Geosynthetics Engineering: In Theory & Practice

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Lecture No - 09
GEOSYNTHETICS ENGINEERING: IN THEORY AND PRACTICE

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Module - 2
LECTURE - 9
AN OVERVIEW OF GEOSYNTHETICS

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RECAP of previous lecture.....

- Design example
- Sustainability using geosynthetics
- Application of sustainable geosynthetics in infrastructures
Major Applications of Geosynthetics:

- Geosynthetics applications for railroads
- Geosynthetics to deal reflection cracking in pavements
- Geosynthetics applications for hydraulic structures
- Geosynthetics to mitigate coastal and riverbank erosion
- Geosynthetics applications for food and agriculture
- Geosynthetics applications in mining engineering
- Geosynthetics applications in tsunami
- Geosynthetics applications for waste water treatment
- Geosynthetic for landfills
- As early warning system for rain-triggered landslides and debris flows
- Geosynthetics applications as noise barrier
- To combat or mitigate the acts of terrorism and/or natural disasters

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Geosynthetics applications for railroads:

- Geosynthetics (geogrids, geotextiles, geocomposite, geocells, and geotextile tubes) can be effectively used for separation, filtration, drainage and reinforcement for railway rehabilitation and new railway track construction.

- Geosynthetics can be placed between the subgrade and ballast. In railway, it is needed to provide very good drainage and filtration.

- Improve the load bearing capacity and reduce the settlement.

- The geosynthetics should be designed properly so as it can resist the tear, puncture and burst.

- Also Geofoams can be used to construct railway tunnels.

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Geosynthetics in railways

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Geosynthetics applications for reflection cracking

- The reflection cracking is a great concern in highways and roads of any country. Geosynthetics act as barrier. In many projects the use of geosynthetics does not give satisfactory results.

- The proper selections, specifications and installation of geosynthetics are very much needed based on the types of crack patterns.

- If the geosynthetic is introduced as reinforcement and barrier, it reduces the thickness of pavements, costs as well as improves the life time or durability and performance of pavement.

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Geosynthetics to mitigate reflection cracking of an existing pavement

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Geosynthetics applications for hydraulic structures

- Geosynthetics can be effectively used in hydraulic structures such as for the construction of new dams, canals and retrofitting of ageing concrete dams.

- Particularly, geomembranes or geosynthetics clay liners as impervious material can be used on the upstream face of dams as hydraulic barrier.

- Geomembrane can also be used to prevent the bank erosion of canals. Sometimes, geomembranes may be damaged due to puncturing.

- In such case, geotextile can be placed over and/ or below the geomembrane to prevent the puncturing. Here geotextile acts as a cushion.

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Geosynthetics in hydraulic structures

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Geosynthetics applications for coastal and riverbank erosion

- Geosynthetics can be effectively used for erosion control to replace conventional graded granular filters. Geosynthetics must retain soil particles (filtration) and allow water to pass (drainage).

- It can be used below hard armor or riprap in coastal, revetments, lake shore line, and channel; for scour protection around structures such as bridge piers and abutments as well as for slope protection to prevent erosion from surface runoff and for bank protection.

- Three dimensional geosynthetic erosion control mats are also used to retain the soil and moisture to promote vegetation growth. Roots can grow from the vegetation and reinforced the mats.

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Cross-section of stream bank revetment

Geotextile concrete mattress for slope protection

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Geosynthetics applications for food and agriculture

- The seepage loss in pond, canals, concrete tanks and ditches is about 30 to 50 percent.

- Water is costly and scarce particularly in drought region. The surface waters and ground waters become polluted due to animal wastes.

- In arid regions, farmers need water to preserve or store in reservoirs, ponds, canals, storage tanks and water harvesting catchments in order to supply for farm use.
The use of geosynthetics can save valuable water and environmentally control the polluted ground water and surface water. Geomembranes or geosynthetic clay liner can also be used to replace or repair the old cracked concrete canals to prevent water seepage loss.

Biogas is generated from the animal waste and used to produce electricity for farmers. Geosynthetics can be used to cover the lagoon for biogas collection.
Application of geosynthetic in agriculture

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Geosynthetics applications for mining engineering

Geosynthetics can be effectively used in mining industry for bulk storage system and handling. It can also be used in slot storage system as well as to prevent landslides.

Liner design for mining application (After Lupo and Morrison, 2007)

Reinforced earth arch (After Behnia, 1972)
Geosynthetics applications for tsunami

- Geosynthetics have a very important role for the protection, mitigation and rehabilitation of the coastal areas damaged by recent devastation due to tsunami.

- Geosynthetics can act as reinforcement, filtration, drainage, protection and barrier.

- Geosynthetics can perform erosion control, strengthen the retaining walls and embankment as well as resist the catastrophic failures occurred due to strong earthquakes associated with tsunami.

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Geosynthetics applications for waste water treatment

Geosynthetics can be used in various projects for waste water treatment such as

- Dewatering municipal and industrial sludge,
- Liner and cover system,
- Evaporation system, and
- Animal waste and marine waste

Geotextile tube (Woven and non woven) is a permeable membrane and can be used for sludge dewatering. The geotextile tube has a very good filtration property.

The sludge with high water content can be inserted into the geotextile tube and dry them rapidly to a solid state. The geotextile tube with dredged sands can also be used to build dykes and groynes.

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Typical geotextile tube

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Geotextile tube dewatering gravel pad

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Geosynthetics applications for sustainable waste management and landfills

- 70 percent to 90 percent of landfills are open dumping in India (Visvanathan et al., 2003). It creates environmental pollution in water, land and air.

- During heavy rain it also causes the drainage difficulties and leachate.

- Proper plan, liner and monitoring wells systems are needed to check gas or water quality. It is also required leachate detection, collection, removal and treatment system.

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Only in Mumbai, municipal solid waste generated is about 6,500 metric tons per day. 5 percent of total waste is segregated by rag-pickers. Only 7% is treated and disposed of scientifically.

Each year e-wastes generated in India are more than 1,46,000 tons. Mumbai generates 23000 metric tons of e-waste per year. It leaves behind carbon.
Central Pollution Control Board-CPCB (2012) and Ministry of Environment and Forests (2010) reported that in India total plastic generation is 5.6 million tons/year.

- Out of which 60% i.e., 3.36 million tons/year will be collected as plastic waste for recycling process, and

- 40% i.e., 2.26 million tones/year will be remained as uncollected plastic waste.
### Central Pollution Control Board-CPCB (2012) and Ministry of Environment and Forests (2010)

<table>
<thead>
<tr>
<th>City</th>
<th>Total plastic waste generated (tons/day)</th>
<th>Plastic waste collected for recycling (tons/day)</th>
<th>Uncollected plastic waste (tons/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolkata</td>
<td>425.35</td>
<td>255.21</td>
<td>170.14</td>
</tr>
<tr>
<td>Chennai</td>
<td>429.30</td>
<td>257.58</td>
<td>171.72</td>
</tr>
<tr>
<td>Mumbai</td>
<td>421.01</td>
<td>252.60</td>
<td>168.40</td>
</tr>
<tr>
<td>Delhi</td>
<td>688.84</td>
<td>413.30</td>
<td>275.536</td>
</tr>
</tbody>
</table>
It is a major threat to environment and health hazard to the humanity and animals.

In modern landfills, geosynthetics can provide cost effective long term environment-friendly engineering solutions.

Need for proper rules and regulations governing the construction of different type of landfill systems.

“pay-as-you-throw” (PAYT).

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Leachate formation causing contamination of ground water and surface water

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Applications of geosynthetics in landfills

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Wet Landfilling (Bioreactor Landfills)

- Rate of decomposition of organic waste in a dry landfill is not satisfactory and the leachate will continue to contain significant amounts of contaminants many years (viz. more than 20 years) after a landfill is encapsulated.
- Many researchers also expressed skepticism regarding the longevity of the liner and leachate collection system. It is required to flush out the contaminants faster using bio-degradation of the wastes.
- Wet landfilling where liquid is purposely added to the waste mass, can enhance the degradation process.

- The wet landfilling strategies are:
  - Leachate recirculation
  - Anaerobic bioreactor
  - Aerobic bioreactor
Leachate recirculation

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Geosynthetics applications for protection against falling stone

- The mechanically stabilized reinforced soil walls can protect the falling stone.
Geosynthetics applications for noise reduction barrier

- The mechanically stabilized reinforced soil walls can act as noise barrier
Geosynthetics applications to combat or mitigate acts of terrorism and/or natural disasters

- Geosynthetics can be used as retrospective. Geotextile tubes filled with sand can be dumped from trucks into the emergency sealing of levee breaks.

- The military people can use geotextile tube filled with soil as blast-resistant barrier walls. The fiber reinforced soil tube can be used as resistant to blasts. The polyurea liner can be used for retrofitting building.

- Geosynthetics based barrier can be used for building security. The biological agent can be added to the slurry to obtain potable water.

- Geosynthetics can be used as camouflage. Geosynthetics net can be used to evacuate people from building roof top.
### International Geosynthetics Society (IGS): A few milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>First International Conference on geosynthetics, Paris - France</td>
</tr>
<tr>
<td>1982</td>
<td>Second International Conference on geosynthetics, Las Vegas, Nevada - U.S.A</td>
</tr>
<tr>
<td>1986</td>
<td>Third International Conference on geosynthetics, Vienna - Austria</td>
</tr>
<tr>
<td>1990</td>
<td>Fourth International Conference on geosynthetics, The Hague - Netherlands</td>
</tr>
<tr>
<td>1994</td>
<td>Fifth International Conference on geosynthetics, Singapore</td>
</tr>
<tr>
<td>1998</td>
<td>Sixth International Conference on geosynthetics, Atlanta - U.S.A</td>
</tr>
<tr>
<td>2002</td>
<td>Seventh International Conference on geosynthetics, Nice – France</td>
</tr>
<tr>
<td>2006</td>
<td>Eighth International Conference on geosynthetics, Yokohama – Japan</td>
</tr>
<tr>
<td>2010</td>
<td>Ninth International Conference on geosynthetics, Sao Paulo – Brazil</td>
</tr>
<tr>
<td>2014</td>
<td>Tenth International Conference on geosynthetics, Berlin – Germany</td>
</tr>
<tr>
<td>1985</td>
<td>IGS News Letter</td>
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</table>

### Two International Journals
- International Journal geotextiles and geomembranes.
- Geosynthetics International Journal
- Total IGS Chapters - 37
- For student membership is free

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Role of IIT Bombay

- 1985: Geosynthetic Research and Testing Laboratory.
- 1986: Video film on “Geosynthetic edge”
- 1988: Founder of International Geosynthetics Society (Indian chapter)
- 1989: Video course on “Geosynthetics Engineering”.
- 1993: Turning point program on” Geotextiles”
- Editorial Board member of International journal of geotextiles and geomembranes.
- Many Continuous Education program, workshops, seminars etc.
- Many innovative Research, Testing, consultancy projects have been completed. Development of new materials and software.
- Two Books: Geosynthetics world and A guide to geotextile testing.
- More than 400 technical papers on geosynthetics have been published.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Probability of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Disease</td>
<td>0.25</td>
</tr>
<tr>
<td>Cancer</td>
<td>0.23</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.036</td>
</tr>
<tr>
<td>Car</td>
<td>0.012</td>
</tr>
<tr>
<td>Suicide</td>
<td>0.009</td>
</tr>
<tr>
<td>Fire</td>
<td>0.0009</td>
</tr>
<tr>
<td>Airplane</td>
<td>0.0002</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.0002</td>
</tr>
<tr>
<td>Lightening</td>
<td>0.00001</td>
</tr>
<tr>
<td>Earthquake</td>
<td>0.000009</td>
</tr>
<tr>
<td>Flood</td>
<td>0.000007</td>
</tr>
</tbody>
</table>

Source: ISSMGE Bulletin, Vol.6, No-1, P-18 (Probability of failures)

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Please let us hear from you

Any question?
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THANKS FOR LISTENING