What are geosynthetics?

The types of geosynthetics

What are geosynthetics made of?

The functions of geosynthetics

Stabilisation

Reinforcement

Drainage

Erosion control

Filtration

Separation

Barrier

Protection

Geosynthetic applications

Roads, pavements & trafficked areas

Rail trackbed improvement

Earth retaining structures and steep slopes

Embankment foundations

Drainage systems

Containment and Landfill





a. Stabilisation

Where geosynthetics are used to stabilise granular soils, this typically occurs via an interlocking mechanism. With geogrids, for example, the apertures between ribs allow aggregate to strike through and interlock, confining the aggregate material. Provided that the geogrid has strong junctions, and ribs that offer high stiffness at low strain, movement of the soil particles can be minimised, improving the mechanical behaviour of the soil. This mechanical ground stabilisation creates a composite layer that is stronger and more resistant to deformation.

Geogrid stabilisation is common in roadway foundations and in working platforms that will endure heavy loads, as it increases bearing capacity and reduces deformation under load. You can learn more about the stabilising power of interlock in this Tensar article.

b. Reinforcement

Geosynthetics that have high stiffness and high strength, such as certain types of geogrids and some geotextiles, can improve the mechanical properties of a soil mass by adding a reinforcing element that provides increased strength and deformation resistance.

The use of geosynthetics providing a reinforcement function enables engineers to build embankments on soft foundations and create earth slopes with steeper slope angles.

c. Drainage

The drainage function of geosynthetics allows groundwater or other fluids, to be collected and pass through less permeable soils. Drainage geosynthetics can be used to dissipate pore pressure below embankments, intercept groundwater in slopes or behind structures, and provide edge drainage to road pavements.

Drainage geosynthetics are usually geocomposites, typically combining a geonet drainage core with one or more layers of geotextile. They are able to pass water (and other liquids or gas) through their structure to a collector or open space.

Good drainage is essential for roadways as water under the surface can lead to softening of subgrade soils and eventual loss of strength in the road structure. Therefore geosynthetics can commonly be found in roads and railways, behind retaining walls, as well as below embankments where less permeable soils exist.

Visit our guide on pore water pressure for more on the importance of drainage.

d. Erosion control

Erosion control is the practice of limiting damage to land due to the action of wind or water. Once the top layer of land is eroded, re-growth takes a long time, and this is where erosion control geosynthetics come in to give nature a helping hand.

Erosion control geosynthetics, typically, in the form of multi-layered mats, reduce soil erosion caused by impact of water droplets and surface runoff. They are rolled onto a surface and pegged in place. Some products combine synthetics with natural materials to provide enhanced moisture retention to encourage vegetation growth.

In areas where land is exposed to water flow or rainfall, erosion control geosynthetics are ideal for protecting the top layer of soil, encouraging vegetation to grow and preventing soil loss in the future. This is particularly common around areas of water and embankment slopes.

e. Filtration

Soil particles, particularly finer particles, can be transported by water passing through soils. Filtration geosynthetics, usually geotextiles, are designed to retain soil particles on the upstream side of the filter, while allowing water to pass freely through. Even fine soil particles can be retained due to the ‘bridging’ effect of larger particles on the upstream side of the filter. Filtration is therefore most effective with one-directional water flow.

The filtration properties of geotextiles can be designed by varying the type and density of fibres, and the thickness and structure of the fabric.  They are often combined with a drainage core in the form of a geocomposite. Suitably engineered products may be used to prevent soil migration into drainage aggregate layers or gravel filled drains, or for critical applications below riprap protection in river or coastal works.

f. Separation

To function as a separator, the geosynthetic must prevent soil with different particle size distributions from intermixing and causing the structural integrity to fail.

Separation is a required function in many applications, however it is vitally important to the layers of roads and pavements. Geotextile separators are routinely used below road and rail construction, in isolation or combined with a geogrid in the form of a geocomposite.

A geogrid can prevent expensive subbase material from punching into the soft subgrade. When a well-graded subbase is stabilised with a geogrid the geogrid/soil composite layer can prevent finer grained soil from migrating up into the subbase. When soil moisture levels are high, a geocomposite with geogrid and separator/filter properties may be used.

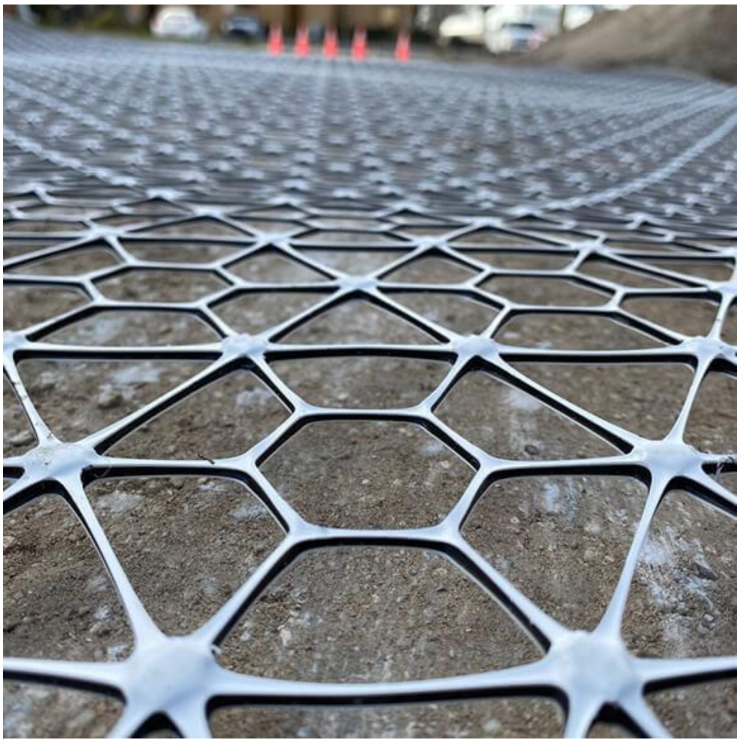
## g. Barrier

Geosynthetics can be used to provide a relatively impermeable barrier for the containment of fluids or gasses.  There are several forms of barrier geosynthetic. Geomembranes manufactured from polyethylene, polyvinyl chloride (PVC) or rubber, offer high impermeability. Geosynthetic Clay Liners (GCL's) are an alternative with a degree of self-healing capability.

Geosynthetic barriers are used for fluid containment in mining, industrial and agricultural applications. They are also used in conjunction with drainage composites in waste containment and landfill capping.

## h. Protection

Geosynthetics can perform a protection function by acting as a cushion to a sublayer. Non-woven geotextiles can be designed to protect geomembranes from puncture damage during placement of covering fill. Geonet type materials can be used to provide protection to coated pipelines during backfill operations.



a. Roads, pavements & trafficked areas

Geosynthetics are often applied in areas such as roadways, railways, airports and more.

For roads and runways, they’re primarily useful in stabilising and separating unbound pavement layers. However, they can also be used to address issues with the underlying soil, or in providing side drainage.

Geogrids have been used to aid construction and enhance the performance of roads over soft ground since the 1970s. More recent advancements have led to their increased use to enhance the service life of paved roads, reducing whole life costs.  Visit this page on roads, pavements and trafficked areas to discover more on how Tensar products improve road construction projects.

b. Rail trackbed improvement

Geosynthetics can be applied to solve a variety of problems below rail track. Stabilisation geogrids are routinely used to increase the bearing capacity and stiffness of the trackbed over areas of weak soils. They can also be placed below the ballast layer to control lateral migration and deterioration of the ballast particles. Differential stiffness issues associated with transitions from rigid to flexible foundations can be addressed with geogrid stabilised transition zones.

Geotextile separators and drainage geocomposites are used to control moisture related problems, while highly specialised sand filled geotextile mats can replace sand filters below trackbed.

c. Earth retaining structures and steep slopes

Reinforcing geogrids and high strength geotextiles can be used to construct steepened slopes that have a reduced footprint compared to natural slopes. Geogrids are also used to construct reinforced soil walls and bridge abutments. These are quicker and cheaper to construct compared to concrete or piled retaining walls.

d. Embankment foundations

The construction of earth embankments over weak soils presents challenges that can be addressed by the use of geosynthetics. Over-stressing of the foundation soil as construction proceeds can result in a deep rotational failure. The inclusion of geosynthetic reinforcement in the base of the embankment can maintain stability against this failure mechanism.

Three-dimensional cellular mattress systems,, provide reinforcement at the base, but in addition, the inherent stiffness of the cellular mattress distributes load and influences the settlement profile. Learn more about the benefits of a cellular foundation mattress ,Geosynthetic wick drains, driven deep into the foundation soil can relieve excess pore pressure as the embankment rises, enabling more rapid construction.

e. Drainage systems

Geosynthetics are well established for use in drainage systems, for filtration, separation and water movement. Geocomposite drainage materials can replace aggregate filled ‘French drains’ alongside roadways or as slope interceptor drains. They also provide drainage and pore pressure relief behind buried structures. Filter geotextiles are used to prevent contamination of perforated drainage pipes and drainage aggregate layers, while prefabricated vertical drains relieve pore pressure below embankments, accelerating construction.

f. Containment and landfill

New landfill sites can be lined with layered geosynthetic systems comprising geosynthetic protection, drainage composites and impermeable barriers. Capping of landfill sites will utilise drainage composites and barriers for gas containment and venting. The mining industry uses impermeable membranes to line tailings lagoons, while geogrids and geocomposites may be used to stabilise lagoon capping after use.

The benefits of geosynthetics in geotechnical engineering

Correctly designed and applied geosynthetics have the potential to provide many benefits. Their use has been proven over time in multiple applications, soil types and climate zones. Benefits are wide ranging, from enabling access over 'impossible' ground to extending the life of roads. From reducing the volume of aggregate usage in construction to protecting waterways and coastal areas from erosion. Here are some of the benefits of using geosynthetics:

Improved lifespan: maintaining high performance for an extended lifetime.

Cost savings: reducing the quantities of imported fill, aggregates and waste, accelerating construction, providing more efficient design options

Simplicity of construction: straightforward and fast installation using well proven methods.

Strength: in reinforcement applications they have a high strength to weight ratio.

Durability: highly resistant to weathering, biodegradation and chemical contaminants. As an example, allowing the use of lower-cost non-standard fill in reinforced soil structures.

Customisable: can be tailored to the needs in terms of structure, size and composition.

Design creativity: new solutions, new construction methods and new ideas.

Environmentally beneficial: can enable alternative construction methods that reduce material volumes, transportation and construction methods – and their associated carbon emissions, to offer a net environmental benefit

Resilience: geosynthetics have enabled new and innovative solutions that help safeguard infrastructure against the effects of environmental change, such as higher rainfall, flooding, and changes to  freeze-thaw weathering and degradation of roads

Sustainable: geosynthetics like geogrids can improve the service lives of structures, cut maintenance requirements and reduce whole life costs. To learn more, see this Tensar article 'What role can plastics and geogrids play in sustainability?'

Geosynthetics are synthetic products used to stabilize terrain. They are generally polymeric products used to solve civil engineering problems. This includes eight main product categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. They can also be used in exposed applications. Geosynthetics are available in a wide range of forms and materials. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geoenvironmental, hydraulic, and private development applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture and agriculture.

Geotextiles form one of the two largest groups of geosynthetics. They are textiles consisting of synthetic fibers rather than natural ones such as cotton, wool, or silk. This makes them less susceptible to bio-degradation. These synthetic fibers are made into flexible, porous fabrics by standard weaving machinery or are matted together in a random non woven manner. Some are also knitted. Geotextiles are porous to liquid flow across their manufactured plane and also within their thickness, but to a widely varying degree. There are at least 100 specific application areas for geotextiles that have been developed; however, the fabric always performs at least one of four discrete functions: separation, reinforcement, filtration, and/or drainage.

Geogrids represent a rapidly growing segment within geosynthetics. Rather than being a woven, nonwoven or knitted textile fabric, geogrids are polymers formed into a very open, gridlike configuration, i.e., they have large apertures between individual ribs in the transverse and longitudinal directions. Geogrids are (a) either stretched in one, two or three directions for improved physical properties, (b) made on weaving or knitting machinery by standard textile manufacturing methods, or (c) by laser or ultrasonically bonding rods or straps together. There are many specific application areas; however, geogrids function almost exclusively as reinforcement material

Geonets, and the related geospacers by some, constitute another specialized segment within the geosynthetics area. They are 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. Two types are most common, either biplanar or triplanar. Alternatively many very different types of drainage cores are available. They consist of nubbed, dimpled or cuspated polymer sheets, three-dimensional networks of stiff polymer fibers in different configurations and perforated mini-pipes or spacers within geotextiles. Their design function is completely within the drainage area where they are used to convey liquids or gases of all types.

Geomembranes represent the other largest group of geosynthetics, and in dollar volume their sales are greater than that of geotextiles. Their growth in the United States and Germany was stimulated by governmental regulations originally enacted in the early 1980s for the lining of solid-waste landfills. The materials themselves are relatively thin, impervious sheets of polymeric material used primarily for linings and covers of liquids- or solid-storage facilities. This includes all types of landfills, surface impoundments, canals, and other containment facilities. Thus the primary function is always containment as a liquid or vapor barrier or both. The range of applications, however, is great, and in addition to the environmental area, applications are rapidly growing in geotechnical, transportation, hydraulic, and private development engineering (such as aquaculture, agriculture, heap leach mining, etc.).

Geosynthetic clay liners, or GCLs, are an interesting juxtaposition of polymeric materials and natural soils.

They are rolls of factory fabricated thin layers of bentonite clay sandwiched between two geotextiles or bonded to a geomembrane. Structural integrity of the subsequent composite is obtained by needle-punching, stitching or adhesive bonding. GCLs are used as a composite component beneath a geomembrane or by themselves in geoenvironmental and containment applications as well as in transportation, geotechnical, hydraulic, and many private development applications.

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.

Geocells (also known as Cellular Confinement Systems) are three-dimensional honeycombed cellular structures that form a confinement system when infilled with compacted soil. Extruded from polymeric materials into strips welded together ultrasonically in series, the strips are expanded to form the stiff (and typically textured and perforated) walls of a flexible 3D cellular mattress. Infilled with soil, a new composite entity is created from the cell-soil interactions. The cellular confinement reduces the lateral movement of soil particles, thereby maintaining compaction and forms a stiffened mattress that distributes loads over a wider area. Traditionally used in slope protection and earth retention applications, geocells made from advanced polymers are being increasingly adopted for long-term road and rail load support. Much larger geocells are also made from stiff geotextiles sewn into similar, but larger, unit cells that are used for protection bunkers and walls.

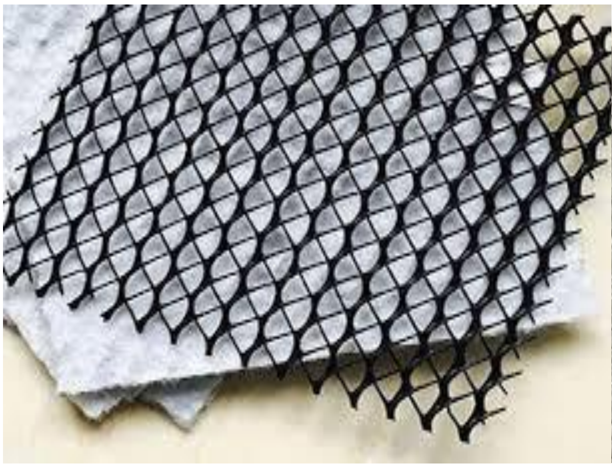
Geodrains are prefabricated product consisting of one or more polymeric core elements transporting fluid (perforated mini-pipes, geonets, cuspated sheets) and one or more geosynthetics separating the flow region from the surrounding environment.

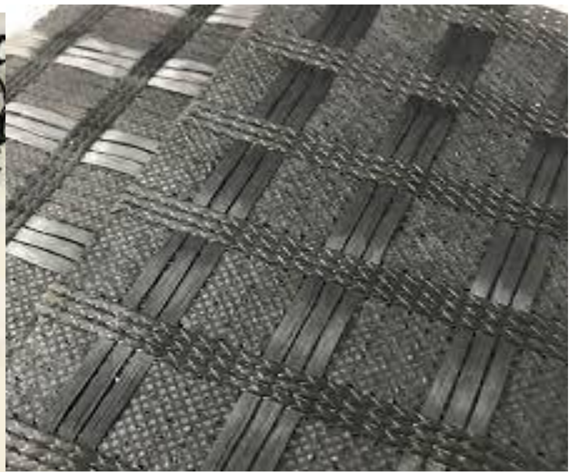
A geocomposite consists of a combination of geotextiles, geogrids, geonets and/or geomembranes in a factory fabricated unit. Also, any one of these four materials can be combined with another synthetic material (e.g., deformed plastic sheets or steel cables) or even with soil. As examples, a geonet or geospacer with geotextiles on both surfaces and a GCL consisting of a geotextile/bentonite/geotextile sandwich are both geocomposites. This specific category brings out the best creative efforts of the engineer and manufacturer. The application areas are numerous and constantly growing. The major functions encompass the entire range of functions listed for geosynthetics discussed previously: separation, reinforcement, filtration, drainage, and containment.









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