO)	1998	H_2M_5 & 4000 m^2 & Cocolog (200 Nos.)
17.	Erosion control in reservoir	Kakkayam Hydro – electric Project, KSEB, Kerala (Coir Board & KSEB)	1998	H_2M_5& 3000 m^2
18.	Erosion control of slope of road	Gangtok, Sikkim (Coir Board & BRO)	1998	H_2M_5 & 2000 m^2
19.	Erosion control on Railway embankments	Kudal, Konkan Railway, Maharastra (Coir Board & Konkan Railway)	1998	H_2M_8 & 1530 m^2
20.	Erosion control of River embankment of Periyar	Chowara, Aluva, Kerala.(Coir Board)	1999	H_2M_5 & 1200 m^2
21.	Stabilization of fish pond	Mancompu (Coir Board and Kuttanadu Vikasana Samithi)	1999	M_2BV3 & 200 m^2
22.	Erosion control of soil and water conservation at varying slopes	Soil Conservation Research Station, Konni, Kerala (Coir Board & KAU)	2000	H_2M_6 /H_2M_5 / H_2M_8& 7000 m^2
23.	Regeneration of exposed rocky patches	Soil Conservation Research Station, Konni, Kerala (Coir Board & KAU)	2000	H_2M_8 / Coco log & 200 m^2
24.	Template planting and as soil mulch for cultivation of different crops (Pineapple, Brinjal, Ladiesfinger)	Soil Conservation Research Station, Konni, Kerala (Coir Board & KAU)	2000	Rubberised coir & 250 m^2 Coir needled felt & 1000 m^2
25.	Erosion control of Road embankments through revegetation	Bidadi Industrial Area, Karnataka (Coir Board & Karnataka Industrial Area Development Board(KIADB))	2000	H_2M_6 & 2350 m^2
26.	Erosion control of River Embankment of lake	Vellamathara, Kuttanad, Kerala (Coir Board)	2000	M_2BR_3 & 150 m^2
27.	Erosion control of Bridge embankment through revegetation	Railway overbridge, Nedumbasseri, Cochin International Airport, Kerala (Coir Board)	2001	H_2M_5 & 1800 m^2

28.	Erosion control of Road embankments through revegetation	Kohima, Nagaland (Coir Board & BRO)	2001	H_2M_8 & 6000 m^2
29.	Erosion control of Road embankments through revegetation	Campus of Indian Institute of Management, Kozhikode, a stretch of 5 km road (Coir Board)	2002	$H_2M_{6/}$ H_2M_5
30.	Stabilisation of River bank of Pampa	Soil Conservation Research Station, Tiruvalla (Coir Board & KAU)	2002	Cocolog & 180 running meter
31	Erosion control of Embankment through revegetation	Forest Research Institute, Tapovan, Gwalior, Madhya Pradesh (Coir Board)	2003	H_2M_6 & 800 m^2
32	Erosion control of Road embankment through revegetation	NH 53 at 23.10 km from Silchar, Assam (Coir Board & BRO)	2003	H_2M_6 & 4000 m^2 H_2M_8 & 2625 m^2
33.	Erosion control of Road embankment through revegetation	NH – 39 Kohima – Maran Road at 180.30 km, Kohima, Nagaland (Coir Board & BRO)	2003	H_2M_8 & 2625 m^2 & Cocolog (30 Nos.) of 30 cm diameter and 5 metre long.
34.	Stabilization of landslide through revegetation	Khandikhal village near Kempty water falls ,Uttarachal(Coir Board and Central Soil And Water Conservation Research and Training Institute(CSWCRTI)	2004	H_2M_6& 2000 m^2
35.	Stabilisaiton of embankment of road	Bhubaneswer, Orissa	2004	H_2M_6 & 100 m^2
36.	Soil stabilisation of Rural unpaved Road	Thaneermukkam, Cherthala, Kerala. (Coir Board and CUSAT)	2005	H_2M5 &1200 m^2
37.	Erosion control of Road embankments through revegetation	2nd phase at IIM (K), (Coir Board)	2005	$H_2M_{6/}$ H_2M_5
38.	Construction of pavement road	Kuttiyadi Augmentation Scheme, KSEB, Kozhilkode, Kerala (Coir Board & KSEB)	2005	Coir needled felt (1000 gm / m^2) and 1000 m^2
39.	Stabilization of rain harvesting pond / Road side	Kurichi, Coimbatore (Coir Board and Govt. of Tamil Nadu)	2006	H_2M_5 & 250 m^2
40	Erosion control of Road embankments through revegetation	3rd phase at IIM (K) (Coir Board)	2006	$H_2M_{6/}$ H_2M_5
41.	Stabilization of rain harvesting pond	Tanjavoor (Coir Board and Tamil Nadu Co-Operative Coir Marketing Federation (TANCOFED)	2007	H_2M_5 & 900 m^2

42.	Stabilization of rain harvesting pond	Madurai, (Coir Board & TANCOFED	2007	H_2M_5 & 350 m^2
43.	Stabilization of rain harvesting pond	Kanchipuram, (Coir Board and TANCOFED	2007	H_2M_5 & 1200 m^2
44.	Stabilization of rain harvesting pond	Yanepoya Medical College, Mangalore	2007	H_2M_6 & 2000 m^2
45.	Stabilisaitn of Hill slope	Shillong, Meghalaya (Coir Board & BRO)	2007	H_2M_6 & 50 m^2
46.	Stabilization of rain harvesting pond	Thozhuthur, Kumbakonam, Tamil Nadu with Indian Waste Land Development Project, DRDA, Cuddallore	2008	H_2M_5 & 200 m^2
47.	Erosion control of Road embankments through revegetation	Kohima, Nagaland (Coir Board & BRO)	2008	H_2M_8 & 5100 m^2
48.	Stabilization of rain harvesting pond	Thozhuthur, Kumbakonam, Tamil Nadu with Indian Waste Land Development Project, DRDA, Cuddallore	2008	H_2M_5 & 1000 m^2
49.	Stabilization of the Embankment	Madhuvanan, Sree Sathya Sai Trust, Thiruvananthapuram (Coir Board)	2008	H_2M_5 & 1200 m^2
50.	Stabilization of slip prone embankment of clay	Padijarethara,Kerala(Coir board & Centre for Water Resources Development & Management(CWRDM))		Coir needle felt (1000gsm ,length 36Km and width 4.5m)
51.	Stabilization of mining dump	Orissa Mining Corporation, Kaliapani (Coir Board and Aspinwall)	2008	H_2M_8& 6000 m^2
52.	Drainage medium for soft ground improvement and as random reinforcing material	Bangalore (Coir Board and Indian Institute of Science, Bangalore)	2008	Coir Needled felt
53.	Stabilization of embankment	Campus of College of Engineering, Thiruvananthapuram (Coir Board)	2008	H_2M_9& 100 m^2
54	Stabilization of unpaved road	Mangalabharathy - SN Kadavu Road, Alappuzha, Kerala,Coir Board & CoE , Thiruvanathapuram	2008	H_2M_8 &100 m length
55.	Stabilization of unpaved road	Kannali Palam, Haripad(Coir Board)	2009	H_2M_5 & 150 m^2

56.	Stabilization of rain harvesting pond	Ramanatham Water Shed, Thozhuthoor, DRDA, Cuddallore (Coir Board)	2009	H_2M_5 & 1700 m^2
57.	Stabilization of unpaved road	Chammuruthy – Njakkad Road, Varkala, Thiruvananthapuram Coir Board & CoE , Thiruvanathapuram	2009	H_2M_5 & 150 m^2
58.	Stabilization of mud wall	Rajagiri College of Engineering, Kalamassery (Coir Board)	2009	M_2BR_3 & 150 m^2 & Cocolog 3 Nos.
59.	Stabilization of mud wall	Arattupppuzha, Haripad, Alappuzha, Kerala (Coir Board)	2009	H_2M_5 & 600 m^2
60	Stabilization of stream and embankment protection	Arattupppuzha, Haripad, Alappuzha, Kerala(Coir Board)	2009	H_2M_5 & 250 m^2
61	Stabilization of unpaved road	Chirakkad- Kumbakkad road(Varkala), Thiruvanathapuram, Kerala Coir Board & CoE , Thiruvanathapuram	2009	H_2M_6 &100 m length
62	Stabilization of water harvesting pond	Forest Research Institute, Gwalior	2009	H_2M_8 & 300m^2
63	Stabilization of village road	Karuvatta,Alappuzha, Coir Board & College of Engineering , Thiruvanathapuram	2009	H_2M_5 &150 m^2
64	Stabilization of road embankment	27 th Mile, Kallar, Coir Board & College of Engineering , Thiruvanathapuram	2010	H_2M_6 &150 m^2
65	Slope Stabilization of river embankment	Mrs.Radha.S.Pillai, Moonukulangara House, Parappuram.P.O, Kanjoor, Ernakulam (dist).	2010	H_2M_5 & 600 m^2
66	Stabilization of unpaved village road under PMGSY	Puthusserikadavu-Kakkatikara in Ernakulam Dist. ,Coir Board & CoE , Thiruvanathapuram	2011	H_2M_5 & 222m
67	Stabilization of unpaved road under PMGSY	Kozhinada-Murukkampuzha road, Thiruvanathapuram, Kerala Coir Board & CoE , Thiruvanathapuram	2011	Non woven (Coir needled felt) &100 m length
68	Stabilization of unpaved village road under PMGSY	Karikuzhi- Chikidampara in Trivandrum Dist.,Coir Board & CoE , Thiruvanathapuram	2011	H_2M_5 & 470m

69	Stabilization of unpaved village road	Attukal- Pamapadi Trivandrum Dist, Coir Board & CoE , Thiruvanathapuram	2011	H_2M_5 & 150m
70	Stabilization of unpaved village road under PMGSY	Kumbarivila-Kollante mukku in Kollam Dist., Coir Board & CoE , Thiruvanathapuram	2011	H_2M_5 & 1.168km
71	Stabilization of unpaved village road under PMGSY	ANC Jn.-Mulamootilpadi in Pathanamtitta Dist. ,Coir Board & CoE , Thiruvanathapuram	2011	H_2M_5 & 2.500km
72	Slope stabilization in a coffee drying yard	Hope Estate, Meppady.P.O., Wayanad.	2011	H_2M_5 & 800m^2
73	Stabilization of road embankment	Slope stabilization at HPCL site Gaighat, Bihar (Premises of Petrol Bunk)	2012	H_2M_5
74	Stabilization of Mine Dump	Mine Site Reclamation Work Project ,Coir Board and NMDC Limited, Kirandol, Dantwada ,Chattisgarh	2012	H_2M_5
75	Stabilization of unpaved village road under PMGSY	Manakodam Ration kada Road , Aleppey Dist. ,Coir Board & CoE , Thiruvanathapuram	2013	H_2M_5 & 750m
76	Stabilization of unpaved village road under PMGSY	Keelaiyur-Mattankarai Road, Nagapattinam District, Tamil Nadu, Coir Board &NIT, Trichy	2014	H_2M_5, H_2M_6 & H_2M_8 & 250 m
77	Stabilization of unpaved village road under PMGSY	Thiruvilaiyattam-Neelaveli-Kodavilgam Road, Nagapattinam District, Tamil Nadu, Coir Board &NIT, Trichy	2014	H_2M_5 & H_2M_6 & 200 m
78	Stabilization of unpaved village road under PMGSY	Vellalar Theru Road, Thanjavur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	H_2M_5 & H_2M_6 & 200 m
79	Stabilization of unpaved village road under PMGSY	Aeirakanni Road, Thiruvarur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	H_2M_5, H_2M_6 & H_2M_8 & 250 m
80	Stabilization of unpaved village road under PMGSY	Km 2/4 of Cheyur – Kuttagam-Salaipalayam, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	1250 m H_2M_5, H_2M_6 &
81	Stabilization of unpaved village road under PMGSY	Kandiyan Koil-Thayampalayam, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	3400 m H_2M_5, H_2M_6 &

82	Stabilization of unpaved village road under PMGSY	Kolumam-Kallapuram Road- Navalodai Colony, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	1000 m H_2M_5, H_2M_6 &
83	Stabilization of unpaved village road under PMGSY	Sugar mill road- Kalliyapuram road, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	1800 m H_2M_5, H_2M_6 &
84	Stabilization of unpaved village road under PMGSY	Erisinampatty- Thirumurthi Settlement, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	2850 m H_2M_5, H_2M_6 &
85	Stabilization of unpaved village road under PMGSY	Udumalpet-Chinnar road- Etthikalmedu Attumalai Settlement , Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	2800 m H_2M_5, H_2M_6 &
86	Stabilization of unpaved village road under PMGSY	Elayamuthur-Poochimedu Road-Athithura, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	960 m H_2M_5, H_2M_6 &
87	Stabilization of unpaved village road under PMGSY	Elayamuthur- Poonikattuthurai road, Tiruppur District, Tamil Nadu, Coir Board &NIT, Trichy	2014	2150 m H_2M_5, H_2M_6 &
88	Stabilization of unpaved village road under PMGSY	Kamuthi – Sayalkudi road -Perumal Thalaivanendal, Ramanathapuram District, Tamil Nadu, Coir Board &NIT, Trichy	2014	2210 m H_2M_5, H_2M_6 &
89	Stabilization of unpaved village road under PMGSY	Kakkundu- Chavalappara, Kozhikodu District ,Kerala, Coir Board &NIT, Calicut	2014	H_2M_5 & 250 m
90	Stabilization of unpaved village road under PMGSY	Vazhikkadavau- Perumbuzha, Kozhikodu District ,Kerala, Coir Board &NIT, Calicut	2014	H_2M_5 & 500 m
91	Stabilization of unpaved village road under PMGSY	Korothumukku- Vannathipoyil, Kozhikodu District ,Kerala, Coir Board &NIT, Calicut	2014	H_2M_5 & 400 m
92	Stabilization of unpaved village road under PMGSY	Thanjavur – Sayalkudi road- Malatar road, Ramanathapuram District, Tamil Nadu, Coir Board &NIT, Trichy	2015	915 m H_2M_5, H_2M_6 &
93	Stabilization of unpaved village road under PMGSY	Chithirangudi- Ponthampuli road, Ramanathapuram District, Tamil Nadu, Coir Board &NIT, Trichy	2015	1755 m H_2M_5, H_2M_6 &

94	Stabilization of unpaved village road under PMGSY	Mittareddihalli- Komathampat-tipudur, Dharmapuri District, Tamil Nadu, Coir Board &NIT, Trichy	2015	800 m H_2M_5, H_2M_6 &
95	Stabilization of unpaved village road under PMGSY	Chatrapatty - Mallapuram road-Seethapatty, Dindigul District, Tamil Nadu, Coir Board &NIT, Trichy	2015	1505 m H_2M_5, H_2M_6 &
96	Stabilization of unpaved village road under PMGSY	Thallykothanur- B.B.Palayam, Krishnagiri District, Tamil Nadu, Coir Board &NIT, Trichy	2015	600 m H_2M_5, H_2M_6 &
97	Stabilization of unpaved village road under PMGSY	Maradi- Kattapalli, Tiruchirappalli District, Tamil Nadu, Coir Board &NIT, Trichy	2015	2850 m H_2M_5, H_2M_6 &
98	Stabilization of unpaved village road under PMGSY	Sobanapuram –Gandhipuram, Tiruchirappalli District, Tamil Nadu, Coir Board &NIT, Trichy	2015	3500 m H_2M_5, H_2M_6 &
99	Stabilization of unpaved village road under PMGSY	Kottamchantha- Chennankadu, Palakad District ,Kerala, Coir Board &NIT, Calicut	2015	H_2M_5 & 500 m
100	Stabilization of unpaved village road under PMGSY	Narasipuram- Poondi, Coimbatore District, Tamil Nadu, Coir Board &NIT, Trichy	2016	3786 m H_2M_5, H_2M_6 &
101	Stabilization of unpaved village road under PMGSY	Narasipuram - Vaithegi Falls road- Javvukadu (Via) Panchanvayal, Coimbatore District, Tamil Nadu, Coir Board &NIT, Trichy	2016	3750 m H_2M_5, H_2M_6 &
102	Stabilization of unpaved village road under PMGSY	Bhoomivathukkal- Jathiyeri, Kozhikodu District ,Kerala, Coir Board &NIT, Calicut	2016	H_2M_5 & 850 m
103	Stabilization of unpaved village road under PMGSY	Golkhedi- Sukhanipaniya Road to Barkhedi Hajjam	2016	2.1 km &H_2M_9
104	Stabilization of unpaved village road under PMGSY	Bhopal- Raisen Road to Raipura Ramsiya	2016	3.6km &H_2M_9
105	Stabilization of unpaved village road under PMGSY	Umraoganj- Siyakundal Road to Chiroliya	2016	2.3 km &H_2M_9
106	Stabilization of unpaved village road under PMGSY	Khamkheda to Salaikhedi	2016	3.2 km &H_2M_9
107	Stabilization of unpaved village road under PMGSY	Nayagola Road to Narkheda Khadya	2016	2.6km &H_2M_9

Case Studies for Stabilisation of Road, Hill and River Embankments using Coir Bhoovastra by Coir Board

LAKKUR, TAMIL NADU









HOPE ESTATE, WYNAD




Planting Template and as a Mulch

Protection of Irrigation Canal Embankment, Muvattupuza

Pamba River Bank Protection

Regeneration of Exposed Rocky Patches

Stabilisation of Village Road, Thaneermukkam, Alappuzha

Protection of Hills Slope Embankment, Gangtok

Protection of Canal Embankment, Arattupuzha

Protection of Chromites Fields, Kaliapani, Orissa

Protection of Canal Embankment, Bidadi, Karnataka


Protection of Kabani Canal Embankment, Mysore


Stabilization of Landslide, Khandikhal, Uttarkhand


Protection of Clay Embankment, NH Byepass, Kozhikode


Stabilization of Road Embankment, Muvattupuzha


Erosion Control of Soil and Water Conservation, Konni


Erosion Control of Road Embankment, IIM Kozhikode


Erosion Control of Embankment, Tapovan, Gwalior


Construction of Road Pavement, Kuttiyadi, Kozhikode


Stabilization of Fish Pond, Mancompu


Stabilization of Embankment, College of Engineering, Trivandrum


Stabilization of Embankment, Madhuvanam

Reinforcement of unpaved road in paddy field

Slope stabilisation

REINFORCEMENT OF PAVED ROAD

STABILIZATION OF POND

SLOPE STABILISATION OF CANAL

STABILISATION OF HILL SLOPES

Stabilisation of river embankment

KOZHINADA ROAD CONSTRUCTION

Before laying coir geo textiles

Leveled sub grade before laying coir geo textiles at Kozhinada


Laying of coir geo textile and Placing of soil above geo textile in Kozhinada


Placing of coir geo textile and surfacing of road Mangalabharathy SN Kadavu road in Haripad


Placing of coir geo textile and surfacing of Chirakkad- Kumbakkad road (Varkala)

Karikuzhy- Chekidampara Road


Before Construction

During Construction

During Construction

After Construction

Attukal- Pamapadi Road

Before Construction

During Construction

After Construction

Kumbarivila-Kollantemukku Road

Before Construction

During Construction

After Construction

ANC Jn.-Mulamootilpadi Road

Before Construction

After Construction

Puthusserikadavu-Kakkatikara Road

Before Construction

After Construction

Keelaiyur-Mattankarai Road, Nagapattinam District, Tamil Nadu

Finished Subgrade

Fixing of Coir Geo textile

H2M8 Coir Geo textile Ready for Sub base

Finished Road

Thiruvilaiyattam-Neelaveli- Kodavilgam Road, Nagapattinam District

Proposed PMGSY Road

Finished Subbase Ready for Coir Geo textile laying

Fixing of Coir Geo textile

Vellalar Theru Road, Thanjavur District, Tamil Nadu

Finished Sub grade

Laying of Coir Geo textile

H2M6 Coir Geo textile Ready for Sub base textile

Laying of Sub base over H2M6 Coir Geo textile

Compacting Sub base with Road Roller

Finished Road

Aeirakanni Road, Thiruvarur District, Tamil Nadu

Proposed PMGSY Road

Finished Sub grade

Laying of Sub base

Compacting Sub base with Road Roller

Laying of Coir Geo textile

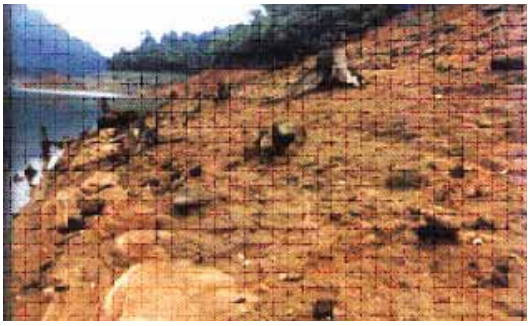
Finished Road

Kakkundu – Chavalapara road , Kozhikode Dist

Vazhikkadavu - Perumboola road,Kozhikode Dist

Korothumukku - Vannathipoyil road, Kozhikode Dist

Slope Stabilisation and Growth of Vegetation, Nedumbassery Airport Approach Road




Protection of Dam Against Siltation , Kakkayam Reservoir in Kerala


Protection of Road Embankment, Upputhodu


Protection of Periyar River Embankment, Chowra, Aluva


Protection of Road Embankment in the Campus of IIM Kozhikode


Protection of Road Embankment, Itanagar, Arunachal Pradesh


Protection of Road Embankment, Kohima, Nagaland


Reinforcement of Mudwall, Mankompu, Kuttanad


Protection of Road Embankment, Silchar, Assam


Reinforcement of Stream Embankment, Vellamathara, Kuttanadu


Reinforcement of Rain Water Harvesting Pond, Thozhuthur, Kumbakonam, Tamil Nadu


Protection of Railway Embankment , Konkan Railway

Stabilisation Periyar River Embankment,Kanjoor,Kerala



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