USE OF GEOSYNTHETICS FOR SOIL REINFORCEMENT

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Abstract
Geo-textile have been utilised in the construction of reinforced soil walls since the early 1970's. Geo-textile sheet are used to wrap compacted soil in layers producing a stable composite structure. Some of the advantages of geo-textile reinforcement walls over conventional concrete walls are the following: they are economical; construction is easy and rapid; regardless of the height or length of the wall, support of the structure is not required during construction as for conventional retaining walls; they are relatively flexible and can tolerate large lateral deformations and large differential vertical settlements; they are potentially better suited for earth-quake loading because of the flexibility and inherent energy absorption capacity of the coherent earth mass.
This paper presents the properties of the materials, design method and procedure, raw materials and applications.
Key words: Geo-textiles, soil reinforcement, advantages, wall.

1. Introduction

Soil, especially granular, is relatively strong under compressive stresses. When reinforced, significant tensile stresses can be carried by the reinforcement, resulting in a composite structure which possesses wider margins of strength. This extra strength means that steeper slopes can be built.

2. Textile solutions for soil reinforcement

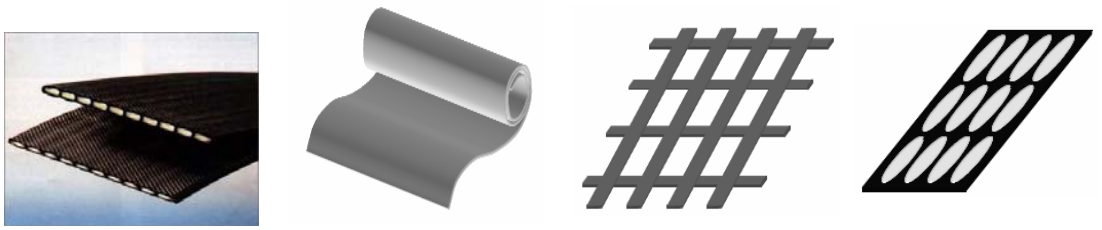
In many cases of construction, shallow foundations are built on top of existing cohesive soil deposits, resulting in low bearing capacity and/or excessive settlement problems. This can cause structural damage, reduction in the durability, and/or deterioration in the performance level. Conventional treatment methods are either to replace part of the weak cohesive soil by an adequately thick layer of stronger granular fill, or to increase the dimensions of the footing, or a combination of two. An alternative and more economical solution is the use of reinforced soil foundation. This can be done by either reinforcing cohesive soil directly or replacing the poor soils with strong granular fill in combination with geo-synthetics reinforcement. The resulting composite zone (reinforced soil mass)will improve the load carrying capacity of the footing and provide better pressure distribution on top of the underlying weak soil, hence reducing the associated settlements. During the past 40 years, the use of reinforced soil to support shallow foundations has received considerable attention.[1]
Geo-synthetic is a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure or system.
The reinforcement function of a geo-synthetic means the use of a geo-synthetic material to resist stresses or contain deformations in geo-technical structures.
Reinforced fills are engineered fill structures incorporating discrete layers of soil reinforcement, generally placed horizontally, which are arranged between successive layers of fill during construction.

The scope of reinforced fill applications considered includes:
- earth retaining structures (vertical, battered or inclined) with a facing to retain the fill placed between the reinforcing layers;
- reinforced steep slopes (45º to 75º) with a facing, either built-in or added or wrap-around;
- reinforced shallow slopes (<45º) without a facing but with some kind of erosion protection;
- embankments with basal reinforcement.

Reinforced fill structures are widely used in the field of construction for specific applications such as retaining walls, bridge abutments, industrial structures, containment structures, dams, slope stabilization, steepened slopes, embankments.

Fill reinforcements can be made from metals, generally steel, or polymeric materials. Fibre glass and carbon fibre reinforcements have been used experimentally. Natural fibres may also be used, mostly for temporary structures.

Geo-strips, see figure 1.a), are geo-synthetic strips. The most common types used in reinforced fills consist in discrete bundles of closely packed high strength fibres, parallel to each other, encased in a robust and durable polymeric sheath. The polymeric sheath provides the protection against the mechanical and chemical aggressivities of the fill. High tenacity polyester and aramids are widely used fibres.



a). geo-strip b). geo-textile sheet c). geo-grid d). geo-grid

Figure 1. Types of geo-synthetics used for soil reinforcement

Geo-textiles sheets (polymeric) may be woven, non-woven or knitted, see figure 1.b).

Woven geo-textiles are produced by interlacing, usually at right angles, two or more sets of yarns, fibers, filaments, tapes or other elements.

Non-woven geo-textiles are in the shape of manufactured sheet, web or batt of directionally or randomly oriented fibers, bonded by friction and/or cohesion and/or adhesion.

Knitted geo-textiles are produced by interloping one or more yarns, fibers, filaments or other elements.

Geo-grid is a geo-synthetic formed by a regular network of integrally connected elements with apertures greater than 6.35 mm (1/4 in) to allow interlocking with surrounding soil, rock, earth, and other surrounding materials to function primarily as reinforcement, see figure 1.c) and 1.d). Geo-grids are manufactured from different raw materials utilizing different manufacturing techniques. Most commonly used are extruding, weaving and knitting, welding and interlacing.

Table 1 provides an overview of different manufacturing techniques and corresponding raw material:

Table 1. Different manufacturing techniques and corresponding raw material

Manufacturing Techniques	***Raw Material***
Extrusion	PP, HDPE
Weaving and Knitting	PET, PVA, PP, AR
Welding	PP, PET

Integral geo-grids manufactured by extrusion starting with the extrusion of a sheet that is either perforated during extrusion or subsequently punched to give a precise arrangement of holes in a separate operation. The punched sheet is then, either stretched in one direction to produce a uniaxial grid, or two directions to form a biaxial grid. This stretching is carried out under controlled conditions inducing a high degree of molecular orientation to achieve a higher level of tensile strength.
Woven geo-grids are made by the textile manufacturing technique known as weaving. The number of threads per unit and their individual strength lead to final product strength.
For woven and knitted materials used in civil engineering, usually a coating is applied in order to provide protection against various influences.
Geo-synthetic (geo-grid or geo-textile) wrapped around
The most widely used soft facing unit is the wrapped facing in which full width reinforcement, such as geo-grid or geo-textile, is extended forward from the reinforced fill to wrap around the face or each intervening layer of fill.

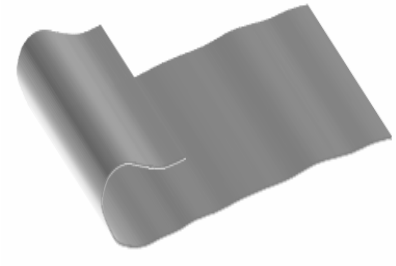


Figure 2.a). geo-textile sheet

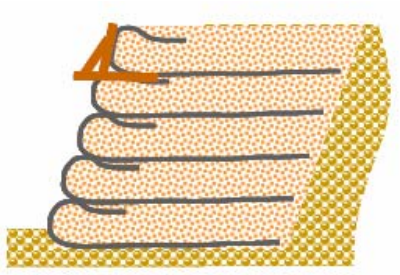
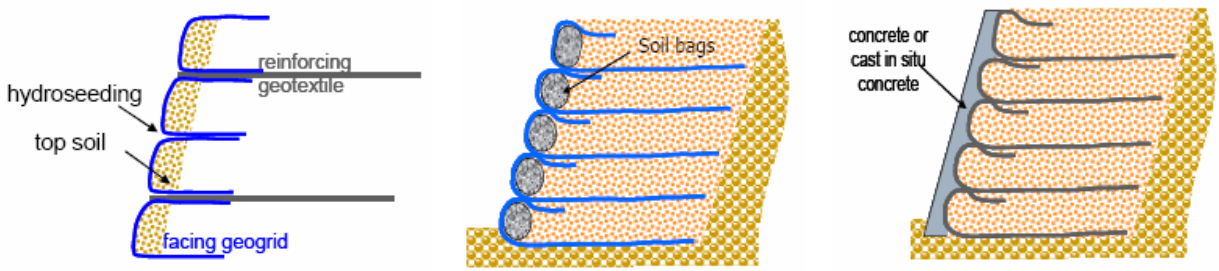


Figure 2.b). retaining wall

Except for shallow slopes, it is common practice to use temporary formwork to construct such flexible facing to an acceptable alignment. Fair construction tolerance (±100mm) can be obtained with care and a better quality fill.
For vertical or battered wall faces where geo-grids are used, these may be faced, or backed, with a suitable geo-textile to guard against erosion of the face. Alternatively, the facing units may be formed as fabric containers filled with soil.
In most cases this type of facing is sprayed or seeded to produce a vegetative cover or, rarely, may be sprayed with shotcrete. As an exposed and untreated facing, the material should be considered for only temporary wall applications, i.e., exposure to sunlight results in steady ultraviolet degradation with time.[2]



a). b). c).

Figure 3. The design method recommended for retaining walls reinforced with geo-textile

The functional requirements for geo-textiles in soil reinforcement are presented in table 2. The tensile strength and maximum extension of geo-textiles are presented in table 3.

Table 2. Required functions of geo-textiles used for soil reinforcement

Geo-textile functions	
Tensile strength	iii
Elongation	iii
Chemical resistance	ii-iii
Biodegradability	iii
Flexibility	i
Friction properties	iii
Interlock	iii
Tear resistance	i
Penetration	i
Puncture resistance	i
Permeability	i
Creep	iii
Resistance to flow	i
Water	iii
Properties of soil	iii
Burial	iii
UV light	ii

iii- highly important; ii-important; i-moderately important.

Table 3. Tensile strength and maximum extension for different types of geo-textiles

Geo-textile construction	***Tensile strength (kN/m)***	***Maximum extension (%)***
NON-WOVENS		
Melt-bonded	3-25	20-60
Needle-punched	7-90	50-80
Resin-bonded	5-30	25-50
WOVEN		
Monofilament	20-80	9-35
Multifilament	40-800	9-30
Tape	8-90	10-20
GEOGRIDS		
Textile based	25-300	3-20
Polymeric sheets	10-160	11-30
Cross laid strips	20-160	10-15
Geocomposit link structures	100-1200	3-15

3. Advantages of geo-synthetics in soil reinforcement

Geo-synthetics, including geo-textiles, geo-membranes, geo-nets, geo-grids, geo-composite, geo-composites and geo-synthetics clay liners, often used in combination with conventional materials, offer the following advantages over traditional materials:

- *space saving*- sheet-like, geo-synthetics take up much less space in a landfill than do comparable soil and aggregate layers.
- *material quality control*- soil and aggregate are generally heterogeneous materials that may vary significantly across a site or borrow area. Geo-synthetics on other hand are relatively homogenerous because they are manufactured under tightly controlled conditions in a factory. They undergo rigorous quality control to minimize material variation.
- *construction quality control*- geo-synthetics are manufactured and often factory "prefabricated" into large sheets. This minimizes the required number of field connections, or seams. Both factory and field seams are made and tested by trained technicians. Conversely, soil and aggregate layers are constructed in place and are subject to variations caused by weather, handling and placement.
- *cost savings*- geo-synthetic materials are generally less costly to purchase, transport and install than soil and aggregates.
- *technical superiority*- geo-synthetics have been engineered for optimal performance in the desired application.
- *constructing timing*- geo-synthetics can be installed quickly, providing the flexibility to construct during short construction seasons, breaks in inclement weather, or without the need to demobilize and remobilize the earthwork contractor.
- *material deployment*- layers of geo-synthetics are deployed sequentially, but with a minimum of stagger between layers, allowing a single crew to efficiently deploy multiple geo-synthetic layers.
- *material availability*- numerous suppliers of most geo-synthetics and ease of shipping insure competitive pricing and ready availability of materials.
- *environmental sensitivity*- geo-synthetic systems reduce the use of natural resources and the environmental damage associated quarrying, trucking, and other material handling activities.[3]

4. Conclusion

A study from The Freedonia Group Inc., shows that demand for geo-synthetics is projected to advance 2.5 percent annually to over 900 million square yards in 2012, valued at $2.1 billion. Gains will be promoted by rebounding road and highway construction spending.

Another study say that the global demand for geo-synthetics is projected to increase 5.3 percent annually to 4.7 billion square meters in 2013. Countries such as China, India and Russia that are building large-scale infrastructure developments and face evolving environmental protection regulations and building construction codes are expected to post the strongest gains through the forecast period.

5. References

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