

Educate The Educators

About Geosynthetics

Online Edition, April 2021



Introduction to Geosynthetics

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The World of Geo- Materials





Huge Display of Geosynthetics Since the 70's



Courtesy: Boyd Ramsey

[illegible]

Today... Austin, Texas, USA

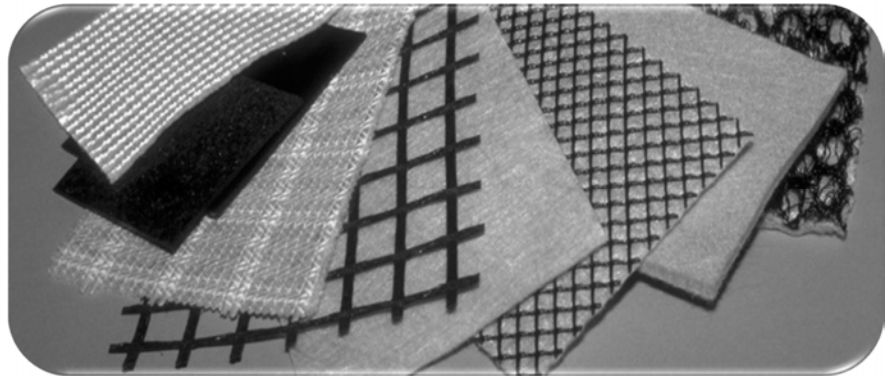


What are Geosynthetics?

Geosynthetics: Synthetic polymeric materials that are specifically manufactured to be used in geotechnical and geoenvironmental applications

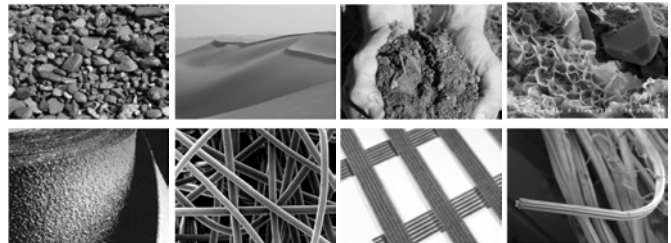
They are...

- ... quality-control manufactured
- ... installed rapidly
- ... generally used to replace earthen construction resources



Geosynthetic Types

- Geotextiles
- Geogrids
- Geomembranes
- Geonets
- Geocomposites
- Geocells
- Geosynthetic clay liners
- Erosion control products
- Many others:
 - Geofibers
 - Geofoam
 - Geopipes
 - Paving interlayers



Geosynthetic Functions

- Separation
- Reinforcement
- Stiffening
(a.k.a Stabilization)
- Filtration
- Barrier
- Drainage
- Protection

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Types of Geosynthetics

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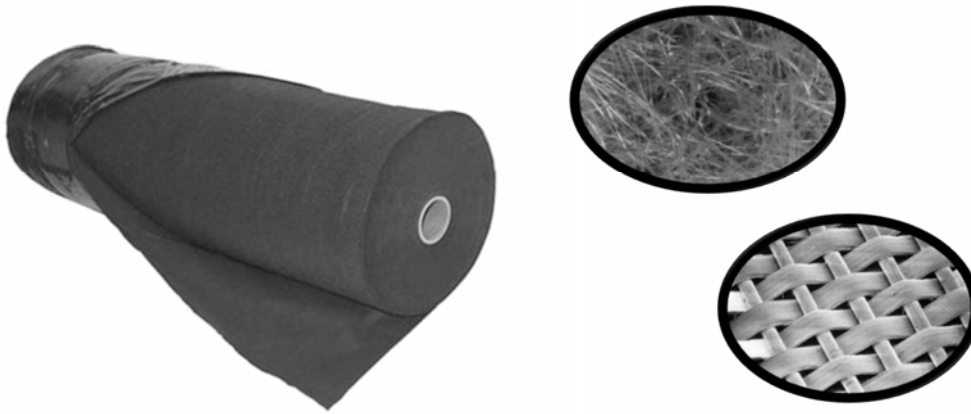
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Geotextiles

Geotextile: A permeable textile, usually manufactured using synthetic fibers, used in geotechnical applications.

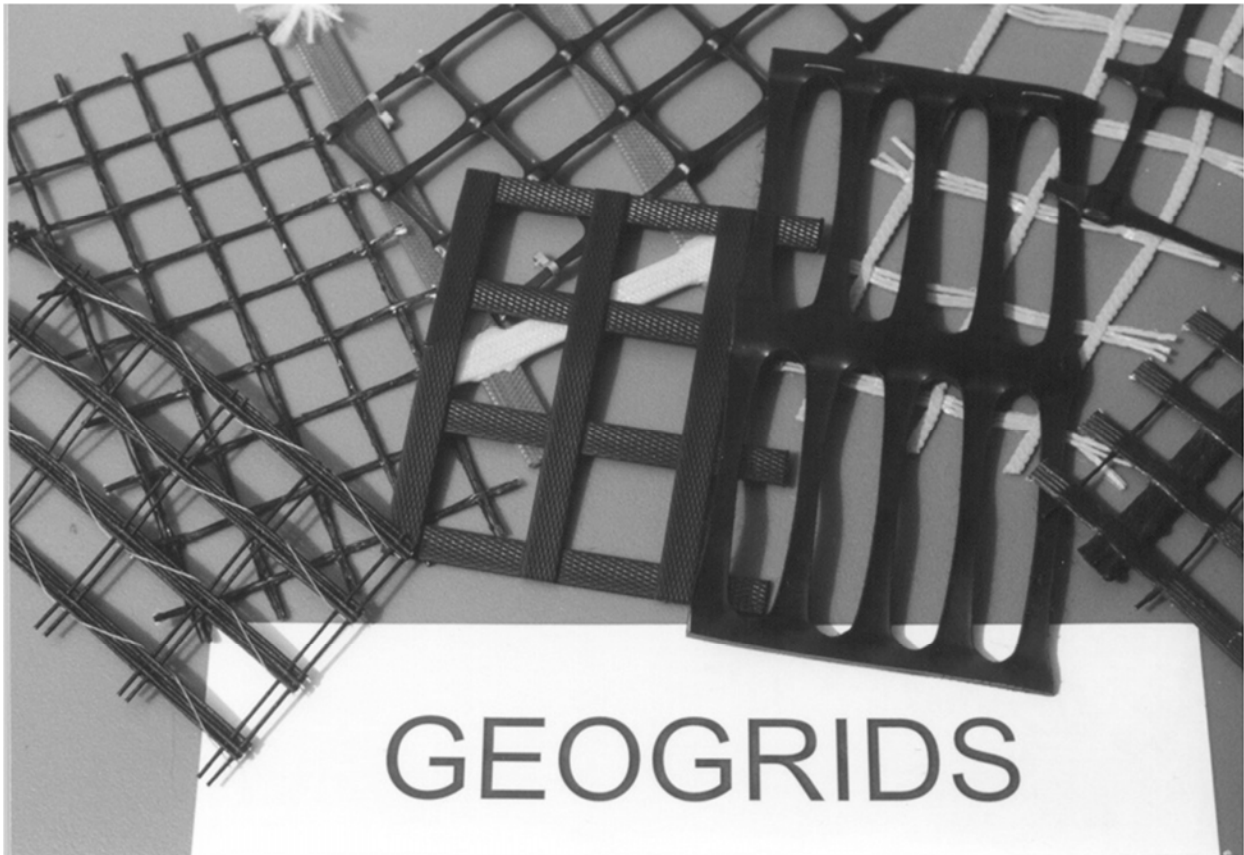
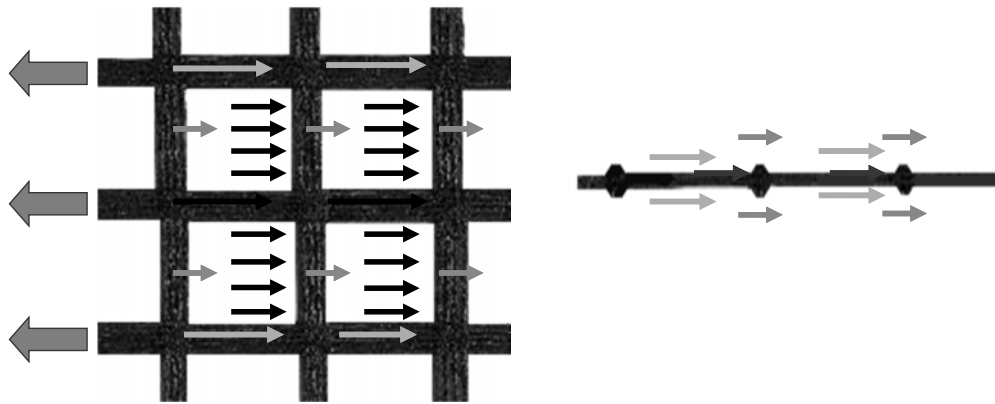
They have a wide range of mechanical and hydraulic properties and can be used for many functions in numerous applications. They are continuous sheets of woven, nonwoven, or knitted fibers or yarns.



Geogrids

Geogrid: A woven, knitted, welded or integrally formed (punched-drawn) sheet with an open grid structure.

Geogrids are distinguished by the regular network of tensile elements (longitudinal and transverse ribs) that form openings that are large enough to interlock with the surrounding soil matrix.



Geomembranes

Geomembrane: An essentially impermeable geosynthetic composed of one or more synthetic sheets.

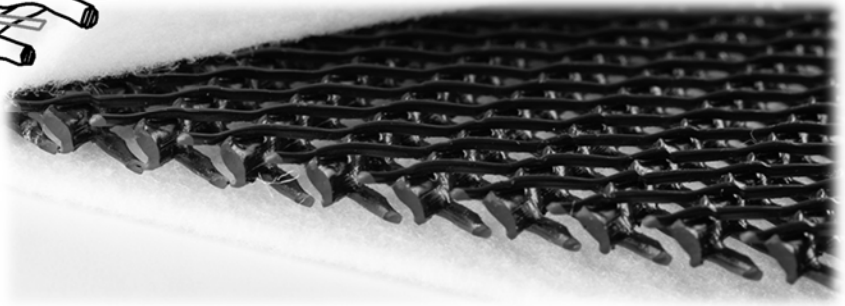
They are continuous and flexible sheets used as barriers to fluids, gases or vapors. They are manufactured from a wide range of polymers.



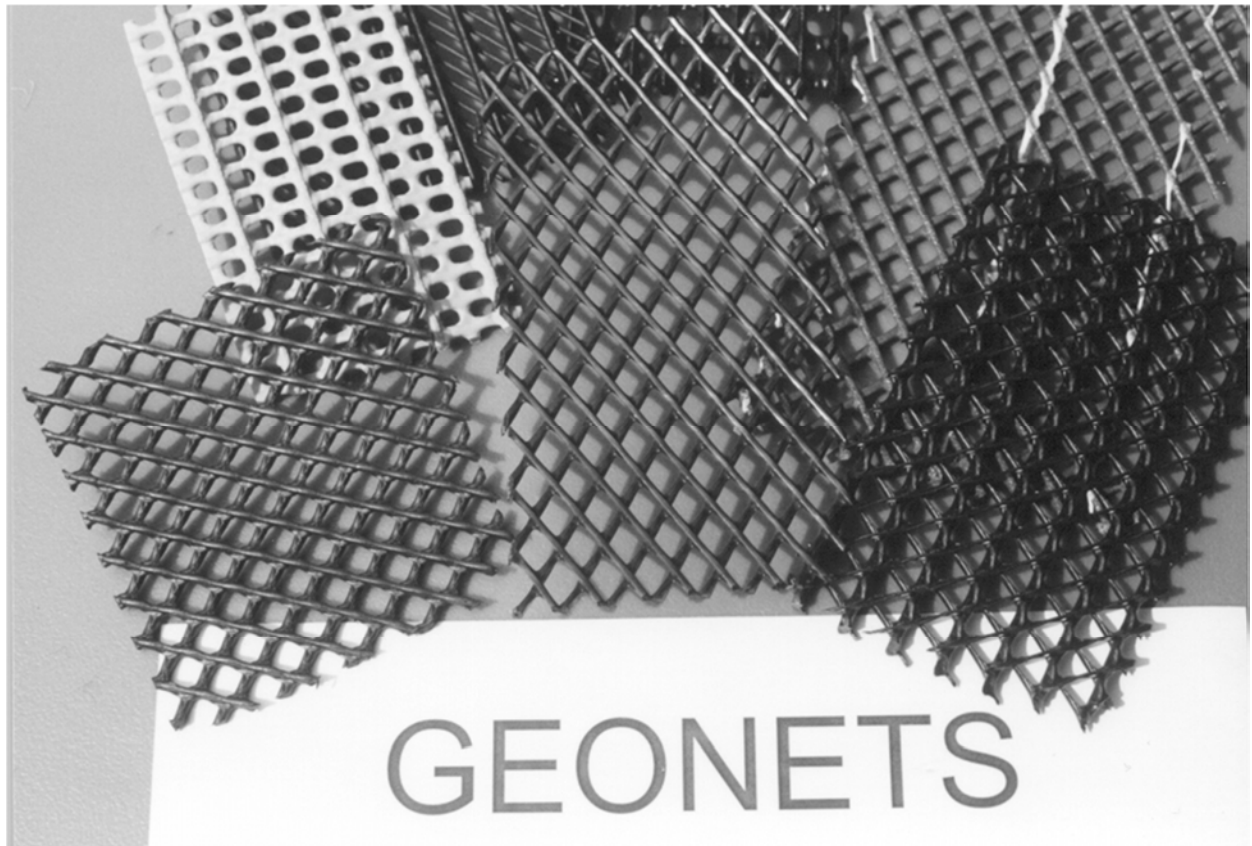
Geonets

Geonet: A geosynthetic consisting of integrally connected parallel sets of ribs overlying and integrally connected with similar sets at various angles.

They are used for in-plane drainage of liquid or gases.



Source: International Geosynthetics Society (IGS)

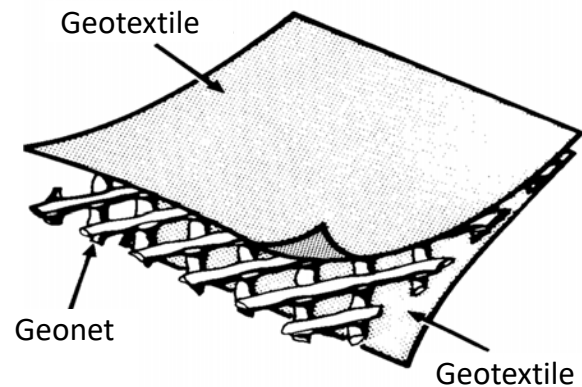
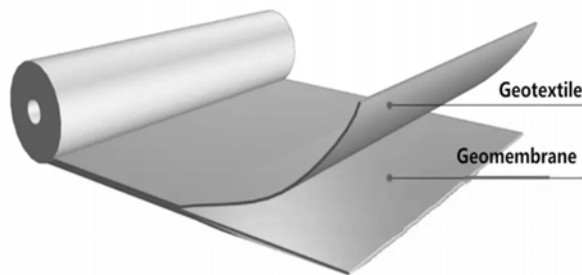


Source: Geosynthetic Institute (GSI)

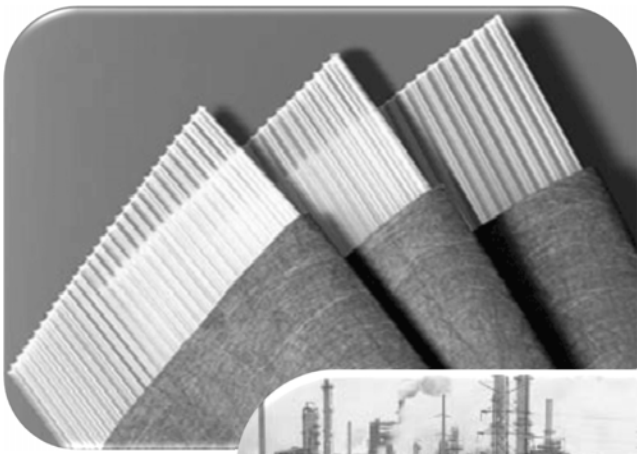
Geocomposites

Geocomposite: Geosynthetics made from a combination of two or more geosynthetic types.

For example, geocomposite drains formed by a geonet sandwiched between geotextiles acting as filters.



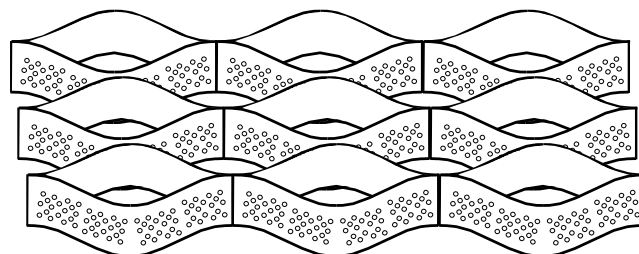
Prefabricated Vertical Drains



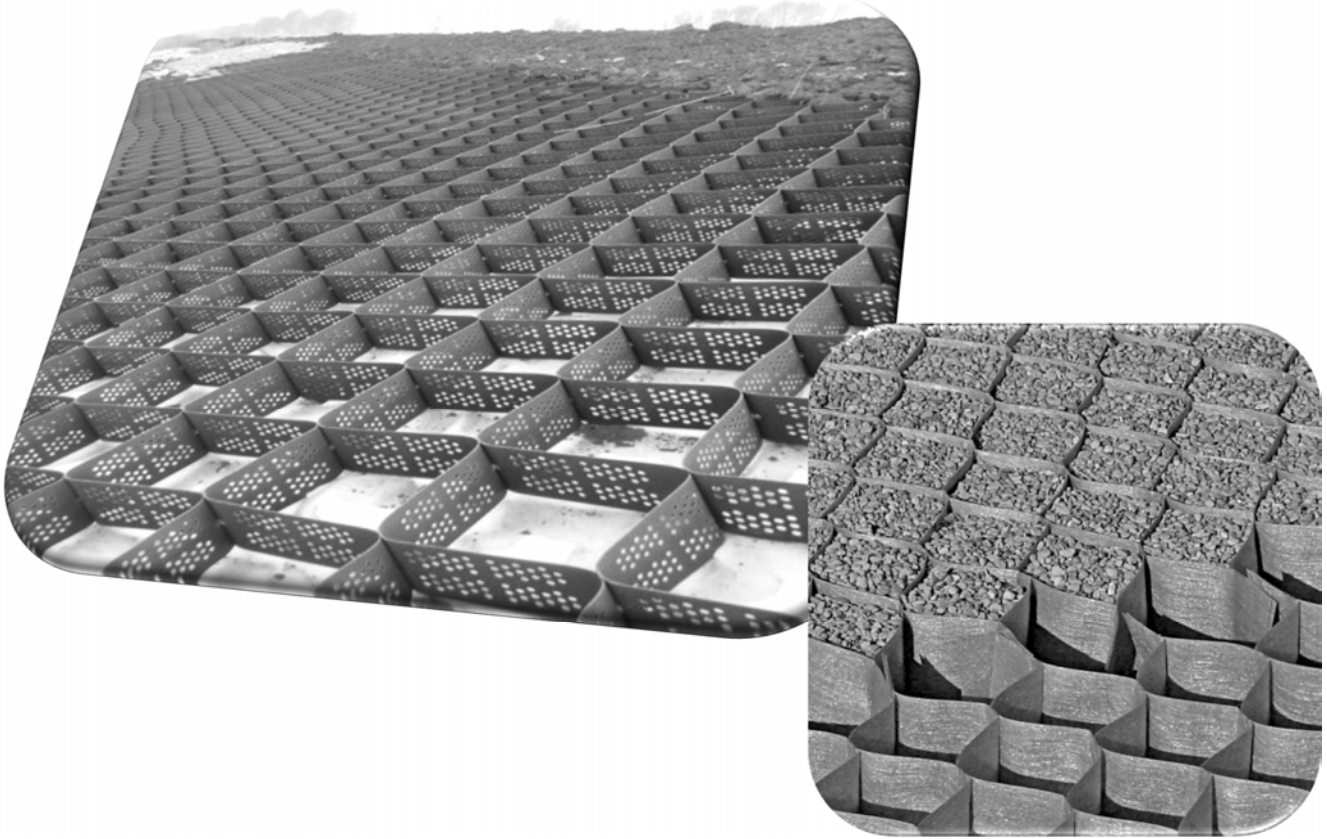
Geocells

Geocells: Relatively thick, three dimensional systems constructed from strips of polymeric material.

Strips are joined together to form interconnected cells that are infilled with soil or concrete. They can be used in many geotechnical and hydraulic structures.



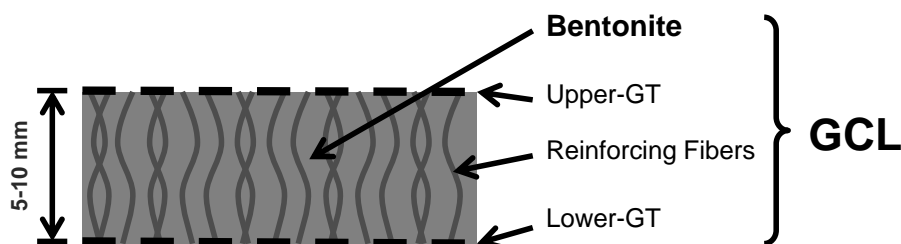
Geocells

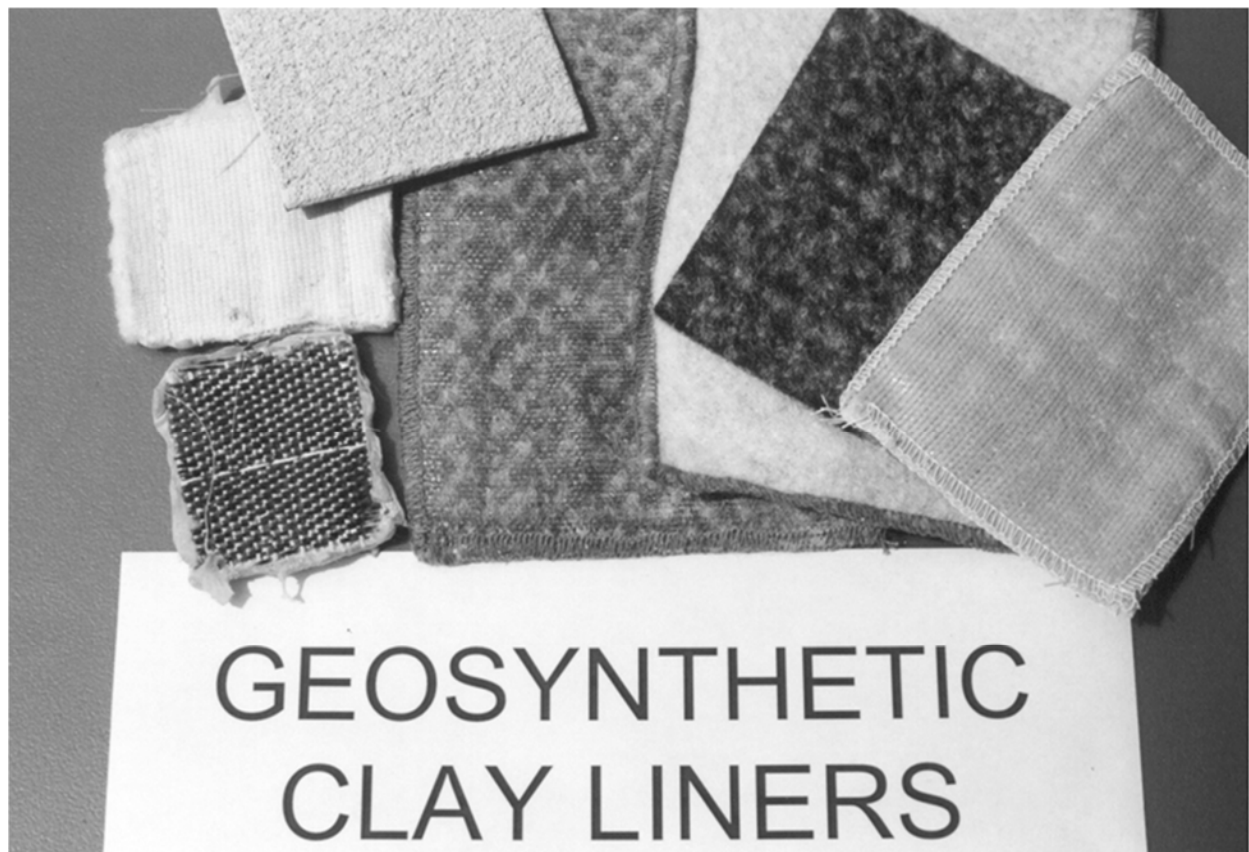


Geosynthetic Clay Liners (GCLs)

Geosynthetic clay liners: Prefabricated bentonite clay layers placed between two geotextiles or adjacent to a geomembrane.

They are used as a barrier for liquid in waste containment facilities. They are often placed under a geomembrane to form a composite liner.



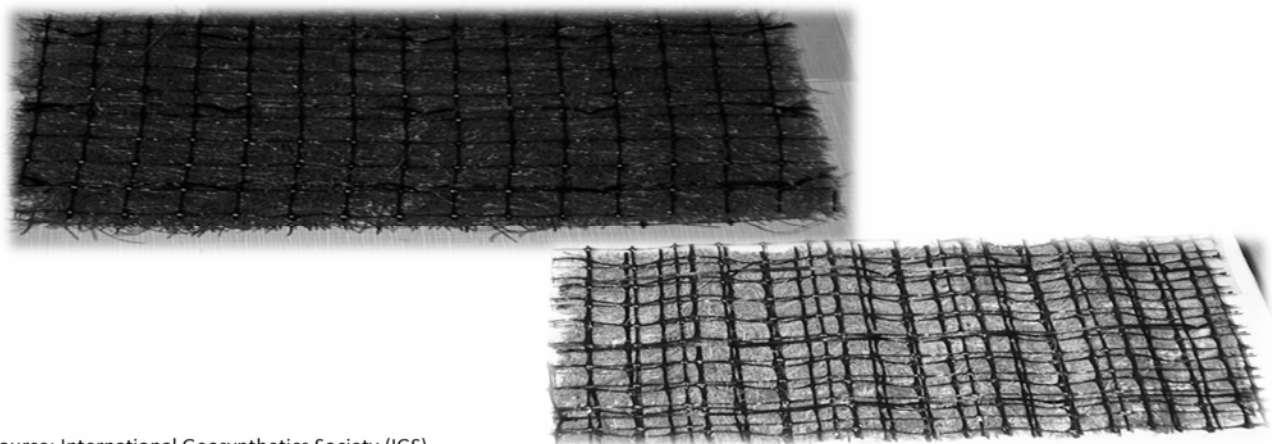


Source: Geosynthetic Institute (GSI)

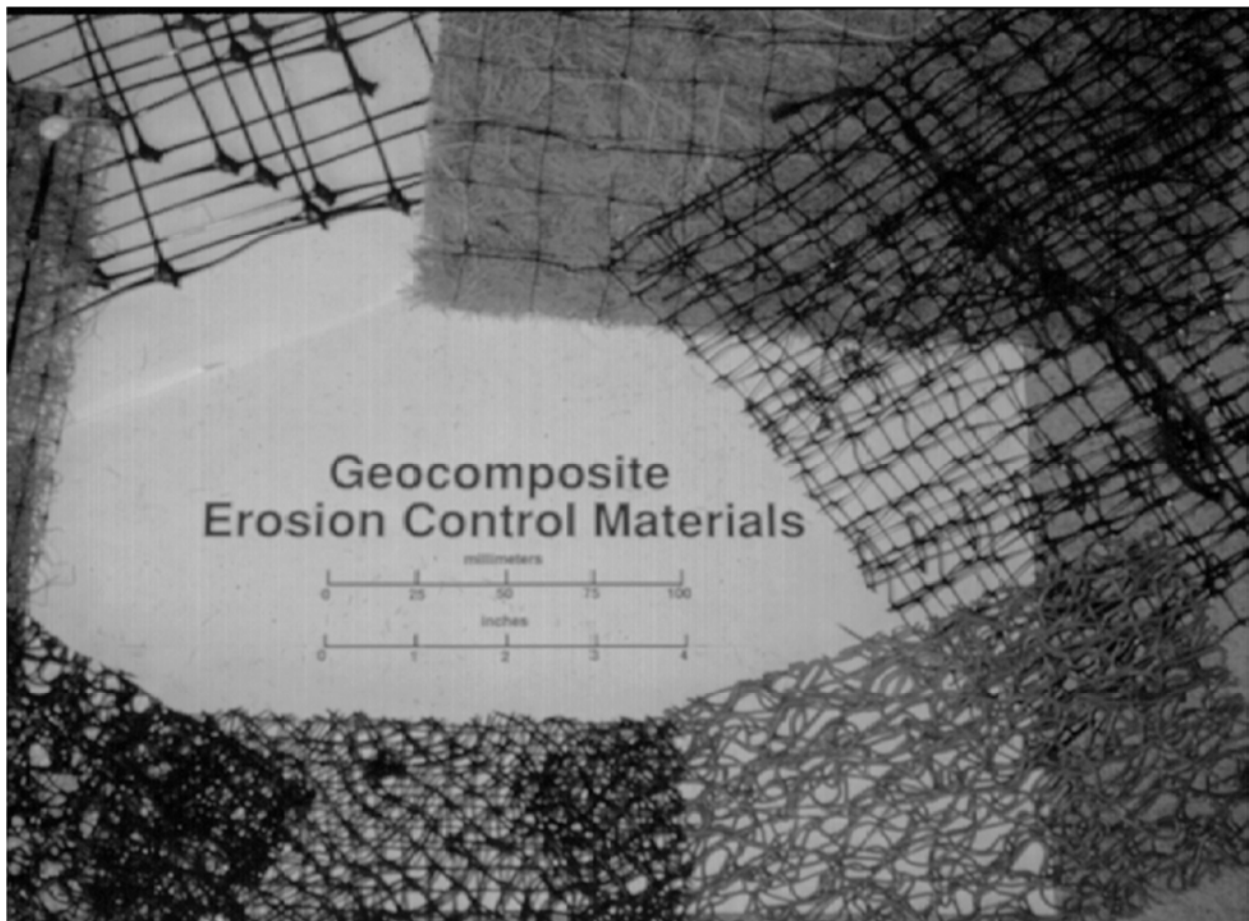
Erosion Control Products

Erosion Control Products: Used to minimize the detrimental effect on soil caused by the impact of rain and of surface water drainage.

Some of these products are manufactured using biodegradable products.

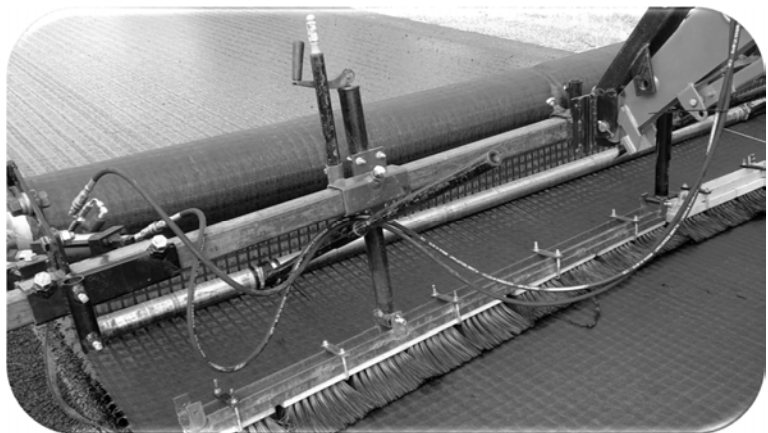
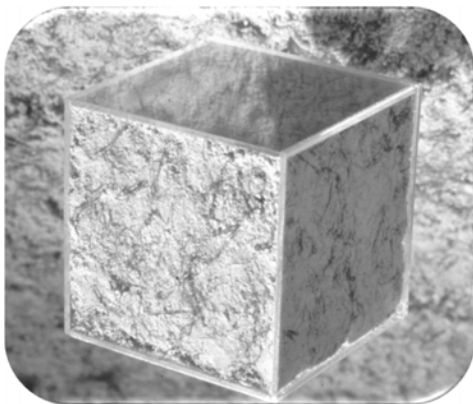


Source: International Geosynthetics Society (IGS)



Source: Geosynthetic Institute (GSI)

Other Geosynthetics



Source: Geosynthetic Institute (GSI)

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Functions of Geosynthetics

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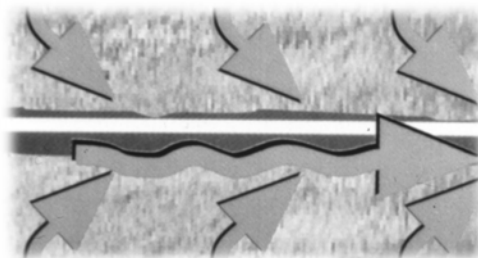
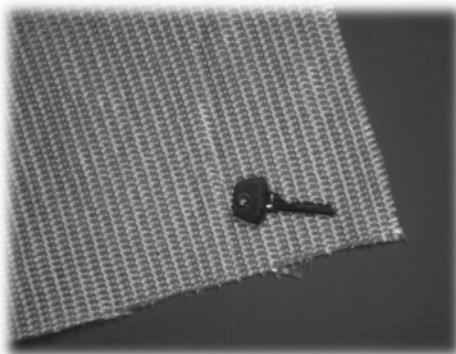
Past-President, IGS



Primary Functions

Geosynthetic applications can be classified according to *primary* functions.

However, it is important to note that geosynthetics may also perform one or more *secondary* functions.



Design by Function

- (a) Evaluate the criticality of the application;
- (b) Determine the function(s) of the geosynthetic;
- (c) Determine the required property value for the function(s);
- (d) Test or otherwise obtain the allowable property of the candidate geosynthetic;
- (e) Calculate the factor of safety (FS);
- (f) Evaluate factor of safety;
- (g) Prepare specifications and construction documents; and
- (h) Observe construction and post-construction performance.

Source: Koerner (2012)

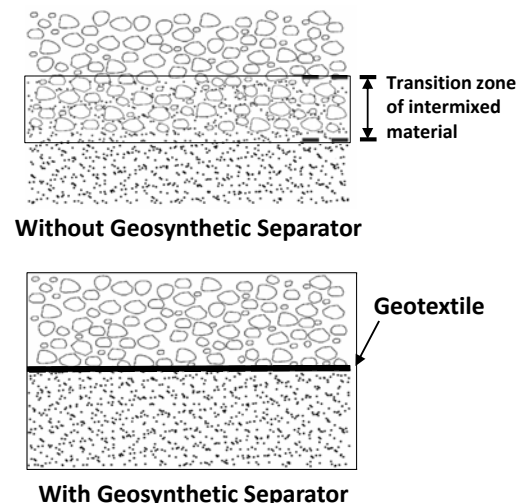
Separation Function

The geosynthetic, placed between two dissimilar materials, maintains them apart to keep their integrity and functionality.

Example: Geotextiles used to prevent base course materials from penetrating into an underlying soft subgrade, thus maintaining its design thickness.

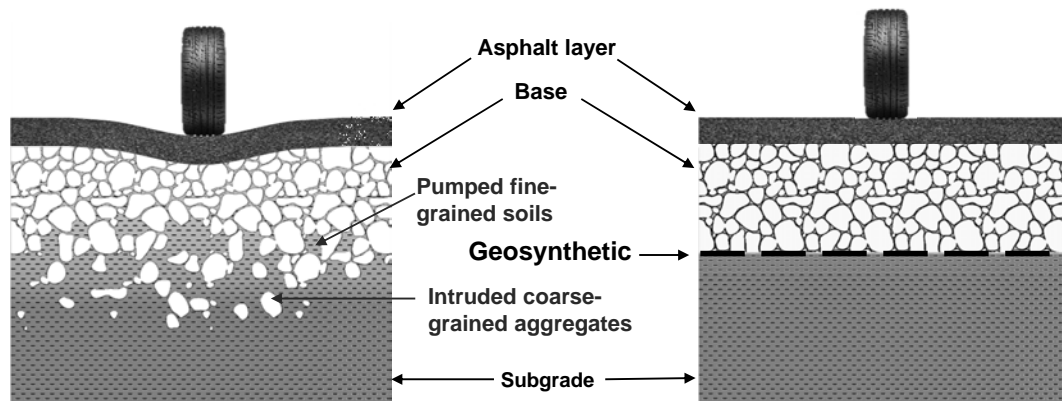
Key properties:

- “Survivability” properties



Source: Zornberg & Christopher (2007)

Separation Function



Road without Geosynthetic Separator

Road with Geosynthetic Separator

Source: Zornberg (2017)

Reinforcement Function

The geosynthetic develops tensile forces intended to maintain or improve the stability of the soil-geosynthetic composite.

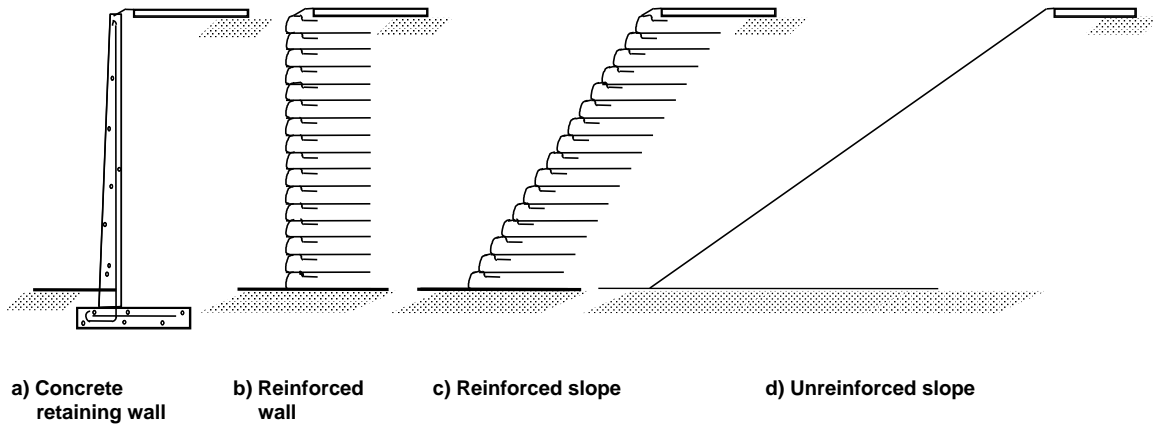
Example: Geosynthetics used to increase the margin of safety of a steep earth slope.

Key properties:

- Ultimate tensile strength
- Interface shear strength
- Reduction factors:
 - Creep
 - Installation damage
 - Durability

Source: Zornberg et al. (1997)

Reinforcement Function



Source: Zornberg and Christopher (2007)



Construction of a geosynthetic-reinforced steep slope to widen roadway through Idaho National Forest

Courtesy: Jorge Zornberg

Stiffening Function

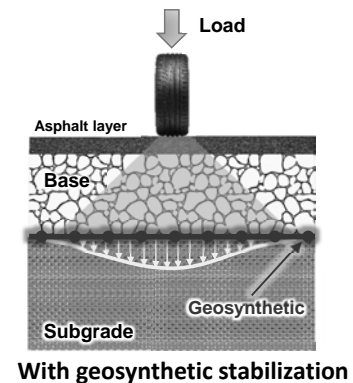
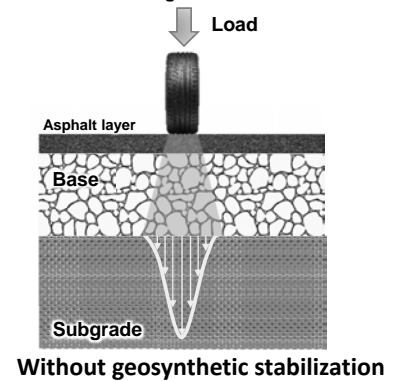
(a.k.a. Stabilization Function)

The geosynthetic develops tensile forces intended to control deformations in the soil-geosynthetic composite.

Example: A geosynthetic used to improve the mechanical properties of the unbound aggregate in a roadway.

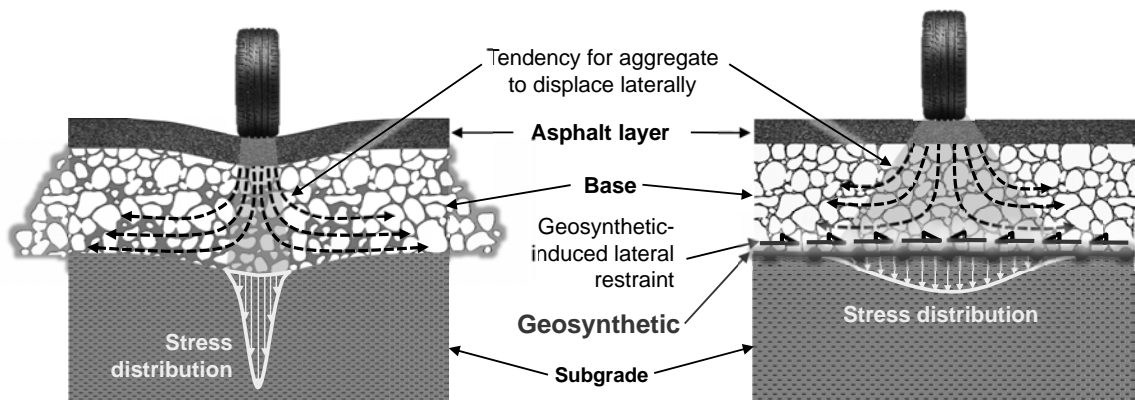
Key properties:

- Geosynthetic stiffness
- Soil-geosynthetic interaction
- Confined stiffness of the soil-geosynthetic composite



Stiffening Function

(a.k.a. Stabilization Function)





Road lane with geosynthetic-stabilized base course

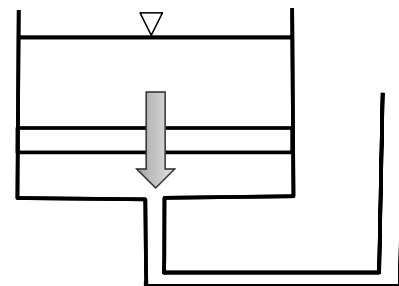
Road lane with non-stabilized base course

Conditions illustrating differences in performance between a geosynthetic-stabilized and control a section in a road founded on expansive clays

Courtesy: Jorge Zornberg

Filtration Function

The geosynthetic allows liquid flow across its plane while retaining fine soil particles on its upstream side.

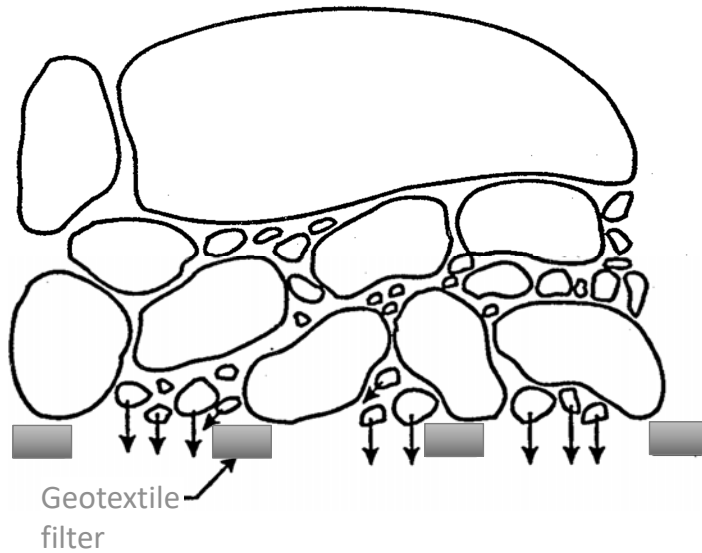


Example: Geotextiles used to prevent soils from migrating into the aggregates in a road drainage system while maintaining adequate liquid flow.

Key properties:

- Permittivity
- Apparent Opening Size (AOS)

Filtration Function



Retention Criterion:

$$AOS \leq B d_{85}$$

Source: Zornberg and Christopher (2007)

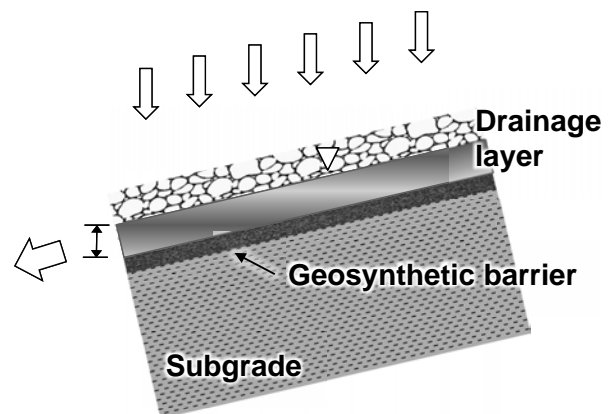
Barrier Function

The geosynthetic minimizes cross-plane flow, providing containment of liquids or gasses.

Example: Geomembranes used as barrier to downward migration of leachate at the base of a landfill.

Key properties:

- *For Geomembranes:*
 - Polymer type
 - Thickness
 - Interface shear strength
- *For GCLs:*
 - Hydraulic conductivity
 - Internal and interface shear strength



Barrier Function

Installation of a GCL in the cover of an MSW landfill



Courtesy: Geosynthetic
Institute (GSI)

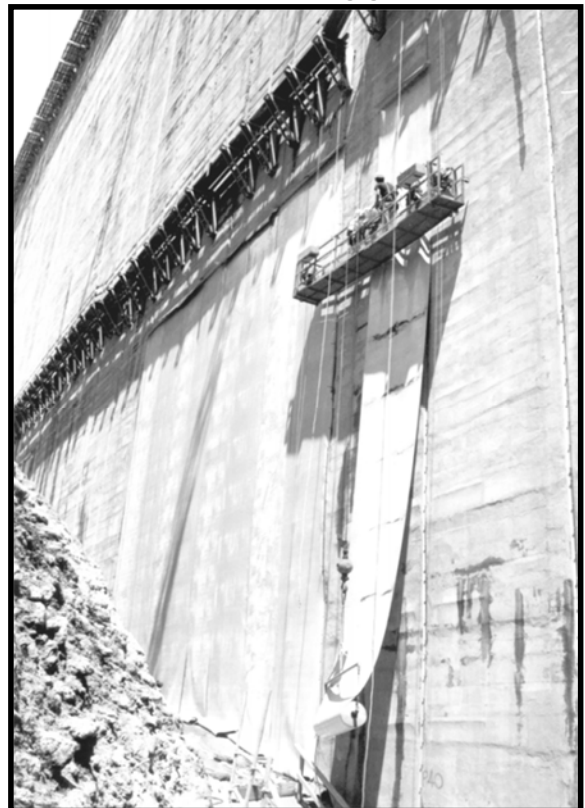
Lining with a geomembrane
at a mining site

Courtesy: International
Geosynthetics Society (IGS)



Lined earth dam:
before rip-rap

Lining of a concrete dam
using geomembranes



Concrete dam leaking!

Source: Geosynthetic Institute (GSI)

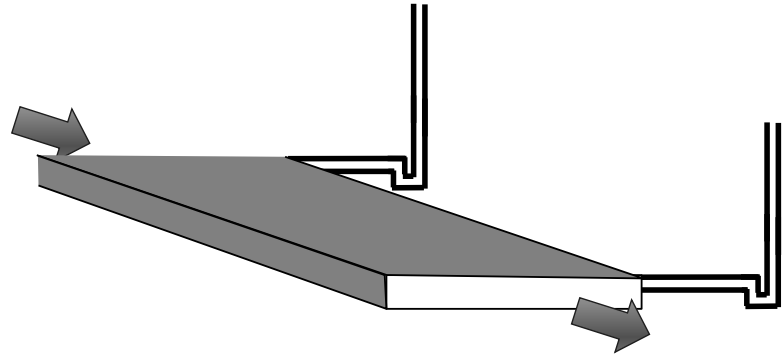
Drainage Function

The geosynthetic allows liquid (or gas) flow within the plane of its structure.

Example: A geocomposite drainage layer used to convey liquids overlying a barrier in a waste containment facility.

Key properties:

- Transmissivity



Drainage Function



Geocomposite drainage layer being installed over the barrier system as part of the closure of a MSW landfill

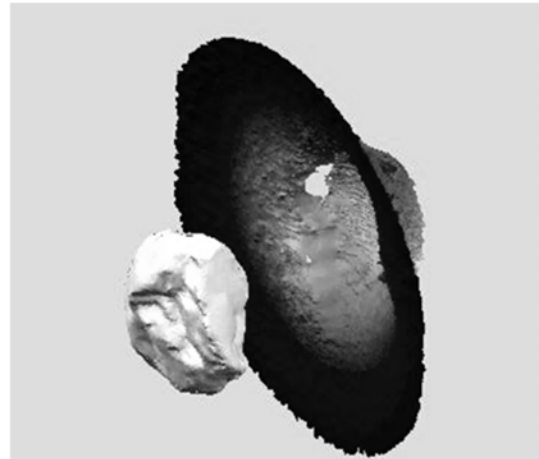
Protection Function

The geosynthetic prevents or limits local damage to other material (e.g., a geomembrane) during construction or operation.

Example: A nonwoven geotextile placed over the geomembrane of a landfill base liner, avoiding puncture by direct contact with gravel particles of the overlying drainage layer.

Key properties:

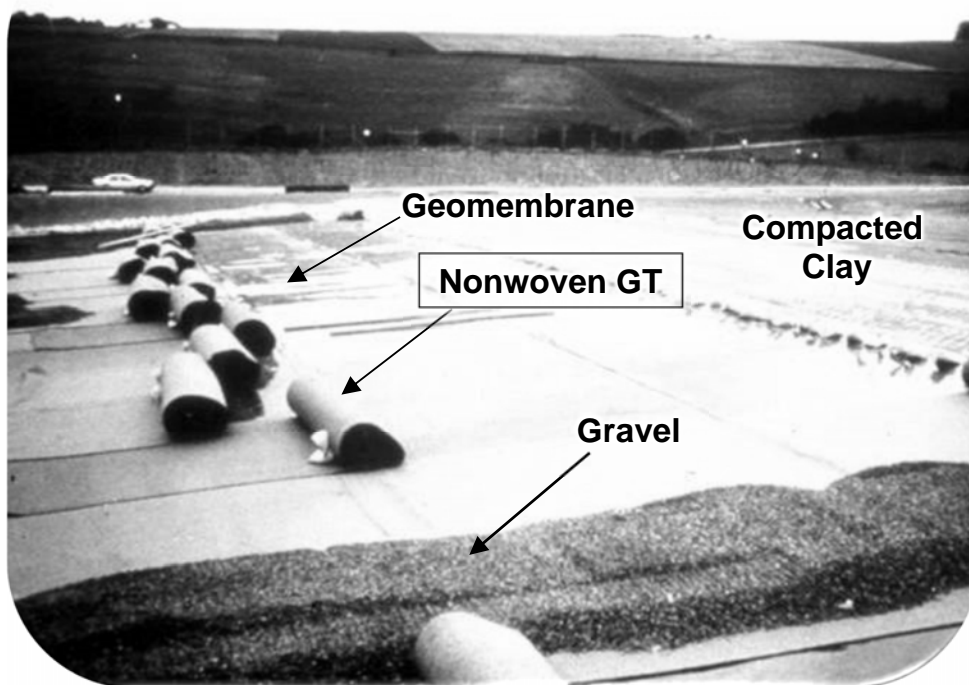
- Puncture strength
- Thickness



Direct contact of geomembrane with rock

Courtesy: Calvin Blake

Protection Function

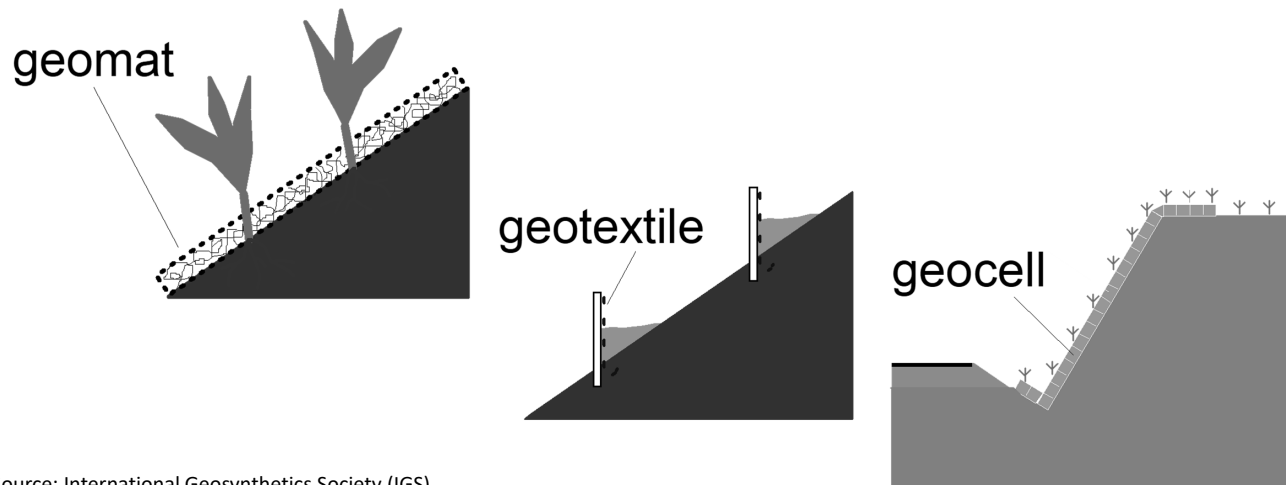


Installation of a nonwoven geotextile over the geomembrane of a composite barrier at the bottom of a MSW landfill

Protection: Erosion Control

Geosynthetic used to minimize the soil erosion caused by rainfall impact and surface water runoff.

Example: A permanent geosynthetic mat (geomat) placed over the otherwise exposed soil surface on an earth slope.



Source: International Geosynthetics Society (IGS)

Protection: Erosion Control



Time-lapse showing soil erosion by surface water

Source: www.Gfycat.com



Erosion control mat placed to promote vegetation and protect the exposed facing of a geosynthetic-reinforced steep slope

Courtesy: Jorge Zornberg

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Geosynthetics: Summary

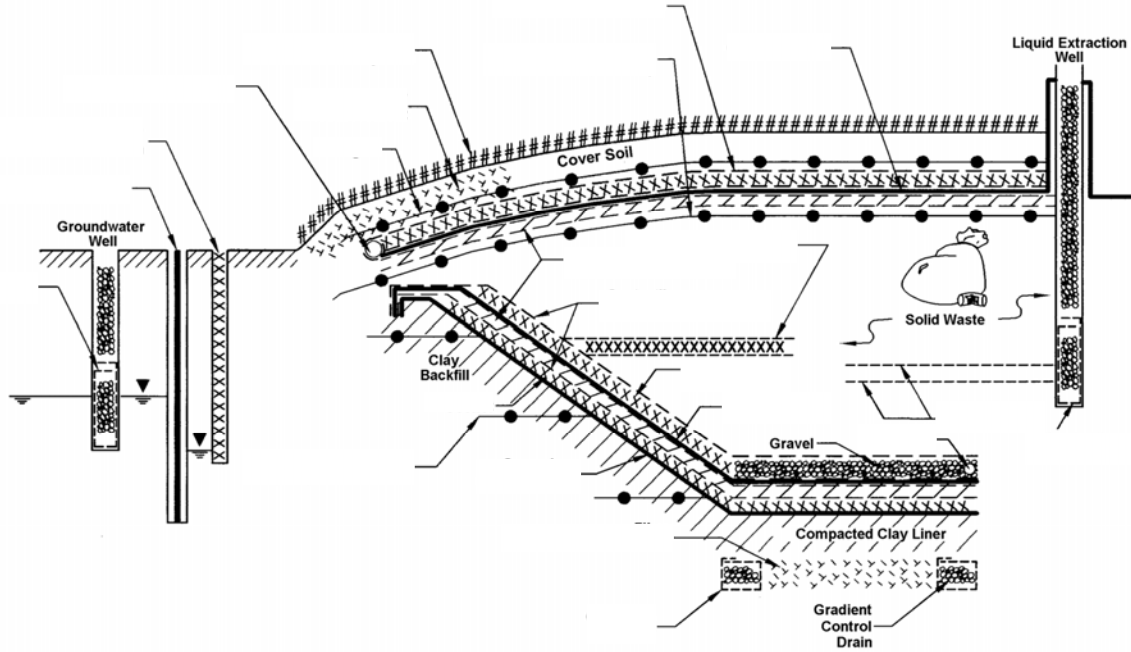
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Functions of Different Geosynthetics



Sources: Zornberg and Christopher 2007, GSI

Functions of Different Geosynthetics

	GEOTEXTILE	GEOGRID	GEO-MEMBRANE	GEONET	GEOCOMPOSITE SHEET DRAIN	GEOCELL	GCL	EROSION CONTROL PRODUCT
Separation								
Reinforcement								
Stiffening (*)								
Filtration								
Barrier								
Drainage								
Protection								

(*) a.k.a Stabilization

Summary

- Geosynthetics are geomaterials
- The number of geosynthetic types is large, and continuously growing
- Geosynthetics are engineered materials and, as such, engineering properties are needed for their design
- The properties of geosynthetics are selected according to their functions (7 of them)

Major Organizations on Geosynthetics

- International Geosynthetics Society (IGS)
www.geosyntheticsociety.org
- National chapters of the IGS (e.g., IGS-NA)
- Geosynthetic Institute (GSI)
- Geosynthetics Manufacturers Association (GMA)
- Standards Organizations (e.g., ASTM, ISO)
- Erosion Control Technology Council (ECTC)

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Thank You

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