Usage of Geosynthetics for Road Construction

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Geosynthetics

- **Geosynthetics** – Generic name for
  - Geotextiles – Woven and Non woven
  - Geogrids – Flexible and Rigid
  - Geonets, Geostrips, Geomembranes, etc
- **Major Polymers used** – Polypropylene and Polyester
- **Others** - PVC, Polyamide, Polyethylene, Polyvinyl alcohol, Aramids, etc
- Polypropylene is preferred material in North America and Europe
- Polyester is relatively cheaper in Asia

Few Examples of NHAI Projects

Project	Purpose	Quantity
Visakhapatnam	In Marshy/ Slushy Soils	1,08,100 sq m
Vallarpadam, Cochin	Geotextile (non woven) as separation/ filtration layer	4,30,260 sq m
Tuticorin	Below sub-grade	2,55,000 sq m
Paradip	(i) for high embankment over band drains (ii) below sub-grade	1,04,250 sq m 40,640 sq m
JNPT Package II (SH-54 & Aamra Marg)	Woven geotextile below embankment	64,600 sq m

Geosynthetic Usage for Road Works

- **Reinforcement – Strengthening of soil slopes, RE Walls for Bridge approaches, Construction on soft soils, reinforcing pavement layers**
- **Consolidation – Removal of water from saturated marine clay layers**
- **Separation – Partitioning of two adjacent but dissimilar materials to prevent intermixing**
- **Erosion control, Filtration & Drainage, Crack arresting layer in wearing course**

Pioneering Studies on Usage of Geotextiles by CRRI

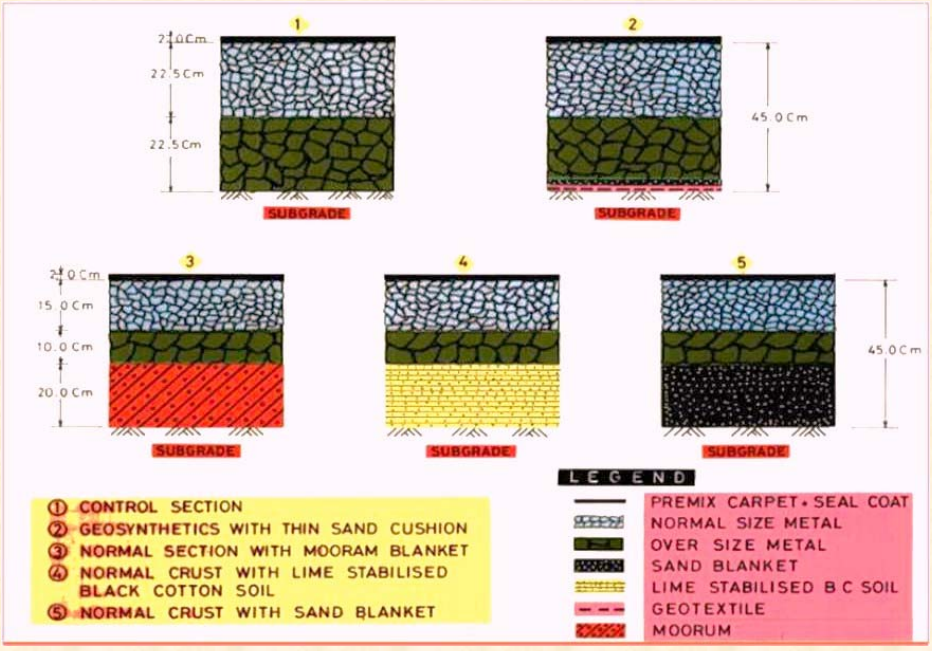
- **Objective of Study:** To study relative efficacy of geotextile as compared to use of conventional techniques for BC soils
- **Location of Sites:** Ten roads in Gujarat and Maharashtra each 4-6 Km

Typical test specifications

- Control section of conventional construction
- Geotextile with thin sand cushion
- Conventional section with moorum blanket
- Conventional section with lime stabilised BC soil
- Conventional section with sand blanket

Ref – AVSR Murty, S.Mathur, et al, 1992

Typical Test Sections Incorporated for Field Trials



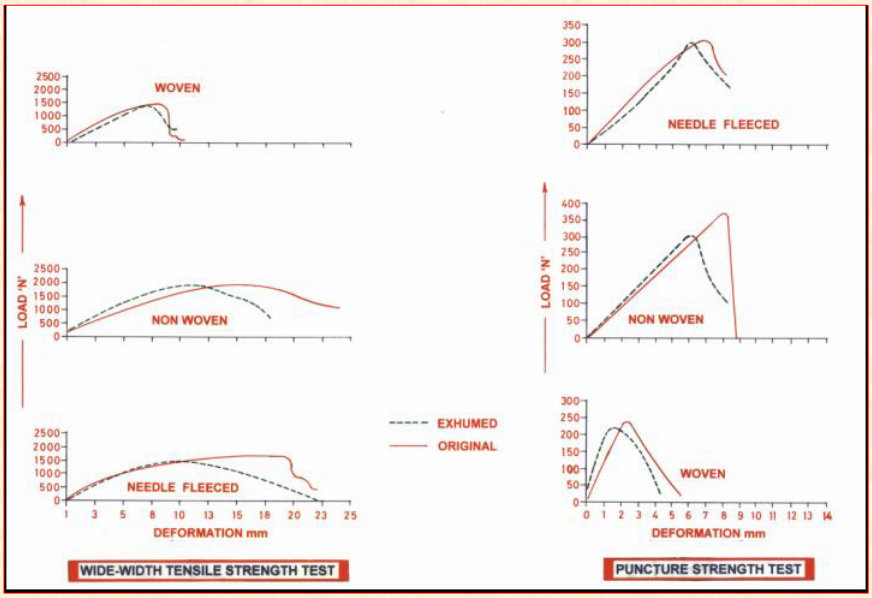
Laying of Geotextile on Subgrade

Pavement Performance Evaluation (3 Yrs)

Sl. No	Test Specification	Rut depth(mm)	Deflection(mm)	Distress (%)
1	Control Section	6 – 18	1.6 – 2.5	12 – 15
2	Section with Geotextile	6 – 9	1.5 – 2.0	1.0 – 6.0
3	Section with Moorum	8 – 14	1.7 – 3.5	3.0 – 8.0
4	Section with lime stabilised BC Soil	7 – 20	2.5 – 3.8	5 – 17.0
5	Section with sand blanket	4 – 14	1.7 – 2.2	1.0 – 5.0

Condition of Geotextile After Three Years

Strength Loss After Three Years in Service



Outcome of Study

- **Geotextiles are an effective substitute** for conventional sand blanket course
- **It's use is very cost effective** when good quality sub-base materials are not available within economic lead and CBR of subgrade is low i.e. less than 3

Use of Geotextile as Separator in NHDP Work

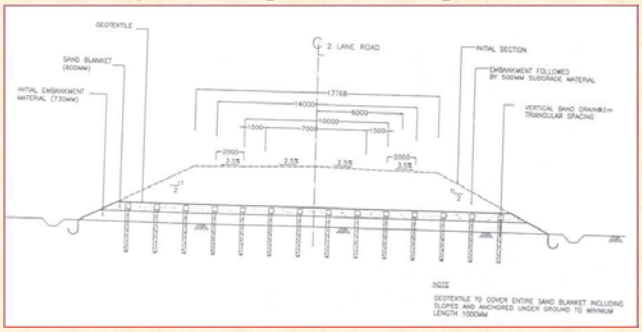
(Four-laning work on NH-6, Dankuni to Kolaghat, Km 17 to 72, West Bengal)

Use of Geosynthetics in Pavement

Ref – IIT, Kharagpur

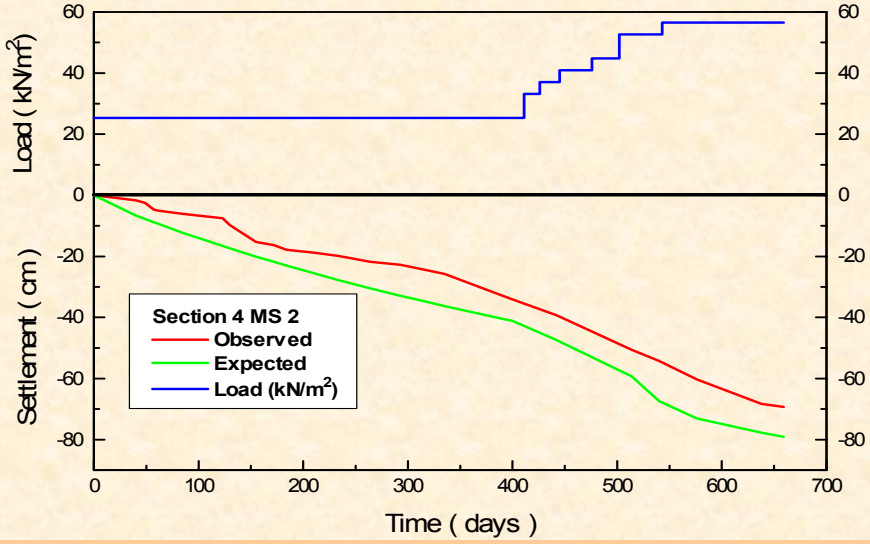
Ground Improvement Using Geosynthetics

- Embankments on soft clay deposits – Band drains, high strength geotextile as basal reinforcement, Geocells with geogrid/ geotextile reinforcement
- Distinguishing feature – Accelerating consolidation or providing reinforcing effect



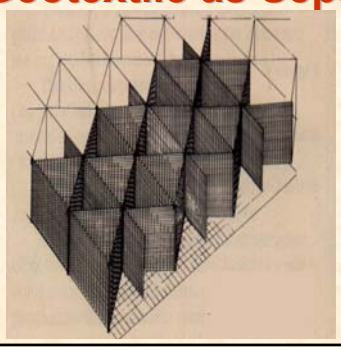
Stitcher for Installation

Time vs. settlement curve



Efficacy of Band Drains, Quality Control, Testing & Specifications

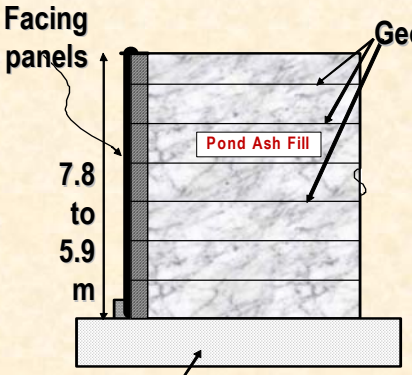
Geotextile as Separator/ Basal Reinforcement



Geocell Mattress

Reinforced Soil Embankment Using Geogrids – Okhla Flyover

- First geogrid reinforced fly ash approach embankment constructed in the country (1996), Performance has been very good
- Length of embankment – 59 m, Height varied from 5.9 to 7.8 m
- Ash utilised – 2,700 cubic metre, Opened to traffic in 1996



Ref- PJ Rao, Bindumadhava, et al, 1996

Reinforced Fly ash Embankment at Sarita Vihar Flyover

Construction of reinforced approach embankment using Geoties

Length of reinforced approach embankment	105 m (Badarpur site) 78 m (Delhi side)
Maximum Height – 5.25 m, Width – 22.5 m	
Fill material	Pond ash from Badarpur thermal power station
Reinforcement	Friction ties made of high tenacity polyester yarns
Opening to traffic	Feb 2001

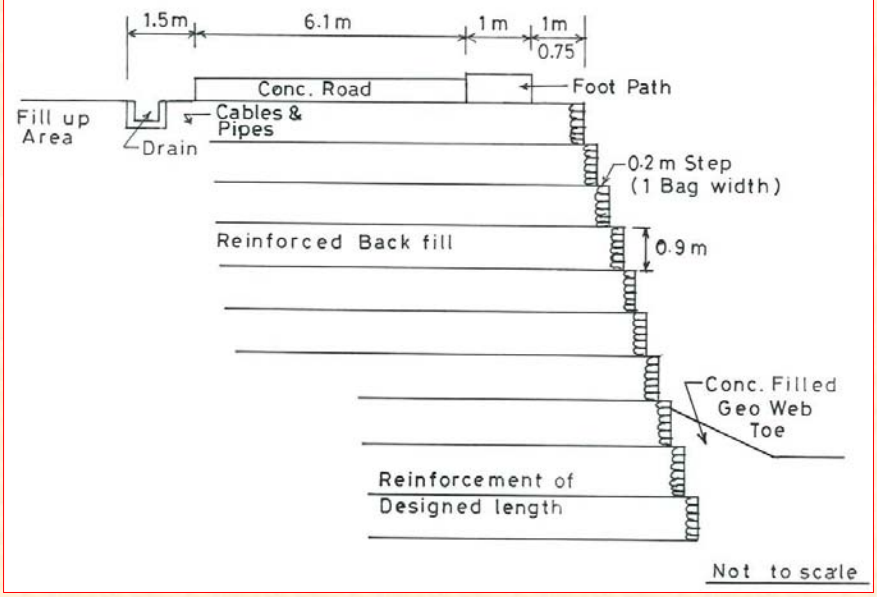
Reinforced Earth – New Trends

- Reinforced Earth – Few hundred RE Walls have been constructed in India
- Full head fascia panels to overcome misalignment problems
- Anchoring of reinforcement at both ends to withstand earthquake forces
- Gabion faced RE Walls to improve aesthetic look
- Failure of RE walls – Mismatch between design and actual construction at site

Failure of RE Walls – Some Case Studies

- Case study from Central India – Reinforced earth embankment constructed to extend a hill cut terrace and road constructed over the reinforced earth embankment
- Flexible geogrids used as reinforcement
- Flexible soft fascia – Wrapping geogrids around good earth filled jute bags adopted
- Turfing of fascia

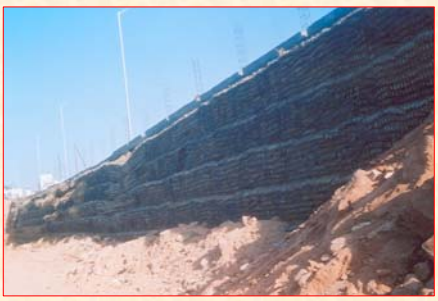
Cross section of RE Embankment

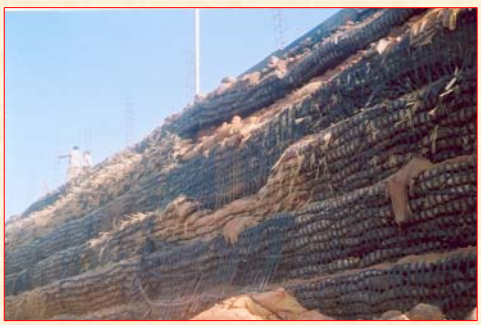


Construction of RE Embankment

Construction of RE Embankment

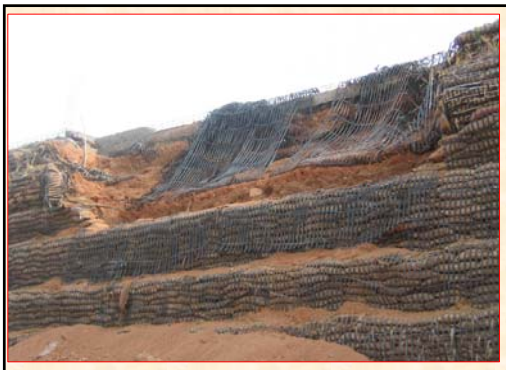
Failure of RE Embankment





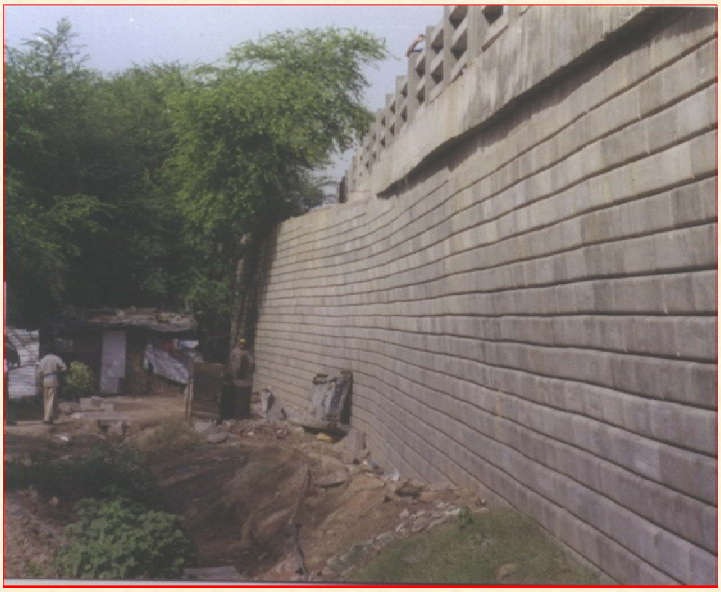
Causes for Failure

- Proper compaction not done at the edges (soft fascia) near the bags
- High vertical spacing between geogrids – 0.9 m
- Sagging of bags occurred due to watering
- Geogrids after wrapping inserted for a length of 50 cm only, no jointing between successive layers of geogrids
- Pull out failure of geogrids and fascia damaged at many locations



Repair work of RE Embankment

Failure of RE Wall Built with Block Fascia



RE Wall Failure showing the storm water drainage pipe

Construction of Retaining Wall in front of RE Wall

Collapse of RE Wall

Shortcomings in Design, Materials and Quality Control Aspects During Construction Need to be Addressed

Agro Based geotextile

- 100 per cent biodegradable
- Can be adopted for
  - Erosion control
  - Vertical drains for consolidation of clays
  - Horizontal drains for stabilisation of slopes
  - Subsurface drains
- Jute and Coir based geotextile

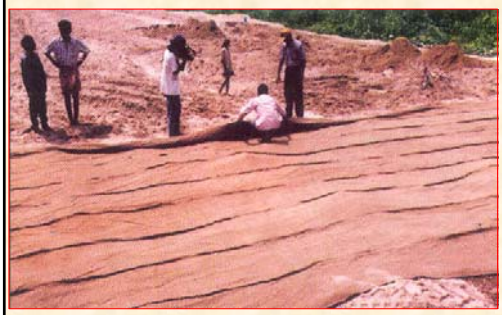
Jute Geotextiles as Reinforcement - Kakinada

- The topsoil up to a depth of 2 m from the ground level – silty sand and clay mixture
- Natural moisture content – 70 to 85%, Bulk density – 1.30 to 1.45 gm/cc
- Undrained shear strength – 4.6 to 6.0 kN/sq. m
- Compression index (C_c) – 0.15 to 0.29

Jute Geotextile Properties	Test value
Thickness	5 mm
Weight	750 gsm
Tensile strength	15 kN/m
Elongation	10%
Puncture resistance	350 N
Overlap length	300 mm
Type of fabric	Woven

Ref- PJ Rao, et al, 1995

Kakinada Port – Use of JGT



Use of Coir Based Geotextile for Road Construction at Kerala

Use of Coir Based Geotextile at Visakhapatnam Port

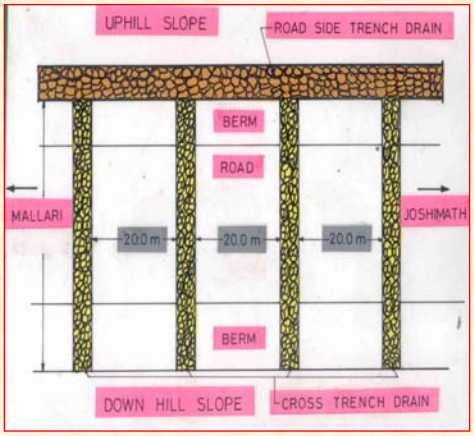
Use of Jute Geotextiles for Improving Performance of PMGSY Roads

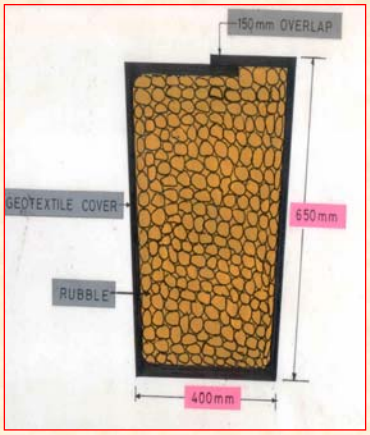
- **Objective – To study the use of jute geotextile in the road pavement**
  - As a drainage layer
  - As a separator
  - Capillary cut-off
  - Shoulder improvement
  - Side slope erosion protection
- **Pilot project taken up in 10 roads across five states under varying soil/ climatic conditions by CRRI & JMDC**

Laying of bitumen treated jute geotextile in West Bengal

Laying of woven and non woven jute geotextile in Orissa

Use of Jute geotextile in trench drains on Joshimath-Malari Road

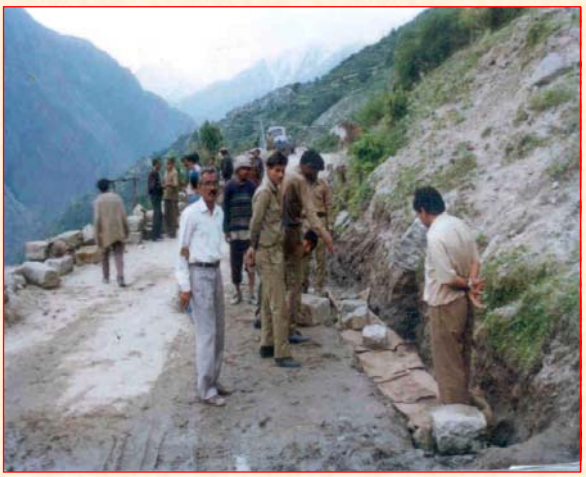




Ref- O.P.Yadav, Kanwar Singh et al, 1998

Use of Jute Geotextile in Trench Drains

Jute geotextile laid in position



A view of completed drain

Erosion Control & Landslide Mitigation

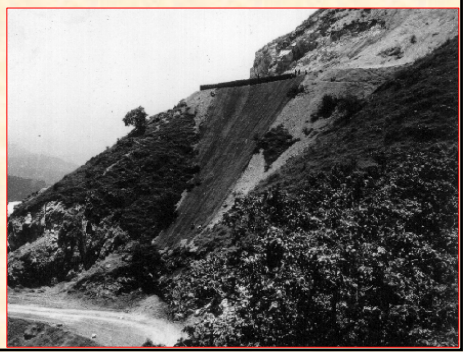
Ratighat, 1984

- Loss of excessive material from the surface of natural or manmade slope by the action of wind or water
- Woven jute geogrid with square grids used
- Mass of geogrid – 750 gsm

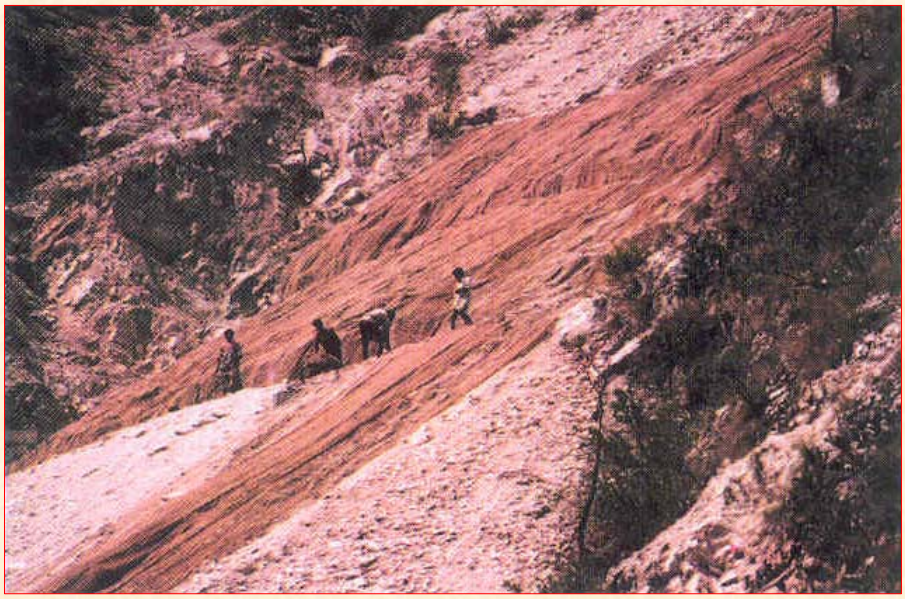
Erosion control on Steep slope - Lambidhar, Masoorie

Slope at Masoorie protected with Geogrid

Ref – T.S.Natarajan, Jai Bhagwan et al



Stabilisation of Hill Slope – Kaliasaur 1996



CRRI

Erosion Control of Slopes

Use of jute geotextile for erosion control,

Sataun, H.P, 1997

Use of Synthetic Geogrids for Erosion Control at Varunavat, Uttarkashi

Laying Jute Geotextile at Sonapur Landslide on NH 44

JMDC Photos

Vegetation Growth After Laying Jute Geotextile at Sonapur Landslide

JMDC / BRO Photos

Tunnel Construction Works at Sonapur Landslide (Jan 2008)

Use of Coir Geotextile at NH 39

Use of Jute Geotextile at Varunavat, Uttarkashi

Erosion Control of Road Embankment at Rann of Kutch

- Embankment height 1.5 – 2.0 m
- Silty soil having high salt content
- Erosion due to surface runoff as well as wave action of water flooding on both sides of alignment
- Use of non woven geotextiles to contain erosion of side slopes
- Failure of geotextile layer due to improper anchoring

Protection of embankment by geotextile

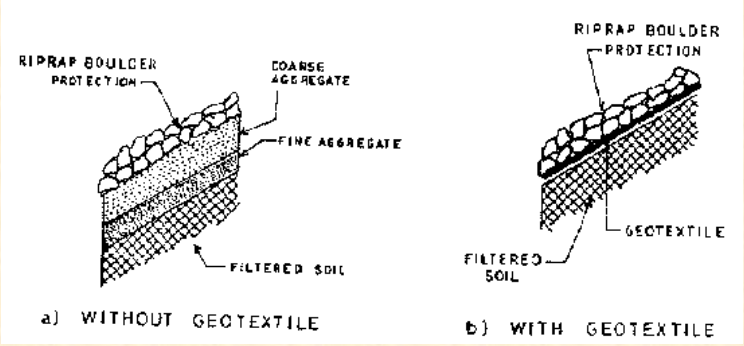
Geotextile for Erosion Control

Erosion of unprotected section

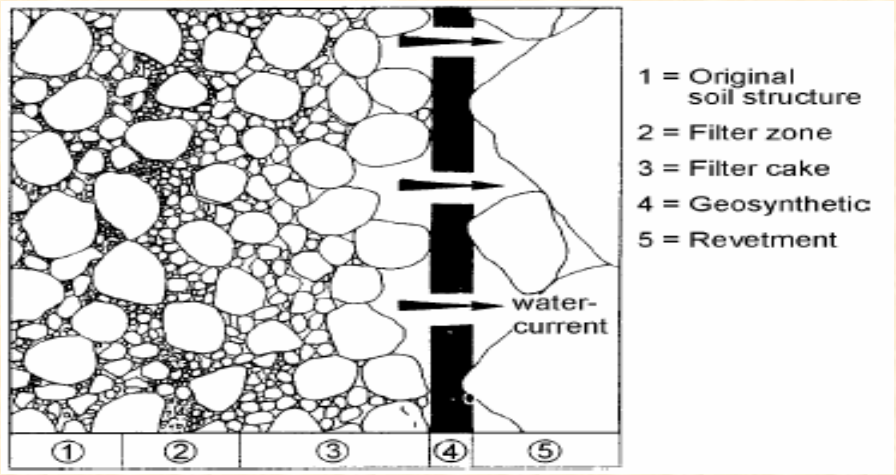
Failure of geotextile layer

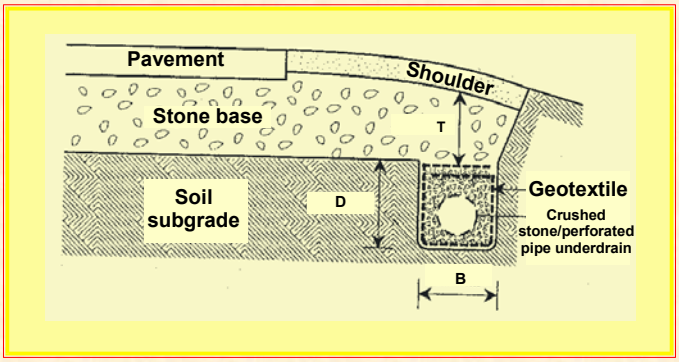
Filtration/Drainage

- Geotextile filter system
- To retain soil particles
- Permit water to pass through

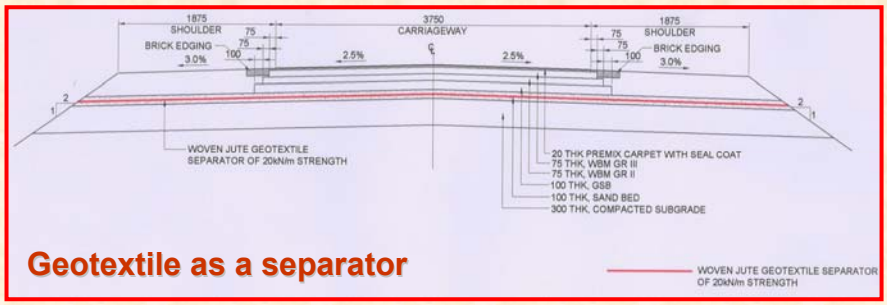


Natural Filter Cake Formation





Trench Drains



Geotextile as a separator

Geosynthetic Usage in Road Works – The Way Forward

- **Under PPP regime,** Road Projects would be taken up on **DBFO** Basis
- **Geosynthetic usage can be boosted** in case it is techno economically feasible for the Concessionaire
- **For proven applications** like RE walls, Erosion Control and Ground Improvement **usage will be enhanced**
  - **QC/ QA** of the geosynthetics to be ensured
  - Use of right type of **materials/ correct techniques**
  - Evolving our own **codes/ guidelines**
  - Establishing countrywide **geosynthetic testing / certification facilities**

Geosynthetic Usage in Road Works – The Way Forward

- For potential application areas like reinforcing pavement layers, for bituminous overlay, drainage / separation, etc usage can be further enhanced
  - R&D Efforts required to refine the techniques
  - Evolving rational design procedures and solving problems associated with construction
  - Taking up field demonstration projects followed by performance monitoring
  - Application to be cost effective
- Agro based geotextiles – Price & environmental advantage over synthetic product is vital, ideally suited for erosion control applications

Usage of Geotextiles in Road Works – Some Issues

- What Geotextiles can do and can not do?
  - Right type of material for appropriate application
  - Geotextile marketing strategies of producers
  - Increase in CBR value of subgrade soil – Myth or Reality?
- Filter Cake Formation – When and How?
- Whether to make geotextile usage compulsory – Should it not compete with other technologies?
- Technical issues related to agro based geotextiles – Width, laying procedure, etc
- Supply of geotextiles – Imported or Indigenous
- Consistent quality of geotextiles

Mere usage of Geosynthetics will not ensure good performance. Proper selection of Geosynthetics, correct design and quality assurance are essential

THANK YOU

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