Introduction to Geosynthetics
What are Geosynthetics?

Geo = earth
Synthetic = human made

Geosynthetics = human made materials (polymers) used with soil, rock, earth or other geotechnical materials as an essential part of a project, structure or system.
# Types & Functions

<table>
<thead>
<tr>
<th>Type</th>
<th>Separation</th>
<th>Reinforcement</th>
<th>Filtration</th>
<th>Drainage</th>
<th>Containment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geotextiles</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Geogrid</td>
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<td>X</td>
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<tr>
<td>Geonet</td>
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<td>X</td>
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<tr>
<td>Geomembrane</td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>GCL</td>
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<td></td>
<td>X</td>
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<tr>
<td>Geofoam</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Geocell</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Geocomposite</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Geotextiles

Two Types

Woven
- Used for separation, reinforcement and drainage.
- Used with pavement, roads, railroads, structures, and rip rap.
- Strength is support, stabilization, and drainage to prevent erosion and or collapsing of the ground around a road, railroad, etc.

Nonwoven
- Used for separation, reinforcement, and filtration.
- Used with drains, geomembranes, aggregate
- Reclamation mainly uses as a cushion to protect geomembranes from being punctured by aggregate, the subgrade, etc.
Geomembranes

- Function: contain liquids or gases. Reclamation uses geomembranes in canals, ponds, reservoirs, dam faces, and roof tops to prevent water from seeping into unwanted areas.
- The primary makeup of most Geomembranes is any of the following polymers:
  - HDPE, LLDPE, PP, PVC, CSPE, or EPDM
- Additives are used to improve properties required for durability, UV exposure, etc.
  - Carbon Black is a pigment that is used for UV stabilization.
  - Plasticizers impart flexibility to prevent punctures and tears
  - Biocides to kill organic material
Geonet

• Geonets are grid like materials consisting of parallel sets of ribs overlaying other parallel sets of ribs at various angles. They are often sandwiched between GT’s.

• The function of a geonet is to laterally drain liquids or gases within the plane of the material.
  ➢ Example – used under sports fields or putting greens to prevent sitting water.

• Two main types of geonets used.
  ➢ Triplanar - these types are used whenever drainage is required under high loads.
  ➢ Biplanar – these types of geonets are used to transport large fluid or gas flows under very minimal loads such as leak detection layers in ponds.
**Geocell**

- Geocells are a three-dimensional structure much like a honeycomb that is meant to be filled with aggregate, soil, etc. (See images to the right)
- Function
  - Separation
  - Reinforcement
  - Both
- Reclamation has used these to retain a cobble/gravel mixture on the side slope of a detention pond to protect the underlying geomembrane liner from UV degradation and mechanical damage.
- Primary Use
  - Reclamation: canals and ponds
  - Soil stabilization, erosion control, and structural reinforcement for load support.
Geosynthetic Clay Liner

• Geosynthetic Clay Liners (GCL’s) are hydraulic barriers that generally consist of bentonite clay sandwiched between two geotextiles or geomembranes.
• GCL’s are primarily used in landfill applications in place of compacted clay (CC) liners or geomembranes.
  ➢ Fast + Easy to Install
  ➢ Very low conductivity, swell to 15 times size when hydrated.
  ➢ Self healing up to 70 mm holes.
  ➢ Low cost when CC is not available.
  ➢ Maximize capacity compared to CC
• Reclamation has used GCL’s in canals and ponds.
  ➢ 12 in min. soil cover to provide seal
  ➢ Soil cover sloughs from side slopes
  ➢ Cover significantly reduces capacity
Geogrids/Geofoam

**Geogrids**

- Geogrids are used to reinforce soils or other materials.
  - Retaining walls
  - Side slopes
  - Reinforce soils or other base materials below roads or other structures.

**Geofoam**

- Geofoam is large blocks of expanded polystyrene (EPS).
  - Slope stabilizer
  - Retaining wall backfill
  - Road embankments
  - Pavement insulation
Geocomposite

• Geocomposite – a combination of any of the previous discussed geosynthetic materials.
• The goal of a geocomposite is to combine the best properties of the different types of materials to find an optimal low-cost solution to a specific problem.
  ➢ Geocomposite can provide separation, reinforcement, filtration, drainage, and containment.
• Geocomposite Examples
  ➢ Geotextile-Geonet Geocomposite
  ➢ Geotextile-Geomembrane Geocomposite
  ➢ Geomembrane-Geogrid Geocomposite
  ➢ Geotextile-Geogrid Geocomposite
Repair Techniques

- Geomembranes
  - Heat Welder – more economical in most situations and creates strong bond.
  - Adhesive - messy
  - Adhesive Tape – strong bond, pipe boots
Repair Techniques

• Geotextiles
  ➢ Heat Welder – preferred method that creates strongest bond.
  ➢ Stitching – must be used in wet weather as welding won’t work.
Degradation Mechanisms

- Any mechanism that causes chain scission, bond breaking, loss of additives, extraction, or mechanical damage will lead to degradation.
  - UV light
  - Radioactive
  - Biological (animals, fungi or bacteria)
  - Chemical
  - Thermal (expansion and contraction)
  - Oxidative
  - Ozone
  - Vandalism
Canal Lining Research
Project Scope

• Research Question
  ➢ Goal was to study non-traditional liners in canals with high seepage rates (35-50%).
  ➢ Current question: how are the test sections performing after up to 25 years of service?

• Team & Partners
  ➢ Jay Swihart & Mike Walsh (BOR)
  ➢ George Koerner (GRI)
Project Approach

• Test Sections (Arnold, North, and Ochoco)
  ➢ 24 test sections installed 1991 to 2001
  ➢ 7 test sections removed from the study

• Report
  ➢ Failure analysis (7 test sections)
  ➢ Condition Assessment (17 test sections)
  ➢ Sample Coupon Testing (GRI)
    ➢ Correlation between properties and performance
  ➢ Benefit/Cost Analysis
Project Results

• Exposed Geomembrane

• Advantages
  – Can be durable (25+ years)
  – Low cost
    – Initial construction
  – Effectiveness (90%)

• Disadvantages
  – Maintenance
    – Difficult
    – Higher cost
  – Service conditions
    – Soil migration
    – Liner Uplift + whales
    – Capacity reductions
    – Varying B/C ratio
Project Results

• Concrete (reinforced & unreinforced)

• Advantages
  – Durable (50 years)
  – Maintenance
    ➢ Low cost
    ➢ Easy
  – Prevent
    ➢ Soil migration
    ➢ Canal failure

• Disadvantages
  – Low effectiveness (seepage reduction)
    ➢ estimated 70%
  – Fairly Expensive
Project Results

• Concrete over Geomembrane

• Advantages
  – Durable (50 years)
  – Effective (95%)
  – Maintenance
    ➢ Easy
    ➢ Low cost
  – Prevent
    ➢ Soil migration
    ➢ Liner degradation
    ➢ Liner uplift
    ➢ Canal failure

• Disadvantages
  – Expensive
### Project Results

<table>
<thead>
<tr>
<th>Liner Type</th>
<th>Durability (years)</th>
<th>Effectiveness (%)</th>
<th>Maintenance ($/ft²·yr)</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>50</td>
<td>70</td>
<td>0.005</td>
<td>3.0-3.3</td>
</tr>
<tr>
<td>Concrete over Geomembrane</td>
<td>50</td>
<td>95</td>
<td>0.005</td>
<td>3.5-3.7</td>
</tr>
<tr>
<td>Exposed Geomembrane</td>
<td>15-30</td>
<td>90</td>
<td>0.010</td>
<td>2.2-3.8</td>
</tr>
</tbody>
</table>

- Concrete over geomembrane provides consistently high B/C ratio and highest effectiveness (main goal).
WTP Detention Pond

• This slide is intended to highlight how geosynthetics can be used in conjunction with each other.
• The following liner system is being used in a water treatment plant detention pond. The pond is utilized as a storage pond in case the plant is at capacity, there is down time for maintenance, exit streams are dropping in quality for an unknown reason, etc.
Dam Seepage Reduction

• Using geosynthetic materials to reduce seepage through the face of a dam.
• This dam is made from steel plates coated with a protective paint.
• Problems that have arisen.
  ➢ Corrosion of the steel face
  ➢ Movement and heaving of the steel plates
  ➢ Cracking
• This solution utilizes batten strips as well as a proprietary technology to tension the material down to the face of the dam. Wind is obviously a concern in an application like this where in a canal it wouldn’t be as much of an issue.
Elevator Shaft Roof Repair

• Reclamation is involved in roof repair projects that involve finding a waterproof and weatherproof solution to roofing. This project involved fixing a leaky roof over the top an elevator shaft in a hydroelectric plant.
• EPDM is often used as it is very weatherproof, durable and flexible at both high and low temperatures.
Thank you!
Questions?

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