Introduction to GEOSYNTHETICS

• What are Geosynthetics?
• Why would we want to use them?
• How should we use them?

What are Geosynthetics?

• Geosynthetics are human-made materials made from various types of polymers used to enhance, augment and make possible cost effective environmental, transportation and geotechnical engineering construction projects. They are used to provide one or more of the following functions; separation, reinforcement, filtration, drainage or liquid barrier.
Categories of geosynthetics:

- **geotextiles** - flexible, textile-like fabrics of controlled permeability used to provide filtration, separation or reinforcement in soil, rock and waste materials
- **geomembranes** - essentially impermeable polymeric sheets used as barriers for liquid or solid waste containment
- **geogrids** - stiff or flexible polymer grid-like sheets with large apertures used primarily as reinforcement of unstable soil and waste masses
- **geonets** - stiff polymer net-like sheets with in-plane openings used primarily as a drainage material within landfills or in soil and rock masses
- **geosynthetic clay liners** - prefabricated bentonite clay layers incorporated between geotextiles and/or geomembranes and used as a barrier for liquid or solid waste containment
- **geopipes** - perforated or solid wall polymeric pipes used for the drainage of various liquids
- **geocomposites** - hybrid systems of any, or all, of the above geosynthetic types which can function as specifically designed for use in soil, rock, waste and liquid related problems
• The growth of these geosynthetic materials in Transportation, Geotechnical and Environmental related applications has been sustained for the past 20 years.
• Total use and sales of these materials are regularly increasing at rates of 10% to 20% per year in each of the above categories.

Designing with Geosynthetics

Recall the 5 principal functions of geosynthetics
• **Separation**
• **Reinforcement**
• **Filtration**
• **Drainage**
• **Liquid barrier**
Designing with Geosynthetics

• Consider a geotextile under an embankment

• This geotextile may function simultaneously in filtration, separation, drainage and reinforcement

DESIGN BY FUNCTION

• Determine the function of the geosynthetic component in question
• Determine the required properties (filtration size, in-plane or cross-plane hydraulic flow capacity, required tensile strength and modulus)
Design by Function

- Standard “INDEX” Tests have been developed to aid in the evaluation of the required properties and selection of a particular geosynthetic product.
- **Strength (tensile, burst, tear, puncture)**
- **Filtration (AOS, EOS, FOS)**
- **Permeability and Drainage Capacity**

Types of Polymers

- Polyethylene
- Polypropylene
- Polyester
- Nylon
- Polyvinyl Chloride (plasticized or non-plasticized)
Geotextiles

- Geotextiles form one of the two largest group of geosynthetics, and have been steadily growing in use during the past 20 years.
- They are textiles in the traditional sense, but consist of synthetic fibers rather than natural ones such as cotton, wool, or silk. Thus biodegradation is not a problem. These synthetic fibers are made into a flexible, porous fabric by standard weaving machinery or are matted together in a random, or nonwoven, manner.
- The major point is that they are pervious to water flow across their manufactured plane and also within their plane, but to a widely varying degree.
(L) woven monofilament
(R) calendered woven monofilament

(L) woven multifilament
(R) woven slit film

(L) nonwoven needle-punched
(R) nonwoven heat-bonded
There are at least 80 specific applications area for geotextiles that have been developed; however, the fabric always performs at least one of five discrete functions:

1. Separation
2. Reinforcement
3. Filtration
4. Drainage
5. Moisture barrier (when impregnated)
Large Prefabricated Geotextile Tubes and Containers

“Geocontainers”
Designing with Geotextiles

• Determine Critical Function
  FILTRATION, REINFORCEMENT, SEPARATION or DRAINAGE
• If FILTRATION $\rightarrow$ FOS (AOS/EOS)
• If REINFORCEMENT $\rightarrow$ Tensile Strength and Modulus
• If SEPARATION $\rightarrow$ ? Survivability
• Consider long-term performance

Geomembranes
Geomembranes

- Geomembranes represent the other largest group of geosynthetics and in dollar volume their sales are probably larger than that of geotextiles. Their growth has been stimulated by governmental regulations originally enacted in 1982.

- The materials themselves are "impervious" thin sheets of rubber or plastic material used primarily for linings and covers of liquid- or solid-storage or disposal facilities. Thus the primary function is always as a liquid or vapor barrier.

- The range of applications, however, is very great, and at least 30 individual applications in civil engineering have been developed.
Designing with Geomembranes

• Leakage Rates are determined by Quality Control.  **SEAMS**
• Consider compatibility with retained liquid or waste.
• Consider GM as potential slip-surface on slopes
• Consider exposure to long-term environmental agents of weathering (sunlight, air, burrowing rodents)
Geogrids

- Geogrids represent a rapidly growing segment within the geosynthetics area. Rather than being a woven, nonwoven or knit textile or textile-like fabric, geogrids are plastics formed into a very open, gridlike configuration, i.e., they have large apertures.

- Geogrids are either stretched in one or two directions for improved physical properties or made on weaving machinery by unique methods.

- By themselves, there are at least 25 application areas, however, their function is exclusively as reinforcement materials.
Installation of Geogrid over sludge and contaminated soil - former cooling lagoon (Nov. 1998)
Designing with Geogrids

- Consider Tensile Modulus and Strength
- Mechanical Interlock with granular fills
- Damage During Construction

Geonets
Geonets

- Geonets, called geospacers by some, constitute another specialized segment within the geosynthetic area. They are usually formed by a continuous extrusion of parallel sets of polymeric ribs at acute angles to one another. When the ribs are opened, relatively large apertures are formed into a netlike configuration.
- Their design function is completely within the drainage area where they have been used to convey fluids of all types.
Geosynthetic Clay Liners

• Geosynthetic clay liners (or GCLs) are the newest subset within geosynthetic materials. They are rolls of factory fabricated thin layers of bentonite clay sandwiched between two geotextiles or bonded to a geomembrane. Structural integrity is maintained by needle punching, stitching or physical bonding.

• They are seeing use as a composite component beneath a geomembrane or by themselves as primary or secondary liners.
Adhesive Bound Clay to Upper and Lower Geotextiles

Stitch Bonded Clay Between Upper and Lower Geotextiles

Needle Punched Clay Through Upper and Lower Geotextiles

Adhesive Bound Clay to a Geomembrane
Designing with GCL’s

• Leakage Rate
• Compatibility of Bentonite with retained waste or liquid (potential for deleterious mineralogical alteration)
• Consider slip-surface on slopes
Geopipe (aka Buried Plastic Pipe)

• Perhaps the original geosynthetic material still available today is buried plastic pipe.
• This "orphan" of Civil Engineering materials is included in the list due to an awareness that plastic pipe is being used in all aspects of geotechnical, transportation and environmental engineering with little design and testing awareness.
• The critical nature of leachate collection pipes coupled with high compressive loads makes geopipe a bona-fide member of the geosynthetics family. The function is clearly drainage.

Geocomposites

• A geocomposite consists of a combination of geotextile and geogrid; or geogrid and geomembrane; or geotextile, geogrid, and geomembrane; or any one of these three materials with another material (e.g., deformed plastic sheets, steel cables, or steel anchors).
• This exciting area brings out the best creative efforts of the engineer, manufacturer, and contractor.
• The application areas are numerous and growing steadily. The major functions encompass the entire range of functions listed for geosynthetics discussed previously: separation, reinforcement, filtration, drainage, and liquid barrier.
"Geo-Others"

- The general area of geosynthetics has exhibited such innovation that many systems defy categorization. For want of a better phrase, geo-others, describes items such as threaded soil masses, polymeric anchors, and encapsulated soil cells.
- As with geocomposites their primary function is product-dependent and can be any of the five major functions of geosynthetics.
CONCLUSION– Design by Function

• Determine the function of the geosynthetic component in question

• Determine the required properties (filtration size, in-plane or cross-plane hydraulic flow capacity, required tensile strength and modulus)

CONCLUSION– Design by Function

• For geotextile providing SEPARATION only, specify required properties on the basis of “survivability”

• In Specifications, reference required material properties to the Standard “INDEX” Tests. Strength (tensile, burst, tear), Filtration (AOS, EOS, FOS), Permeability and Drainage Capacity
CONCLUSION– Design by Function

• A common (and less than desirable) practice is to specify “Product X or Equivalent”. This begs the question Equivalent what?!!

• Better to provide required properties and examples of specific products that will meet the specs