Historical

- Use of coconut leaf mattresses in Kerala in road construction
- Dragging a bogged down vehicle using leaves, brushes etc
- Cordruoy roads using tree trunks packed next to one another and levelling with gravel for traffic in forest areas
- Natural erosion control by vegetation – turfing, trees etc
Coconut groves

COIR FIBRE
Coir – Essential features

- Coir fibres length: 50 --150 mm
- Diameter: 0.2 – 0.6 mm
- High production in India: Social welfare
- Woven coir geotextiles and non-woven coir blankets: Erosion control
- Biodegradability: 5 years life in saturated condition

DURABILITY

- BUNDENSTAT’S results:

  Whereas cotton degrades totally in six 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.

- The growth of micro-organisms depends on their chemical composition. The longer resistance of coir due to its high lignin content (about 35%) compared to say 12% for jute.
Coir woven geotextiles

H2M6
400 gsm

H2M5
700 gsm

H2M9
900 gsm
# Physical and mechanical properties of woven Coir geotextiles

<table>
<thead>
<tr>
<th>Property</th>
<th>Coir geotextile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll width (m)</td>
<td>E 1.2</td>
</tr>
<tr>
<td>Roll length (m)</td>
<td>F 1.2, 4</td>
</tr>
<tr>
<td>Roll weight (kg)</td>
<td>G 1.2, 4</td>
</tr>
<tr>
<td>Runnage of yarn</td>
<td>H 1.2, 4</td>
</tr>
<tr>
<td>Aperture size (mm*mm)</td>
<td>25*30</td>
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<tr>
<td>Thickness (mm)</td>
<td>6.7</td>
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<tr>
<td>Mass per unit area (g/m*2)</td>
<td>360</td>
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<tr>
<td>Tensile strength m/c (kN/m)</td>
<td>3.86</td>
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<tr>
<td>%Elongation m/c</td>
<td>1.2</td>
</tr>
<tr>
<td>Tensile strength X-m/c (kN/m)</td>
<td>2.5</td>
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<tr>
<td>% Elongation X-m/c</td>
<td>27.5</td>
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<tr>
<td>Initial tangent Modulus at 5 mm</td>
<td>20</td>
</tr>
<tr>
<td>deformation (kN/m)</td>
<td>30</td>
</tr>
</tbody>
</table>

Non-woven coir geotextiles
Non-woven coir geotextiles - types

Studies carried out at
Indian Institute of Technology,
New Delhi
Venkatappa Rao, G., Dutta, R. K. and Balan, K.
### Physical and mechanical properties of non-woven coir geotextiles

<table>
<thead>
<tr>
<th>Property</th>
<th>Non-woven coir geotextiles</th>
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<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Roll width (m)</td>
<td>2.2</td>
</tr>
<tr>
<td>Roll length (m)</td>
<td>25</td>
</tr>
<tr>
<td>Roll weight (kg)</td>
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<td>Thickness (mm)</td>
<td>12</td>
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<td>Mass per unit area (g/m²)</td>
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<tr>
<td>Tensile strength m/c (kN/m)</td>
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<tr>
<td>%Elongation m/c</td>
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<tr>
<td>Tensile strength x-m/c (kN/m)</td>
<td>3</td>
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<tr>
<td>%Elongation x-m/c</td>
<td>9.7</td>
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<tr>
<td>Initial tangent Modulus at 5 mm</td>
<td>68</td>
</tr>
<tr>
<td>deformation (kN/m)</td>
<td></td>
</tr>
</tbody>
</table>

**Strength reduction for coir when submerged in soft saturated clay**
APPLICATION POTENTIAL

1. Erosion Control
2. Rural Roads
3. Road Edge Drains
4. Silt fence
5. Ground Improvement
6. Reinforcement

RILL and GULLY SLOPE
EROSION

EROSION CONTROL
EROSION

• **Surface Soil Erosion** - dislodgement of soil particles and their transportation down slope as a series of events...

• **Erosion control** - restraining the initial movement of soil particles by wind and water.

• An effective erosion-control material will reduce the impact of raindrops on the soil and impede overland water flow.

• So, fewer soil particles become dislodged during rainfall.

• Slowing the flow of water down slope accomplishes two things:

  1. Reduction in the transport capacity of the thin sheet flow, thereby minimising the displacement of dislodged soil particles,
  2. Infiltration of more rainfall into the soil, providing desirable moisture to newly planted seedlings.

ROLLED EROSION CONTROL PRODUCTS (RECPs).

Expected to serve mitigation of erosion both in the short term as well as long term

  • through the establishment and maintenance of vegetation cover

Such solutions are also known as Biotechnical Engineering Solutions.

Before the advent of RECPs MULCHING has been in use for acceleration of vegetation establishment.
Rolled Erosion Control Product

Being installed in a ditch

Figure illustrates the overlap provisions schematically.
Additional anchorage is achieved by installing a row of staples along the crest and toe.

Bridge across Vasista Godavari – Chinchinada, W.G.Dt., A.P.

- 20 m – 25 m thick black cotton soil deposit
- 12m high embankment
- Basal Geocell Mattress
- 3 m high reinforced soil wall
- Erosion control Blanket in place of pitching
ROLLED EROSION CONTROL PRODUCTS

- These products can be classified as:

  I. Erosion Control Nettings (ECN)
  II. Erosion control meshes (ECM)
  III. Erosion Control Blankets (ECB) with single/double net
  IV. Geosynthetic (polymeric) Mattings or Turf Reinforcement Mats (TRM)
EROSION CONTROL TECHNOLOGY COUNCIL (ECTC) CLASSIFICATION

Low velocity degradable RECPs
High-velocity degradable RECPs
Long term nondegradable RECPs

RECPs have major applications in:

- Shore-line stabilization
- Beautification of lakes and ponds
- Landscaping and Golf Courts
- Plant and tree protection systems
- Sand dune stabilization
- Ski slope and high altitude vegetation
- Protection and revegetation of waste dumps
- Wasteland development
- They could also be highly useful in controlling dust and vegetating ash-pond dikes and dams with ore tailings.

CSEB - KORBA SITE (Gar-mat with grass turfing)
THE OLD WAYS (cordrouy roads)
Soft soils in construction

- low bearing capacity
- excessive rutting
- compressible layers
- uneven settlements

... soil reinforcement needed!
Membrane Tension Support

Coir Geotextile in Road Structure
APPLICATION IN RURAL ROADS

- The use of closely woven geotextiles as an interface between the subgrade and the sub-base
  - increases the strength of the pavement and
  - prevents intermingling of the soils and the granular sub-base and improves drainage.
- Under the weight of the base layer and the compactive effort, the subgrade loses water, draining out through coir fabric, and gains in strength.
RURAL ROADs (contd).

- Once the coir geotextile is placed on the weak subgrade,
  - the subgrade stiffens and
  - becomes stronger on consolidation within about a year or so under the action of
    - the granular sub-base surcharge,
    - self-weight of pavement,
    - construction rolling
    - and traffic loads.

Rural Roads (contd)

- With time, the subgrade becomes less and less dependent on the fabric for its stability

- Therefore, the long-term durability aspect of coir should not deter its use as a geotextile for various applications in road construction.
Model test tank

Static load versus deformation behavior of models reinforced with different types of woven geotextiles
Static load versus deformation behaviour of models with different types of non-woven geotextiles

Static load versus deformation behaviour of models reinforced with different non-woven and woven coir geotextiles
BCR versus deformation behaviour of models reinforced with non-woven and woven coir geotextiles

Permanent vertical deformation versus number of load repetitions
**Percentage reduction in permanent deformation**

<table>
<thead>
<tr>
<th>Number of cycles</th>
<th>Percentage reduction in permanent deformation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geotextile type A</td>
</tr>
<tr>
<td>10</td>
<td>21.19</td>
</tr>
<tr>
<td>200</td>
<td>58.85</td>
</tr>
<tr>
<td>700</td>
<td>76.68</td>
</tr>
</tbody>
</table>
STATIC AND CYCLIC BEHAVIOUR OF POND ASH REINFORCED WITH COIR GEOTEXTILE
MVS Sreedhar, Osmania University

The pond ash.

- Collected from NTPC, Ramagundam in AP
- Collected close to the discharge point and hence a coarser pond ash, classified as SP
- Non-plastic
- Spherical in shape with intra-particle cavities
- Crushable to considerable extent with notable modification in particle size.
The coir geotextile

- Product name  CCM-700 H2M2
- Produced by M/s Charankattu Coir Manufacturing Company Pvt. Ltd., Shertallay, Kerala, India.

Test facility
LOAD VS SETTLEMENT CURVE
50 MM SQUARE MODLE FOOTING ON
POND ASH AT 70% OF MDD
EFFECT OF CGT-700 WITHOUT SURCHARGE

CYCLIC LOAD APPLICATION
Comparative observations

- The ability to reduce the cyclic deformations by CGT are lesser than that of WGT
- The ARM of PA+CGT composite is less than that of PA+WGT composite
- This is essentially due to low elastic modulus that govern the cyclic behaviour
Conclusions

• CGT has potential to serve the reinforcement function in frictional material like Pond Ash

• However, low elastic modulus of CGT and hence the PA+CGT composite is resulting in higher level of strain than allowable both under static and cyclic loading.

• This may be due to the inherently low elastic modulus of the fibers/yarns in the CGT

The future prospects

• Efforts need to be made to increase the modulus of CGT such that it serves the reinforcement function at allowable strain levels AND improve its cyclic behaviour.
LOCAL SOIL

- May be unsuitable for construction.

- Low bearing capacity or CBR Value.

- CBR < 2% causes shear failure and rutting.

Site condition benefit from Geotextile Stabilisation

- Poor soil – Clayey sand/silt, organic fatty clay, inorganic silt etc.

- Soils with low undrained shear strength, $c < 100$ kPa.

- Water table near ground surface.

- Seasonally wet subgrade.

- High sensitivity soil.
Functions played by coir geotextiles

1) Separation

2) Drainage

3) Uniform load distribution (Reinforcement)

Design Approaches Using Geotextiles

- Separation, filtration, and Reinforcement when subgrade CBR < 3.
- Only for separation, when subgrade CBR between 3 and 7.
Field studies with Coir Geotextiles by College of Engineering Trivandrum

• Sponsored by
  NCMRI
  Coir Board- NRRDA
• Construction by Rural Roads Dept (PMGSY)
• 100m stretch test road constructed at Chirakkad-Kumbakad road in Varkala Block
Schematic diagram of the cross section with coir geotextiles

COIR GEOTEXTILES USED FOR RURAL ROAD PAVEMENT

Ways in which a geotextile helps stabilise an unpaved road (John 1987)
Unrolling coir geotextiles in Attukal Pambadi road on 23-9-11

Laying of coir geotextiles in Attukal Pambadi road on 23-9-11
Fixing of Coir Geotextiles to ground

Coir geotextiles Laid on Attukal Pambadi road on 23-9-11
Laying GSB layer over coir geotextiles in Attukal Pambadi road

27 July 2016
Coir Geotextiles
G V RAO

Laying of GSB over coir geotextiles in Attukal Pambadi road on 23-9-11

27 July 2016
Coir Geotextiles
G V RAO
Photograph of Chirakkad -Kumbakad road in Varkala Block - Before construction

Photograph of Chirakkad -Kumbakad road in Varkala Block – During construction
Photograph of Chirakkad -Kumbakad road in Varkala Block
During construction – Laying of coir Geotextile

Photograph of Chirakkad -Kumbakad road in Varkala Block
After laying of Premix bituminous concrete layer
ROAD EDGE DRAINS

- The poor performance of roads in India is partly due to construction on soft soils, at ground level, without considering the high ground water level.

- This is more so where black cotton soils are present.

- The road condition can be significantly improved by constructing geotextile lined trench drains.

- In some cases a non-woven coir blanket is of high potential, particularly in rural roads.

Coir Geotextile in Road Structure
GROUND IMPROVEMENT

- Pre-fabricated Vertical Drains (PVD) using synthetic polymeric products (composing of non-woven geotextile sleeve) and core/mesh in vogue the world over
- for consolidating soft clays to improve the ground.
- Successfully used in India at Kakinada Port and Kandla Port recently.
- A simple machine developed at the Textile Technology department of IIT Delhi
- uses coir and jute yarns to manufacture 100% natural fibre PVDs.
Silt Fence - Installation

Maintenance of Silt Fences
• Inspection - physical condition, depth of soil behind fence, base pullout, fabric condition
• Clean-out when half-full.
• Allow soil to overtop and install additional downhill fences

Coir Fibres Type A1
Coir Fibres Type A2
Type A1 25 mm long
Type A2 25 mm long
Placing Fill on Geotextile

Fig. 5: “Tensioned Membrane” function of a geotextile

Fig. 6: Tensile test
BIS
Specifications for Coir Geotextiles [Bhoovastra]


2. Natural fibre geotextiles (jute geotextile and coir Bhoovastra) -


4. Use of coir geotextiles (coir Bhoovastra) in unpaved Roads –
   Guidelines, 2009, IS 15871.

5. Application of coir geotextiles (coir woven Bhoovastra) for rain
   water erosion control in roads, railway embankments and hill

CONCLUSIONS

- **Separator**
  - Yes, Rural Roads

- **Reinforcement**
  - Yes
  - Rural Roads, Low Embankments

- **Filteration & Drainage**
  - Good
  - Erosion control
  - Silt fence

- **Life**
  - As required (5 – 10 yrs)

- **Environmental friendly**
Acknowledgements

- Coir Board
- Indian Institute of Technology, Delhi
- College of Engineering, Trivandrum
- Kerala State Coir Corporation
- Kerala State Rural Road Development Agency
- NCMRI