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Technical solutions about how to use the geosynthetics materials in drainage systems

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Abstract – Geosynthetics is the term used to describe a range of generally polymeric products used to solve civil engineering problems. The term is generally regarded to encompass eight main product categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells (cellular confinement) and geocomposites. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. Properly formulated, however, they can also be used in exposed applications. Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different end use. 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. The paper presents basic aspects of geotextiles, drainage, geocomposite designissues and technical solutions of their use.
Keywords: Geosynthetics, drainage, civil engineering, land slops, erosion control, reinforcement

1.INTRODUCTION

Geosynthetics have multiple uses and can be effectively used as drains and filters in civil and environmental works in addition to or in substitution to traditional granular materials.

Geosynthetics are easier to install in the field and often cost-effective in situations where granular materials available do not meet design specifications, are scarce or have their use restricted by environmental legislations.

Geotextiles and geocomposites for drainage are the types of geosynthetics used for drainage and filtration. These materials can be used in works such as retaining structures, embankments, erosion control, waste disposal areas, etc. If properly specified and installed, geosynthetics can provide cost-effective solutions for drainage and filtration in civil and environmental engineering works.

New drainage products are being developed rapidly. The geosynthetics are separated into four general use categories. Geonets, sheet drains, edge drains, and prefabricated vertical drains are all designed to offer strong, performance enhancing alternatives to traditional drainage systems

Geosynthetics are generally designed for a particular application by considering the primary function that can be provided. As seen below there is five primary functions given, but some specialists suggests even more.

Separation is the placement of a flexible geosynthetic material, like a porous geotextile, between dissimilar materials so that the integrity and functioning of both materials can remain intact or even be improved. Paved roads, unpaved roads, and railroad bases are common applications. Also, the use of thick nonwoven geotextiles for cushioning and protection of geomembranes is in this category. In addition, for most applications of geofoam, separation is the major function.

Reinforcement is the synergistic improvement of a total system's strength created by the introduction of a geotextile, geogrid or geocell (all of which are good in tension) into a soil (that is good in compression, but poor in tension) or other disjointed and separated material. Applications of this function are in mechanically stabilized and retained earth walls and steep soil slopes; they can be combined with masonry facings to create vertical retaining walls. Also involved is the application of basal reinforcement over soft soils and over deep foundations for embankments and heavy surface loadings. Stiff polymer geogrids and geocells do not have to be held in tension to provide soil reinforcement, unlike geotextiles. Stiff 2Dim geogrid and 3Dim geocells interlock with the aggregate particles and the reinforcement mechanism is one of confinement of the aggregate. The resulting mechanically stabilized aggregate layer exhibits improved loadbearing performance. Stiff polymer geogrids, with rectangular or triangular apertures, in addition to three-dimensional geocells made from new polymeric alloys are also increasingly specified in unpaved and paved roadways, load platforms and railway ballast, where the improved loadbearing characteristics significantly reduce the requirements for high quality, imported aggregate fills, thus reducing the carbon footprint of the construction.

Filtration is the equilibrium soil-to-geotextile interaction that allows for adequate liquid flow without soil loss, across the plane of the geotextile over a service lifetime compatible with the application under consideration. Filtration applications are highway underdrain systems, retaining wall drainage, landfill leachate collection systems, as silt fences and curtains, and as flexible forms for bags, tubes and containers.

Drainage is the equilibrium soil-to-geosynthetic system that allows for adequate liquid

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flow without soil loss, within the plane of the geosynthetic over a service lifetime compatible with the application under consideration. Geopipe highlights this function, and also geonets, geocomposites and (to a lesser extent) geotextiles. Drainage applications for these different geosynthetics are retaining walls, sport fields, dams, canals, reservoirs, and capillary breaks. Also to be noted is that sheet, edge and wick drains are geocomposites used for various soil and rock drainage situations.

Containment involves geomembranes, geosynthetic clay liners, or some geocomposites which function as liquid or gas barriers. Landfill liners and covers make critical use of these geosynthetics. All hydraulic applications (tunnels, dams, canals, reservoir liners, and floating covers) use these geosynthetics as well.

Various types of geosynthetics described with the primary function that the material is called upon to serve allows for the creation of an organizational matrix for geosynthetics - see Table below.

Type of Geosynthetic (GS)	Separation	Reinforcement	Filtration	Drainage	Containment
Geotextile (GT)	X	X	X	X	
Geogrid (GG)		X			
Geonet (GN)				X	
Geomembrane (GM)					X
Geosynthetic Clay Liner (GCL)					X
Geopipe (GP)				X	
Geofoam (GF)	X				
Geocells (GL)		X		X	
Drainage cell (DC)		X	X	X	
Geocomposite (GC)	X	X	X	X	X

Table.1. - Identification of the Usual Primary Function for Each Type of Geosynthetic

In essence, this matrix is for understanding the entire geosynthetic field and its design related methodology. In Table 1, the primary function that each geosynthetic can be called upon to serve is seen. Note that these are primary functions and in many cases (if not most) cases there are secondary functions, and perhaps tertiary ones as well. The greatest variability from a manufacturing and materials viewpoint is the category of geocomposites. The primary function will depend entirely upon what is actually created, manufactured, and installed.

Geosynthetics Advantages

The manufactured quality control of geosynthetics in a controlled factory environment is a great advantage over outdoor soil and rock construction. Most factories are ISO 9000 certified and have their own in-house quality programs as well.

The thinness of geosynthetics versus their natural soil counterpart is an advantage insofar as light weight on the subgrade, less airspace used, and avoidance of quarried sand, gravel, and clay soil materials.

The ease of geosynthetic installation is significant in comparison to thick soil layers (sands, gravels, or clays) requiring large earthmoving equipment.

Published standards (test methods, guides, and specifications) are well advanced in standards-setting organizations like ISO, ASTM, and GSI.

Design methods are currently available in that many universities are teaching stand-alone courses in geosynthetics or have integrated geosynthetics in traditional geotechnical, geoenvironmental, and hydraulic engineering courses.

Disadvantages

Long-term performance of the particular formulated resin being used to make the geosynthetic must be assured by using proper additives including antioxidants, ultraviolet screeners, and fillers.

Clogging of geotextiles, geonets, geopipe and/or geocomposites is a challenging design for certain soil types or unusual situations. For example, loess soils, fine cohesionless silts, highly turbid liquids, and microorganism laden liquids (farm runoff) are troublesome and generally require specialized testing evaluations.

Handling, storage, and installation must be assured by careful quality control and quality assurance of which much as been written.

2. DRAINAGE GEOCOMPOSITE DESIGN

Geocomposite drainage systems are engineered to minimize costly, conventional graded-aggregate and/or perforated-pipe subsurface drainage systems. Geonets, sheet drains, pavement edge drains and prefabricated vertical drains (PVDs) have reached acceptance as state-of-the-practice because they provide sufficient in-place drainage and offer reduced material cost, installation time, and design complexity over traditional systems. The selection and design criteria for this category of products are generally simple. However, because of the numerous applications for subsurface drainage systems and varying performance parameters, designers must pay careful attention to the product-performance parameters applicable to a particular subsurface drainage application. See below few such examples (fig.1.).

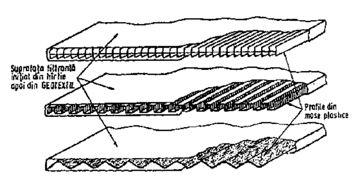
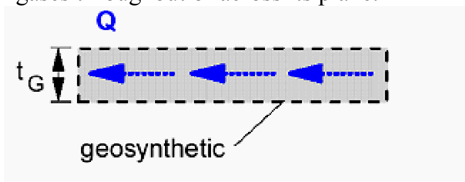


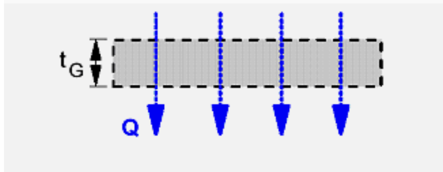
Fig.1. Examples of geocomposite drainage systems

3. DRAINAGE GEOCOMPOSITE TECHNICAL ISSUES

As a drain, a geosynthetic can be specified to attend hydraulic requirements that allow free flow of liquids or gases throughout or across its plane.



Flow along the geosynthetic plane



Flow normal to the geosynthetic plane

Geotextile filters have to attend criteria that assure that the base soil will be retained with unimpeded water flow. Available retention criteria establishes that

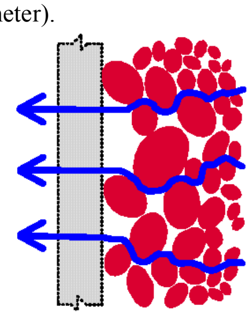
GFS ≤ n x Ds

where

-GFS is the geotextile filtration size, which is associated to pore and constriction sizes in the geotextile,

-n is a number which depends on the criterion used

-Ds is a representative dimension of the base soil grains (usually D85, which is the diameter for which 85% in weight of the soil particles are smaller than that diameter).



The filter has also to be considerably more permeable than the base soil throughout the project life time. Therefore, the permeability criterion for geotextiles establishes that:

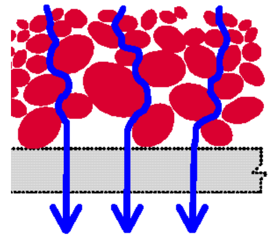
Kgeo ≤ N x Ks

where

-Kgeo is the geotextile coefficient of permeability,

-N is a number that depends on the project characteristics (typically varying between 10 and 100)

-Ks is the permeability coefficient of the base soil.



Clogging criteria require that the geotextile will not clog and are based on relations between geotextile filtration opening size and soil particle diameters that should be allowed to pipe trough the geotextile. Performance filtration tests can also be carried out in the laboratory to evaluate the compatibility between a soil and a candidate geotextile filter.

4.TECHNICAL SOLUTIONS

A very suggestive piece of engineering is showed by the technical hand book offered by TENCATE GEOSYNTHETICS AUSTRIA GMBH. But anyway as the company publisher admitted, the information given in their brochure represents their knowledge true and correct and however new research results and practical experience can make revisions necessary.

We will present some technical solutions how to use the geosynthetic materials in drainage systems from the civil engineering domain, using Tencate Polyfelt DC (fig2) or TenCate Polyfelt Megadrain (fig3).

Tencate Polyfelt DC drainage mats offer the same flow rates as conventional drainage gravel at a considerably reduced thickness. They reduce the space requirements and thus the excavation costs. The working trench can be refilled with the excavation material, thus saving on backfilling costs. Thanks to their structure, DC drainage mats are highly pressure resistant, and therefore offer adequate drainage even under high surcharge loads. They are also suitable in cases where both pressure and shear stresses are evident (such as along slopes or walls). DC drainage mats can be easily installed.

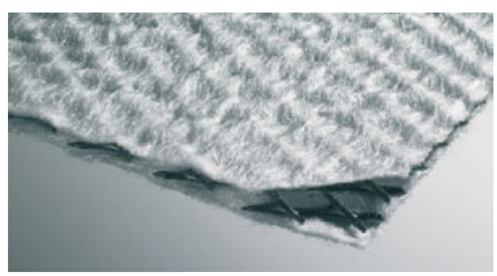


Fig.2. Tencate Polyfelt DC

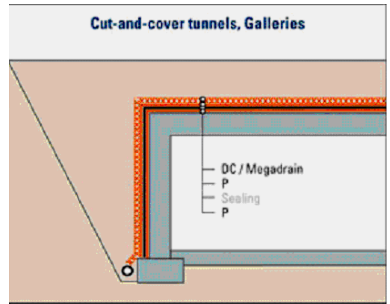
TenCate Polyfelt DC is a geocomposite consisting of a geonet and a filter nonwoven on one or on both sides. The geonet is made from high density polyethylene (HDPE), the filter nonwoven consists of polypropylene (PP). DC is characterised by low compressibility, and is therefore used in situations where effective drainage under high overburden pressures is required. DC drainage mats reduced space requirements and excavation costs, provide high compression resistance, figh chemical resistance and easy installation. Typical applications areas are in wall & cellar drainage, soil retaining structures, cut & cover tunnels, landfill surface drainage/sealing, bridge abutments, water ponds and reservoirs

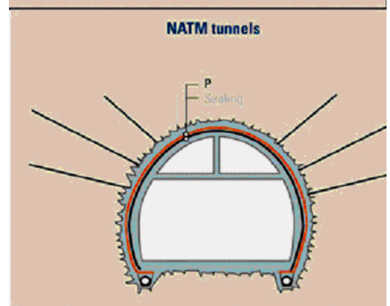
TenCate Polyfelt Megadrain is a drainage product made of three-dimensional polypropylene monofilaments combined with one or two layers of polypropylene filter geotextile. Megadrain has an extremely high voids content offering a high in-plane flow capacity. Megadrain drainage mats are used for surface drainage applications, replacing conventional drainage gravel layers.Megadrain is a drainage mat with high in-plane water discharge capacity. Megadrain drainage mats reduce the space required for drainage systems, and thus reduce construction costs. They offer the same flow rates as conventional drainage gravel at a considerably reduced thickness (one roll replaces up to 20 tons of gravel). The working trench can be refilled with the excavation material thus saving costs on backfilling. Due to its extremely high flow rate, Megadrain drainage mats are suitable for structures with low inclination where large quantities of water need to be drained off.

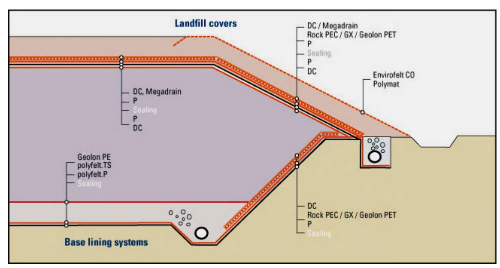
Fig.3. Tencate Polyfelt Megadrain

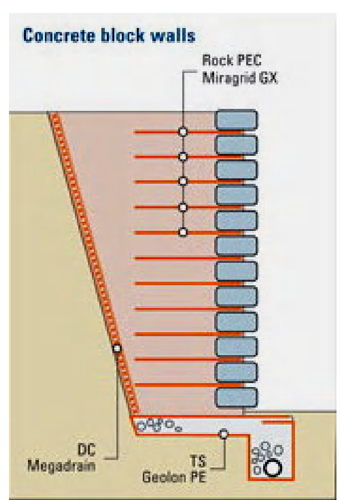
TenCate Polyfelt Megadrain drainage composites are monofilament geomats from polypropylene, with a filter nonwoven (TS) on one or on both sides. The extremely high voids content of Megadrain ensures a high water-flow capacity, especially at low overburden pressures. The benefits of Megadrain are: reduced excavation and construction costs, the high in-plane flow rate of Megadrain corresponds to 20-30 cm of drainage gravel, one roll of Megadrain weights just 24-35 kg, replacing 15-25 tons of gravel, Megadrain can be installed easily, the controlled product quality of Megadrain guarantees constant filtration and drainage performance, guarantees optimum soil retention capability and water permeability, Megadrain is chemically and biologically resistant and absolutely environmentally friendly.

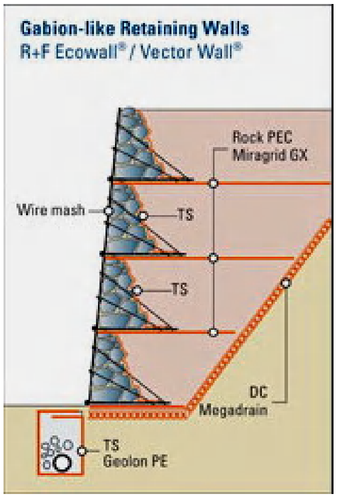
Typical applications areas as landfill surface drainage/ sealing, wall & cellar drainage, retaining wall drainage (see below)

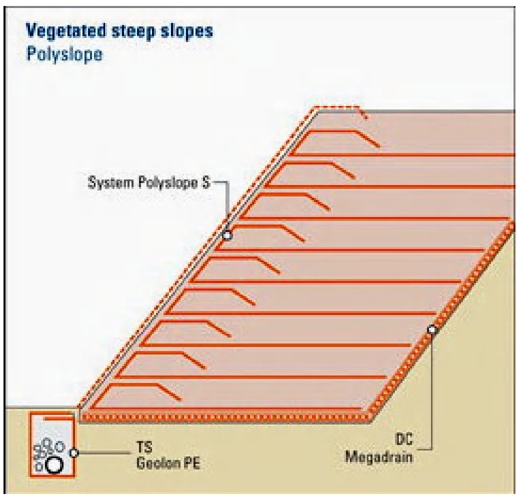












5.CONCLUSIONS

Geocomposite Drainage Mats provide effective surface drainage even under high surcharge loads. This solutions insure a long-term drainage system. The controlled manufacturing process guarantees a consistantly high quality. This simplyfies the quality control on the construction site. Both geonet and filter geotextile offer excellent chemical and biological resistance. Therefore they can be used harmlessly in contact with soil and construction materials such as concrete.

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