Geosynthetics in Civil Engineering and Construction Works

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WHAT IS GEOSYNTHETIC

Generally, geosynthetic refers to a product that is made from polymeric material and is applied as a key component in a structure or system to achieve engineering purposes. The prefix “geo” suggests whose application has to do with soil, rock, and/or earth. There are some basic functions of geosynthetics namely separation, reinforcement, filtration, drainage, containment, barrier, surface erosion control, and protection; any geosynthetic product is expected to provide one or more of the functions. Applications of geosynthetics are mostly found in civil, transportation, geotechnical, environmental, hydraulics, marine, and private development engineering including roads, railroads, embankment, retaining walls, canals, erosion control, waste landfill, land reclamation, breakwaters, jetties, groins, revetments, aquaculture, agriculture, and mining. However, with the development of related products, the applicable range of geosynthetics can extend to areas other than the above mentioned

Geosynthetic is defined as a planar product manufactured from a polymeric material that is used with soil, rock, or other geotechnical-related material as an integral part of a civil engineering project, structure, or system. Most geosynthetics are made from synthetic polymers of polypropylene, polyester, or polyethylene. Geosynthetic products available today include, but are not limited to, geowebs, geogrids, geonets, geomeshes, geocomposites, and geotextiles. Geotextile is a permeable geosynthetic made of textile materials. Geotextile type is determined by the method used to combine the filaments or tapes into the planar structure.

History:

Inclusions of different sorts mixed with soil have been used for thousands of years. They were used in roadway construction in Roman days to stabilize roadways and their edges. These early attempts were made of natural fibres, fabrics or vegetation mixed with soil to improve road quality, particularly when roads were built on unstable soil. They were also used to build steep slopes as with several pyramids in Egypt and walls as well. A fundamental problem with using natural materials (wood, cotton, etc.) in a buried environment is the biodegradation that occurs from microorganisms in the soil. With the advent of polymers in the middle of the 20th century a much more stable material became available. When properly formulated, lifetimes of centuries can be predicted even for harsh environmental conditions.

Early papers on geosynthetics (as we know them today) in the 1960s documented their use as filters in the United States and as reinforcement in Europe. A 1977 conference in Paris brought together many of the early manufacturers and practitioners. The International Geosynthetics Society (IGS) founded in 1982 has subsequently organized a worldwide conference every four years and its numerous chapters have additional conferences. Presently, separate geosynthetic institutes, trade-groups, and standards-setting groups are active. Approximately twenty universities teach stand-alone courses on geosynthetics and almost all include the subject in geotechnical, geoenvironmental, and hydraulic engineering courses. Geosynthetics are available worldwide and the activity is robust and steadily growing.

Functions of Geosynthetics in Civil Engineering and Construction Works

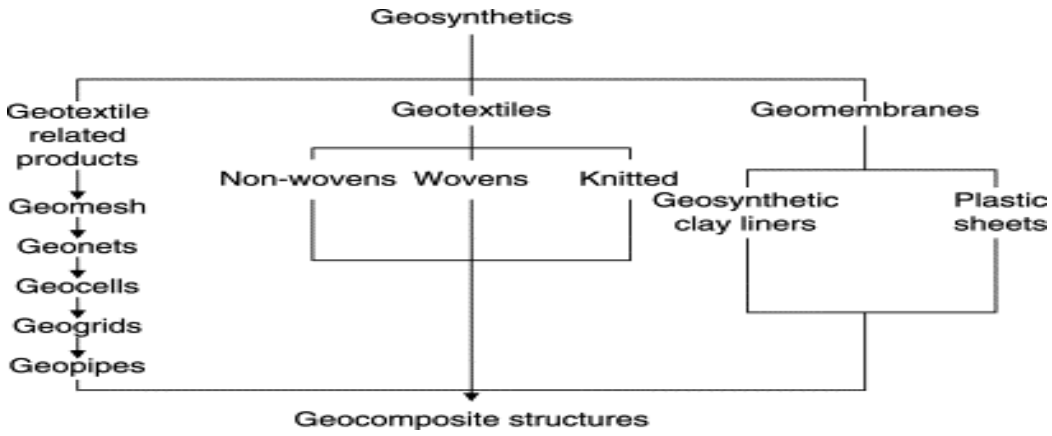
- Soil reinforcement structure
- Basal reinforcement to support the soil reinforcement structure
- Separation between the in-situ soil and the imported soil to avoid mixing and reducing mechanical performance
- Filtration behind all hydraulic structures
- Drainage control at the top 8 m to collect any seepage water coming from the other side of the embankment to avoid contamination on the structural fill
- Erosion control blanket to protect the slope at the top and avoid erosion.

Table: Types of Geosynthetics and their Uses

Type of geosynthetic	Separation	Reinforcement	Filtration	Drainage	Containment
Geotextile	√	√	√	√	
Geogrid		√			
Geonet				√	
Geomembrane					√
Geosynthetic clay liner					√
Geocell			√	√	
Geofoam	√				
Geocomposite	√	√	√	√	

Classification of geosynthetics:

Figure below gives a general classification of geosynthetic materials based on their physical form. As indicated, these materials include solid and perforated plastic sheets, plastic pipes, a range of textile structures, and combinations of these, to form a subcategory referred to as geocomposites. Strictly, the term geosynthetics refers to synthetic polymer-based materials. However, when considering the category of geotextiles, natural fibres as well as synthetic fibres are also of importance, and therefore the subcategory 'natural geotextiles' is 'loosely' incorporated in the general classification.



Types of Geosynthetics in Civil Engineering and Construction Works

Following are the types of geosynthetics used in civil engineering :

1- geotextiles
2- Geogrids
3- Geonets
4- Geomembranes
5- Geosynthetic clay liner
6- Geocells
7- Geocomposites
8- Geofoam

1-Geotextiles:

are typically categorised as either woven or non-woven. Woven geotextiles are manufactured using a loom to interlace synthetic yarns in two directions. Non-woven geotextiles are made in two different ways: either using staple fibre - short fibres interlocked together, usually through a needling process; or continuous filament - long, continuous strands of synthetic threads which are laid together and then needled .to improve strength

Non-woven geotextiles are usually used for separation, drainage, filtration and protection applications whilst woven geotextiles are typically used for reinforcement applications.

Geotextiles can be used in many common applications:

- Unpaved and paved roads in airport runways
- Landfills and stone base courses
- Sidewalks and sand drainage layers
- Parking lots and curb areas
- Green areas and recreational facilities
- Retaining wall structures
- Duct banks and pipe trenches

2-Geogrids

Geogrids is a geosynthetic materials used as reinforcement in construction works. Types of geogrids, its functions and applications in construction works are discussed. Geogrids can be categorized as geosynthetic materials that are used in the construction industry in the form of a reinforcing material. It can be used in the soil reinforcement or used in the reinforcement of retaining walls and even many applications of the material are on its way to being flourished.

The high demand and application of Geogrids in construction are due to the fact that it is good in tension and has a higher ability to distribute load across a large area.

Types of Geogrids:
Based on the manufacturing process involved in geogrids it can be of

1. Extruded Geogrid
2. Woven Geogrid
3. Bonded Geogrid

Based on which direction the stretching is done during manufacture, geogrids are classified as

1. Uniaxial geogrids
2. Biaxial Geogrids

Uniaxial Geogrids
These geogrids are formed by the stretching of ribs in the longitudinal direction. So, in this case, the material possesses high tensile strength in the longitudinal direction than on the transverse direction.

Biaxial Geogrids
Here during the punching of polymer sheets, the stretching is done in both directions. Hence the function of tensile strength is equally given to both transverse and longitudinal direction.

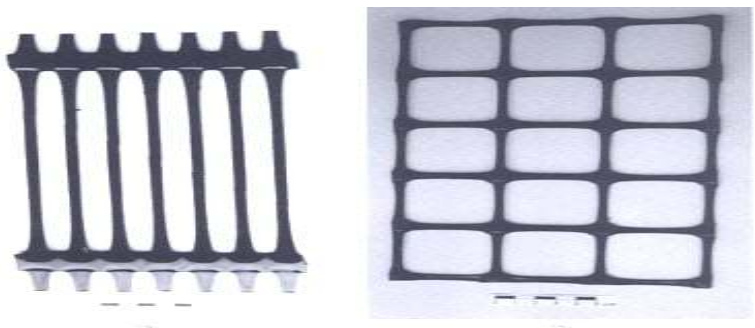


Fig. Uniaxial and Biaxial Geogrids manufactured by the method of extrusion

Advantages of Geogrids in Construction:

Ease of Construction: he Geogrid can be installed in any weather conditions. This .makes it more demanding

Land Optimization: This method of Geogrid installation in soils makes an unsuitable area suitable for preparing it to meet desired properties for construction. Geogrid thus .helps in proper land utilization

*Geogrid promotes soil stabilization

* A higher strength soil mass is obtained

* Higher load bearing capacity

* It is a good remedy to retain soil from erosion

* No requirement of mortar. The material is implemented dry

* No difficulty in material availability

* Geogrids are flexible in nature. They are known for their versatility

*Geogrids have high durability reducing maintenance cost. They are highly resistant against environmental influences.

* Materials are tested based on standard codes and regulations.

Geogrids in pavement construction and retaining wall

2-Geonets

Geonets are used at road construction, their restoration and repair in order to improve the road surface quality, decrease washboard formation, primary and secondary reflected cracking.

Geonets are a mesh structure consisting of overlapping threads/bands (from 3 to 15 mm) at a permanent angle (60-90°). This creates equal holes with the width from 10 to 200 mm. They are obtained by press forming of thermoplastic polymer (usually it is high strength polyethylene) or welding of threads/bands.

Main application objects of the materials:

- Reinforcement of constructive layers of road surfacing during the construction of new and restoration of already existing motor ways;
- Reinforcement of already existing road surfacing;
- Reinforcement of joints of asphalt concrete pavement:
- Preventing cracking when extending road;
- Connecting road surfacing of various types;
- Construction of high load platforms (container terminals, port buildings, airports, warehouse complexes, heavy trucks' parking places, etc);
- Patch work;
- Road segment restoration after underground communications' repair
- Landscape architecture.

4- Geomembranes

Geomembranes are continuous flexible sheets manufactured from one or more synthetic materials. They are relatively impermeable and are used as liners for fluid or gas containment and as vapour barriers.

Geomembranes are being used in environmental, hydraulic, transportation, and oil and gas applications as well as the waste industry. The most common type are the continuous polymeric sheets. When larger geomembranes are needed, they are thermally or chemically melted together at the seams for strength and durability. The size of the geomembrane is completely customizable, so they are can be as small as a backyard fish pond or as large as a football field if necessary.

Basically, geomembranes are used wherever loss of material cannot be allowed, be that clean water, wastewater, vapor, soil, hazardous materials, or any other substance that doesn't need to escape its designated space. Because flowing, pooling, frozen, and standing liquids (and even vapors) can be so devastating if not managed properly, these geomembranes have allowed industries to continue to develop and support many more projects than previously done before.

Applications:

1. Waste and landfills

2. Mining

3. Water storage

4. Canals

5. Aquaculture

6. Agriculture

7. Building and construction

5-Geosynthetic Clay Liners (GCLs):

Geosynthetic Clay Liners (GCLs) are geotextile and bentonite composites (typically sodium bentonite sandwiched between two layers of geotextile) engineered for a variety of environmental containment applications. The geotextiles offer a long lasting resistance to physical or chemical break-down in harsh elements, while the bentonite's high swelling capacity and low permeability provide an effective hydraulic seal.

GCLs provide an excellent alternative to conventional Compacted Clay Liners by replacing a thick section of compacted clay with a thin layer of pure sodium bentonite. Benefits include easy installation, better hydraulic performance and resistance to varying weather conditions. Installation for most GCL projects can be completed by construction personnel using conventional equipment. GCLs also have unique self-sealing attributes, reducing the risk of failure due to adverse field and operating conditions.

TYPICAL LINING APPLICATIONS INCLUDE:

- Canals, stormwater impoundments and wetlands
- Secondary containment
- Highway and civil
- Landfill liners
- Landfill caps
- Mining
- Pond

6-Geocells:

Geocells are engineered for protection and stabilization applications. They are often used to help improve the performance of standard construction materials and erosion-control treatments.

Geocells consist of a robust three-dimensional structure housing a network of interconnected cells that confine and compact soil. The confinement action prevents erosion and improves the structural performance of the soil or aggregate infill providing an alternative to reinforced concrete.

Applications include:

- protection and stabilization of steep slope surfaces
- protective linings of channels and hydraulic structures
- static and dynamic load support on weak subgrade soils
- multi-layered earth-retaining and water-retaining gravity structures

Geocells can be used to great advantage considering that:

1. Geocells are the only prefabricated three□dimensional geosynthetics with significant third dimension properties.

2. They are easily transported as flat strips welded width□wise at regular intervals, and logistics for large quantities is not a problem.

3. Geocells are easy to install and do not require skilled labour. They can be installed in any weather condition.

4. The in□fill has essentially to be non□cohesion material, however the material could be recycled material.

5. Solutions considering geocells as a solution for any civil engineering / geotechnical issue always proves to be cost effective with reduced and economic usage of valuable natural resources, including metal / aggregates, sand, cement, etc. the cost savings can be as substantial as much as 30% for road construction and the time saving can be as much as 50%.

6. When used for roads and pavements, geocells substantially reduce cost of maintenance by improving the longevity of the road / pavement.

Geocells Being Filled on a Hillside Construction Erosion & Sediment Control.

7-Geocomposites

Geocomposites are geosynthetics made from a combination of two or more geosynthetic types. Examples include: geotextile-geonet; geotextile-geogrid; geonet-geomembrane; or a geosynthetic clay liner (GCL). Prefabricated geocomposite drains or prefabricated vertical drains (PVDs) are formed by a plastic drainage core surrounded by a geotextile filter.

Application:

Geocomposite used as barriers / separation layers to separate and contain polluted Soil or waste and avoid migration of pollutants to the surrounding soil or waste and avoid migration of pollutants to the surrounding soil or water.

They can be mounted on solid frames to build below ground physical barriers i.e. separation walls.

In railways applications, geocomposites can replace the sand layers separating the track ballast from the foundation, performing the same function of stopping the upward migration of Fines.

Used in trenches alongside high-ways, behind retaining walls and bridge abutments, under embankments build over compressive soils etc.

8-Geofoam

Geofoam is a polymeric product created by processing polystyrene into a foam consisting of many closed cells filled with air and/or gases. The skeletal nature of the cell walls resembles bone-structures made of the unexpanded polymeric material. The resulting product is generally in the form of large, but extremely light, blocks which are stacked side-by-side and in layers providing lightweight fill in numerous applications.

One of the most popular applications for geofoam is within building construction. The material it is made from is able to withstand pressure, yet is lightweight and easy to manage, making it the perfect material to use for insulation and building foundational structures. A high-density geofoam can act as a buffer between the earth and a wall which can help distribute the weight of the earth more evenly and reduce pressure.

Geofoam is ideal for thermal insulation and can help reduce overall heating and air conditioning costs. It is often used to fill building walls and within roofing and ground structures for all types of residential and commercial buildings. The R-Value of Expanded Polystyrene is the measurement of heat transfer through the sheets or blocks of foam.