GEOSYNTHETICS IN DAMS

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Geosynthetics

- Modern civil engineering construction materials
- Modify/Improve soil/geologic material behaviour
- Developed/Synthesized for specific function or application in construction
- More than 1 billion sq m annual use
Geosynthetics – The wide variety

- Geotextiles – Woven, non-woven Filter fabrics
- Geogrids
- Geomembranes
- Geocomposites
- Geonets, Geofibres, mesh mattings, Geopipes

Woven geotextile
Non-woven Geotextile

Geogrid Manufacture
(a) Uniaxial Geogrid

(b) Geogrid Biaxial
Geocomposites

- Polypropylene
- HDPE
- Polyester
- PVC
- Synthetic Rubber
- Natural fibres – Jute, coir
COIR GEOTEXTILES
Geosynthetics – the functions

- Separation
- Drainage
- Filtration
- Reinforcement
- Moisture barrier
- Cushion

Separation function
Drainage function

Filtration function
Reinforcement function

REINFORCEMENT FUNCTION
Slope Failure

Reinforced Slopes
Geosynthetic Reinforcement

Geosynthetic Basal Mattress
Possible Applications Of Geotextiles As Filters In Fill Dams.

<table>
<thead>
<tr>
<th>Filter location</th>
<th>Purpose of filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Downstream slope protection</td>
<td>Control of erosion by rainfall</td>
</tr>
<tr>
<td>c. Upstream slope protection.</td>
<td>Control of erosion by wave action and by outward flow during drawdown.</td>
</tr>
<tr>
<td>d. Temporary internal drainage.</td>
<td>Dissipation of excess pore pressure during construction of wet fills.</td>
</tr>
</tbody>
</table>
**Possible Applications Of Geotextiles As Filters In Fill Dams (contd.)**

<table>
<thead>
<tr>
<th></th>
<th>Upstream internal fill boundary e.g. upstream core boundary or foundation contact.</th>
<th>Prevention of unacceptable migration of fines in upstream direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>f.</td>
<td>Downstream interface-no-continuous flow from reservoir e.g. beneath weight block.</td>
<td>Prevention of unacceptable migration of fines</td>
</tr>
<tr>
<td>g.</td>
<td>Downstream internal interface-continuous flow from reservoir, e.g. down-stream core boundary or foundation interface near core.</td>
<td>Prevention of internal erosion, including effects of concentrated flow in cracks etc.</td>
</tr>
</tbody>
</table>

![Diagram of dam with geotextiles](image)
Use of Geomembranes

- **In Fill Dams**
- Enhanced watertightness in concrete dams
- In Rehabilitation of concrete and masonry dams

ICOLD – Geotextiles & Geomembranes in Dams

1. Geomembrane
2. Geomembrane underdrain
3. Chimney Drain
4. Finger Drain outlet
5. Protecting & weighing
CASE HISTORIES

Information Sources:

- IGS - *Geosynthetics Case Histories* (Eds. Raymond, G. P.; Giroud, J. P.) 1993
GEOTEXTILE FILTERS UNDER U/S RIP RAP

- For improved erosion protection
- First use of Geotextiles in an Earth Dam (1970)
- Valcros Dam, France, 135 m LONG, 17 m HIGH, (SILTY SAND)

Valcros Dam, France

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 mm stone, 400 mm thick</td>
<td>Geotextile 400 gsm</td>
<td>250 mm stone, 400 mm thick</td>
</tr>
<tr>
<td>6 - 40 mm gravel, 150 mm thick</td>
<td>Geotextile 400 gsm</td>
<td>250 mm stone, 400 mm thick</td>
</tr>
</tbody>
</table>

Figure 1. The three zones of the upstream slope.
Placing the Geotextile filter in the upstream facing of Valcros dam

Valcros Earth Dam in France
Geotextile Antipiping Barrier
Tucurui Dam, Brazil

- Max. Height 103 m
- Foundation – Metabasic
- Tubular Cavities 2 - 200 mm
- Permeability – very high
- Causes High erosion

Foundation rocks with high permeability

Geotextile Filter for Self-Healing Diaphragm

- Semi Impermeable core – “Dry trench” soil cement diaphragm wall.
- Use Geotextile as a self-healing element in case of leakage.

FORMITZ Dam, Germany (1974-78), 33 m high

- 3 layer non-woven Geotextile. 1100 gsm, 9 mm thick
Geotextile for Filter & Erosion Control in Dam

“Dry trench “ soil cement diaphragm wall.
Use Geotextile - in Self healing element (1100 gsm)
- as filter U/s( 600 gsm)
- as filter around relief well (900 gsm) and tow drain

SCHONSTADT DAM, GERMANY, 22 M HIGH (1986)

Geomembranes for Waterproofing

- In Rockfill Dam
- First Use in (1978)
- OSPEDALE Dam, Corsica, France
- 20 m High
- 4.8 mm thick PVC with 400 gsm protective geotextile
- COST REDUCTION  30 %
Codole Dam – U/s Geomembrane

Water Proofing for Rock-fill Dam

Bovilla Dam, Italy
Max. Height, 81 m
Crest Length, 140 m
Bovilla Dam, Cross-Section

Figure 3. Main cross section of Bovilla dam on the Tercuze river. The maximum height of the dam is 81 m and the geosynthetic system has been applied over the top 57 m. The crest length of the dam is about 140 m.

Bovilla Dam - Water Proofing Systems

Figure 4. Cross section of the waterproofing system used at Bovilla dam.

Geomembrane, 3 mm, PVC
Geotextiles, 700 gsm, Polypropylene
Geomembrane for Raising Embankment

- Pactola Dam, South Dakota (USBR)
- Earth & Rock fill Dam 167 m high
- Core – Earth
- 4.5 m Raise for increased PMF
- Replace clay core & graded filter by 1mm HDPE Geomembrane+ 400 gsm GT
- Suits crest Highway geometry, tourist traffic
- 1 m$ SAVINGS

Rehabilitation Of Concrete & Masonry Dams – Geomembrane Water Proofing

- Seepage Problems Th’ Dam body
- Alternate 1-Reinforced Gunite, Steel plate
- Alternate 2-Geomembrane –
  - Simple installation,
  - Rapid,
  - Low cost,
  - Ease of future maintenance

contd.
Rehabilitation of concrete & Masonry Dams – Geomembrane Water proofing (contd.)

- Lago Nero Dam, Italy (1929 – 1934)
- Concrete Gravity Dam – Height 40 m
- Major Remedial Works 1979
- PVC Membrane 1.93 mm
- Support - Polyester Geotextile 200 gsm
- Mechanical fastening ny plates/anchor
- ADOPTED FOR OTHER DAMS IN ITALY,FRANCE,PORTUGAL 1976 - 1991

Lago Nero Concrete Dam
Upstream Facing
Lago Nero Concrete Dam

Upstream Facing After the Rehabilitation Works.
Geocomposite Sliding Layer for Concrete Core Dam

- To reduce wall friction.
- & Resulting high compressive stresses due to differential settlement between concrete core and rockfill.
- Bockhartsee Dam, Austria, world’s first large Rockfill Dam with concrete core diaphragm wall.
- 239.5 m long, 31 m high
- 1.55 H: 1 V Upstream
- 1.5 H: 1 V Downstream

Contd.

Geocomposite Sliding Layer for Concrete Core Dam- Bockhartsee Dam, Austria

600 mm thick concrete wall

Contd.
### Geocomposite Sliding Layer for Concrete Core Dam - Bockhartsee Dam, Austria - Details

<table>
<thead>
<tr>
<th>Layer</th>
<th>Material/Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geotextile 700 gsm Polypropylene, needle punched</td>
</tr>
<tr>
<td>2</td>
<td>4 mm thick bitumen</td>
</tr>
<tr>
<td>3</td>
<td>60 gsm glass fleece</td>
</tr>
<tr>
<td>4</td>
<td>0.01 mm polypropylene separation foil</td>
</tr>
</tbody>
</table>

**Figure 3.** Structure of the geocomposite: 1 geotextile; 2 bitumen layer; 3 glass reinforcement; 4 separation foil.

### Rehabilitation with D/s Geotextile Wrapped Drain

**17 m high YANGDACHENG Dam, China (1980)**

- Homogenous Earth Dam - 2250 m long
- Seepage observed on D/s slope
- Drainage ditch clogged

- 600 mm dia R. C. pipe with 2% Open area
- Wrapped with Geotextiles
- Savings 86%

**Figure 3.** Variation of phreatic line before and after placement of covered pipe.
Rehabilitation with D/s Geotextile Wrapped Drain - Details

Reinforced Concrete Filter Pipe

Geotextile

2-4 cm Crushed Stone A

Sand A

Supporting Pad

Geocomposite Shaft Drain

Replaces granular drain in homogeneous earth dams

10 m high La Parade Hill Dam, France - 1987

Polypropylene Nonwoven geotextile 170-500-170gsm

50% cost of granular Drain
Maraval Dam – France (1976)
Davis Creek Dam: USA

1. Steel Mesh
2. Rockfill
3. Granular filter
4. Clay Core

Moochalabra Dam - Australia

1. Steel Mesh
2. Rockfill
3. Granular filter
4. Clay Core
Geogrids for Crack Prevention in Dam Cores

- Transverse cracking may occur in core at the top of the dam.
- Canales Dam, Spain (1986)
- Height = 158 m
- Cracking may occur – 65 m length
  - 5 m depth
  - Strain > 0.25%

Canales Dam, Spain

- Geogrids @ 150 mm, 6 m below crest, 8 m wide
- Expected crack opening < 10 mm
- Distance between cracks 6.5 m
Geomembrane for Canal
Extensive Seepage Loss in Desert Regions

Kirkuk, Iraq – 120 km long - Gypsum

Similar Indian experience at Indira Nehar, Rajasthan

CANAL BED SCOUR Geotextile lined rip rap

Mitteland Canal, Germany
### Projects In India Using Geoextiles In Earth Dams

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Application</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Medha Creek Dam, Gujarat</td>
<td>Filter layer slope protection</td>
</tr>
<tr>
<td>2.</td>
<td>Hiran Dam-II, Gujarat</td>
<td>Filter layer</td>
</tr>
<tr>
<td>3.</td>
<td>Ramman Hydroelectricity project,</td>
<td>Filter layer</td>
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<td></td>
<td>West Bengal</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Dharoi Earth Dam, Gujarat</td>
<td>U/s &amp; d/s slope Protection</td>
</tr>
<tr>
<td>5.</td>
<td>Salal Hydroelectric project,</td>
<td>Filter layer around the relief well.</td>
</tr>
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<td></td>
<td>Jammu</td>
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</tr>
</tbody>
</table>

Also in Farakka canal: Bed Protection
CONCLUSION

Geosynthetics are immensely useful in concrete, earth and rock-fill dams.

- Better performance ensured
- May reduce costs

CAVEAT:
- Identify function clearly
- Specify unambiguously

GUARANTEE GREEN COVER
**Main functions of geosynthetics in Dams**

<table>
<thead>
<tr>
<th>Main function</th>
<th>Typical products</th>
<th>E+R</th>
<th>C+M</th>
<th>RCC</th>
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<tbody>
<tr>
<td>B</td>
<td>GM,GCM</td>
<td>NC, RB</td>
<td>RB</td>
<td>NC</td>
</tr>
<tr>
<td>D</td>
<td>GT,GN,6CD</td>
<td>NC, RB</td>
<td>RB</td>
<td>NC</td>
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<td>P</td>
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<td>NC, RB</td>
<td>RB</td>
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<td>GT,GG,GCR</td>
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<tr>
<td>E</td>
<td>GT,GA,GL,ST,BA,SL</td>
<td>NC, RB</td>
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Concepcion RCC Dam in Honduras

Hans Strijdom Zoned rockfill Dam
Blue Ridge Parkway Dam - USA