TECHNICAL SOLUTIONS TO CREATE ESTHETICAL CIVIL ENGINEERING STRUCTURES USING THE GEOSYNTHETICS MATERIALS

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Abstract

Geosynthetics is the term used to describe a range of generally polymeric products used to solve some 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 synthetic polymeric nature of these products makes them suitable for use in the ground where high levels of durability are required. Not only because, properly formulated, 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 and landscape architecture.

1. INTRODUCTION

Geosynthetics have multiple uses and can be effectively used for separation, reinforcement, drains and filters and containment 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. 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.

Politechnical University of Timisoara have been studied the geosynthetical materials since 1975 and have developed a segnificant number of studies regarding the characteristics of geosynthetics especially physical, chemical, mechanical and hydraulic properties for the autochthon geosynthetics.

These studies have been the base for the development of numberless solutions that have been used in different works from the civil engineering domain [1].

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 [4, 5].

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 [2].

Drainage is the equilibrium soil-to-geosynthetic system that allows for adequate liquid 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 [2].

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.

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

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

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 [3].

1.1 Geosynthetics Advantages

Cost and time saving with an excelent long term design strenght, flexible and easily handled and high greep resistance.

Ecological and environmently friendly surfaces.

Manufactured quality control of geosynthetics in a controlled factory environment (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 easiness 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 [1].

1.2 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 [1].

2. ESTHETICAL REINFORCED STRUCTURES USING GEOSYNTHETICS

Reinforced soil, an engineering composite material, is now extensively used for construction of earth retaining walls and embankment slopes and in the stabilization of embankments places over soft ground. A number of reinforcement types and proprietary systems have been developed, which offer the advantage of simple design, ease of construction, low cost and the ability to tolerate large deformations without structural distress.
Steel has been the most widely used reinforcement material and the possibility of corrosion of this kind of reinforcement is high.
Geosynthetics reinforces the soil, redeeming the soil strain and increasing its stability. Reinforced structures can be seeded with grass or filled with living plants in the layers during installation. After the plants grow, the structure is beautiful green, providing homes for insects and animals in the environment. This beautiful structures will not be washed away because the geosynthetic has made it stable anchored to the earth.
Reinforced structures can be used with steel mesh or pre-cast panel material finishes, as well as applied in the retaining embankment or shore environment. Thanks to its flexibility, it withstands earthquakes much better than traditional methods.
Granular materials will be reinforced from this

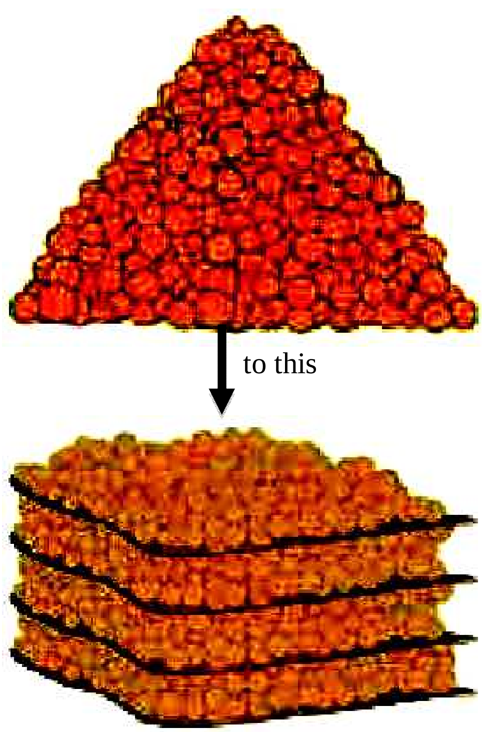

Figure 1 Example of reinforced granular materials

The result could be as in the picture bellow:

Figure 2 Example of reinforced soil using geosynthetic

Geosynthetics offers superior tensile reinforcement. The geogrid consists of polyester yarns with a protective polymer coating, either PVC or nontoxic substance, providing high resistance to soil microorganism chemicals, UV radiation and mechanical damage. With highly efficient automatic production lines and quality control system, geosynthetics are available to different tensile strengths, mesh sizes, and structures having stable, high quality. Installation is problem-free because the material is flexible.

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Using reinforcement is not new. Historically, people have reinforced soils and structures with natural elements such as trees or roots. Now, geosynthetics allow constructors to use natural elements in combination with reinforcement tools, providing better, more economical performance and beautiful results. Here are the diagrams for demonstration of the advantages in land use which can be enjoyed employing our reinforcing materials.

Using the tensile properties of geosynthetic material resists stress or contains deformation in geotechnical structures. (IGS Terminology)

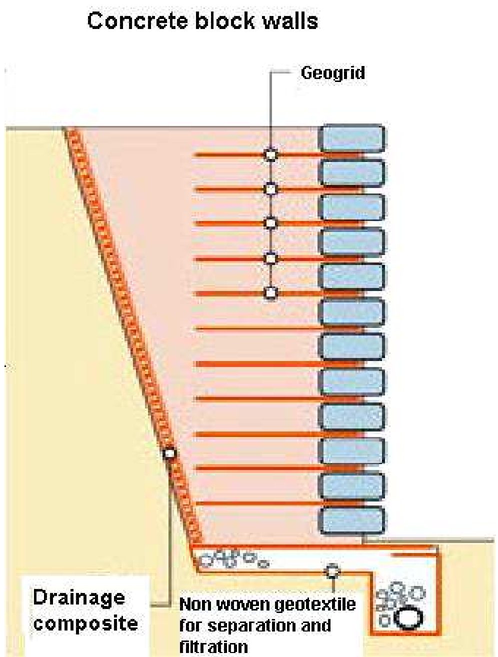
Reinforcement may be incorporated in engineering field, or inserted into natural ground either to provide steeper slopes than would otherwise be possible or to improve load carrying capacity. Reinforcement may also be used to improve the performance of weak soils to support embankments or other resilient structures. (Reference: BSI Standard) 1.IGS: International Geosynthetics Society 2.BSI: British Standards Institution

For example geosynthetic reinforced soil segmental retaining walls utilize reinforcing sheets of geogrid or suitable woven geotextile which are attached to the fascia and are embedded in a body of engineered fill.

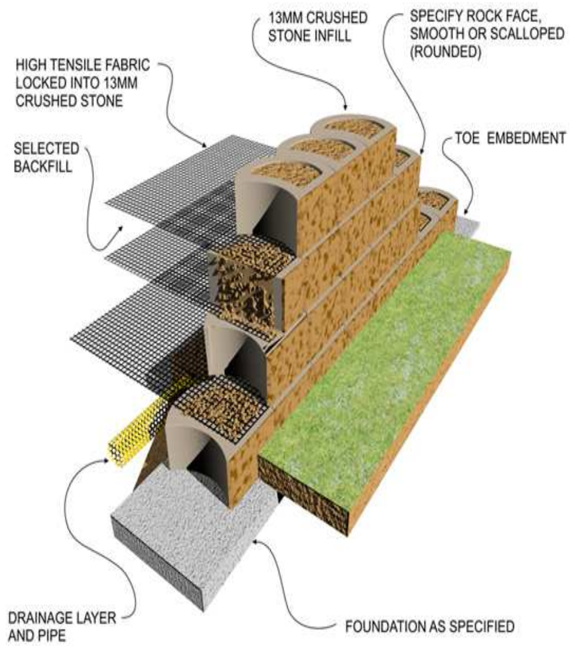
The integrated nature of the fascia and the abutting large body of reinforced soil thereby supports the applied earth forces. In this case the 'gravity' component of the retaining wall is provided by the reinforced soil mass acting as a monolithic unit.

Wrap-around reinforced structure, steel mesh reinforced structure, modular block reinforced structure, precast concrete panel reinforced structure, reinforced retaining wall, slope engineering, traffic engineering, river and maritime engineering, reinforced slope, reinforced embankment, reinforced structure for roadway, reinforced structure for bridge abutment, reinforced structure for road repairing, reinforced structure for waterways, reinforced structure for canals, reinforced dike with vegetation, reinforced structure for landfill, reinforced structure for land increase, ground improvement.

Geosynthetic reinforcement also provide an additional hydraulic function, permeable geosynthetic reinforcement may be especially usefull for soil structures because the drainage capabilities may help increase the structure stability by dissipating excess pore water pressure. In this way the geosynthetic layers may work not only as reinforcements but also as lateral drains.



a)



b)

Figure 3 Technical solution for a concrete block wall reinforced with geosynthetic: a) Transversal view; b) Perspective view.

In order to formulate a rational design that takes into account the in-plane transmissivity of the geosynthetic reinforcement, their hydraulic characteristics must be evaluated. This evaluation includes the correct determination of the reinforcement system drainage capacity, the analysis of the pore water pressure dissipation in the fill, and the assessment of the effect of pore water pressure on the structure stability [1,7,8,9].

Benefits:

-simple construction equipments
-rapid construction procedures
-easy to handle
-flexibility and capability to absorb deformation
-higher seismic resistance
-good drainage
-cost effective
-landscape to fit in with environment
-simple construction equipments
-higher seismic resistance
-good drainage
-landscape to fit in with environment
-excellent esthetics from versatile molding options
-erosion resistance
-horizontal deformation restraint

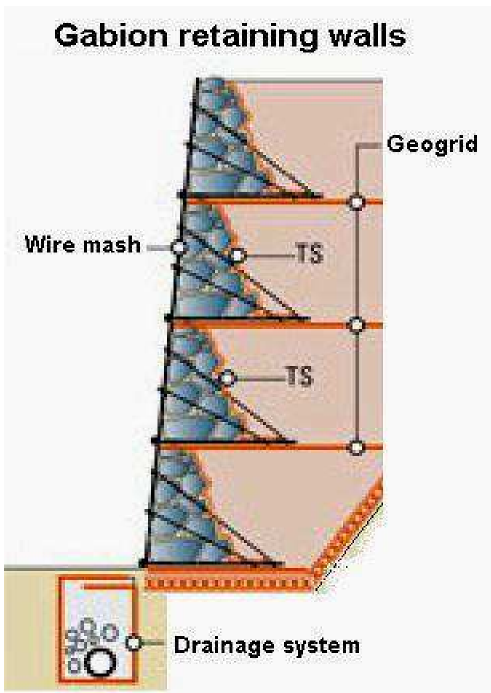


Figure 4 Technical solution for a geosynthetic gabion wall also reinforced with geosynthetic

a)

b)

Figure 5 Examples of retaining walls in the world (a, b)

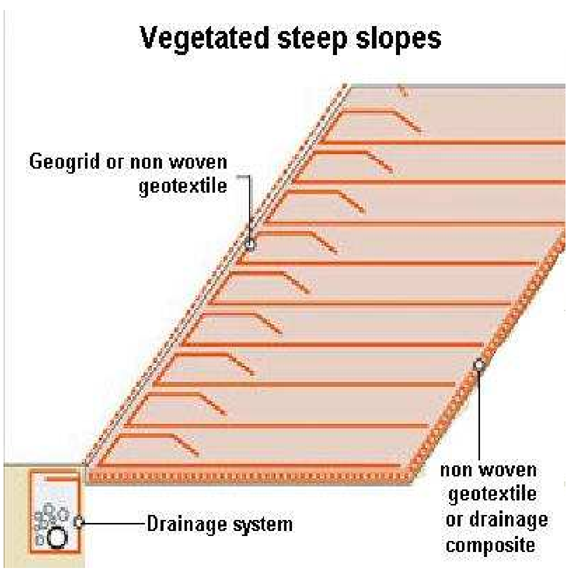


Figure 6 Stabilized slope using geosynthetics materials

a)

b)

Figure 7 Examples of stabized slopes in the world (a, b)

3. CONCLUSIONS

Geosynthetics Mats provide effective reinforcement even under high surcharge loads. This solutions insure a long-term reinforcement system. The controlled manufacturing process guarantees a consistantly high quality. This simplyfies the quality control on the construction site. Both geotextile and geogrid net offer excellent mechanical, chemical and biological resistance. Therefore they can be used harmlessly in contact with soil, water, pant roots and construction materials such as concrete [4,5,6].

The design of geosynthetic reinforced structures must ensure that the long-term stress in the reinforcement do not exceed the strength of the reinforcement at any time during the life of the structure.

The live of the reinforced soil structure depends on the durability of the reinforcing elements. Even if they are not susceptible to corrosion, polymeric reinforcement may be degraded by a number of different actions. This actions includes ultraviolet light, high energy radiation, oxidation, hydrolysis, some chemical reactions, and in additional susceptibility to construction damage.

Geosynthetics have been used extensively in soil reinforcement in the past decades thanks to their typically reduces cost of the construction, increased tolerance of the soil structures to ground movement and soil structure increased feasibility, difficult to construct using the conventional methods especially in the poor soil conditions or limited right of way.

We defined three types of soil structures in geotechnical engineering for soil reinforcement: retaining walls, slopes and embankment on soft foundations [4,5,6].

For a reinforced embankment on a soft foundation, a layer of reinforcement is usually placed at the base of the embankment, to carry part of the horizontal load and to prevent failure in the soft foundation.

For a reiforced wall or slop, reiforced layers are placed within the backfill materials. The location of the maximum tensile force in the reinforcing layer depends on the rigidity of the facing units and the horizontal movement within the backfill. For these reinforcements deformation and stability are the main two concerns. An accurate assessment of deformation in a reinforced slope can only be achieved through a stress-deformation analysis. On the other hand the stability of a reinforced slope can be evaluated using a limit equilibrium method or a stress deformation analysis.

In Romania, there are allready many such works in different techniques from civil engineering domain, as landfill structures creating an esthetical landscape fading away the specific aspect together with the environmental protection, slope reinforcement and other infrastructure works for abutments, bridges, roads and railways.

The issue of long term geosynthetic strength is still the subject of continuous research and the experience already gained is generally based on the case study histories of the structures built using granular backfill. However, reports on the cases in which geosynthetics have been used in soil reinforced structures have indicated satisfactory long-term performance.

4. ACKNOWLEDGMENTS

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