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Role of Geosynthetics in sustainable development

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Abstract

Geosynthetics manufactured from polymeric material are gaining popularity as one of the versatile construction material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made projects like retaining walls, embankment for roadway and railway, to derive benefits out of its presence. Road pavements are one of the areas where use of geosynthetic is gaining momentum. When geosynthetic is used in pavements or other structures, it may require performing more than one function like separation, reinforcement and drainage, filtration and liquid barrier. Wide variety of geosynthetics are available in market from which one can choose a geosynthetic depending upon the function to be performed by the geosynthetics. Their selection to perform one or more than one function depends on the physical, mechanical and hydraulic properties of the geosynthetics.

Keywords: geosynthetics, geotechnical engineering, separation, reinforcement and drainage, filtration and liquid barrier

Introduction

Henry Vidal(1969), a French architect and civil engineer observed that roughly formed mounds of dry sand, an inherently weak material, could be made to stand at a steeper angle after the addition of horizontal layer of fine needles of straw. He concluded that the composite construction material created by combining dry granular soil with a rough material having tensile strength is stronger than soil itself. From this observation emerged the idea of reinforced soil which is a composite construction material consisting of soil and reinforcement in the form of metal/geotextile strips, geogrids and geocells. Frictional forces generated between the soil and the reinforcement enhances the strength of the composite by acting in a way analogous to an increased confining pressure. Reinforcement also unifies the soil mass that would part along a failure surface.

Geosynthetics and it's types

Geo-synthetics have been proven to be the most versatile and cost effective soil properties modification materials, due to the favorable basic characteristics of geosynthetics. Their use has expanded rapidly into nearly all areas of civil engineering like, geotechnical, environmental, coastal and hydraulic engineering. Most geosynthetics are made from synthetic polymer such as polypropylene, polyester, polyethylene, polyamide, PVC etc. These materials are highly resistant to biological and chemical degradation.

Types of Geosynthetics

Geosynthetics can be broadly classified into different categories based on method of manufacture. The current denominations and brief descriptions of geosynthetics are presented in the subsequent articles.

- *Geotextile,*
- *Geogrids*
- *Geonets*
- *Geomembranes*
- *Geocomposites*
- *Geopipes*
- *Geocell*
- *Geofoam*

Basic Characteristics of Geosynthetics

The rapid growth in applications of geosynthetics all over the world is due mainly to the following favorable basic characteristics of geosynthetics:

- Non-corrosiveness
- Highly resistant to biological and chemical degradation
- Long-term durability under soil cover
- High flexibility
- Minimum volume
- Lightness
- Ease of storing and transportation
- Simplicity of installation
- Speeding the construction process

- Making economical and environment-friendly solution
- Providing good aesthetic look to structures

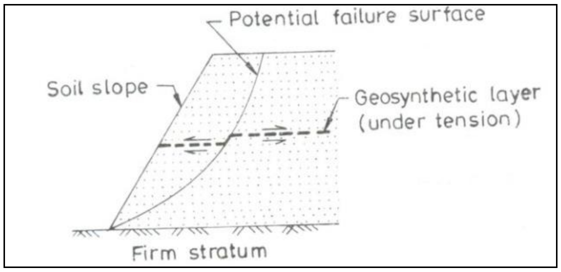

Fig 1

- **Functions of Geosynthetics**

For any given application of a geosynthetic, there can be one or more functions that the geosynthetic will be expected to serve during its performance life. The selection of a geosynthetic for any field application is highly governed by the function (s) to be performed by the geosynthetic in that specific application. Geosynthetics always perform one or more of the following basic functions when used in contact with soil, rock and/or any other civil engineering related materials.

- Reinforcement
- Separation
- Filtration
- Drainage
- Fluid barrier
- Protection

Reinforcement

A geosynthetic performs the reinforcement function by improving the mechanical properties of a soil mass as a result of its inclusion. When soil and geosynthetic reinforcement are combined, a composite material, “reinforced soil”, possessing high compressive and tensile strength is formed. In fact, any geosynthetic applied as reinforcement has the main task of resisting applied stresses or preventing inadmissible deformations in geotechnical structures. In this process, the geosynthetic acts as a tensioned member coupled to the soil/fill material by friction, adhesion, interlocking or confinement and thus maintains the stability of the soil mass. Fig 1 shows basic mechanism involved in the reinforcement function by geosynthetic in an embankment.

Figure 1 Basic Mechanism Involved in the Reinforcement of an Embankment

Separation

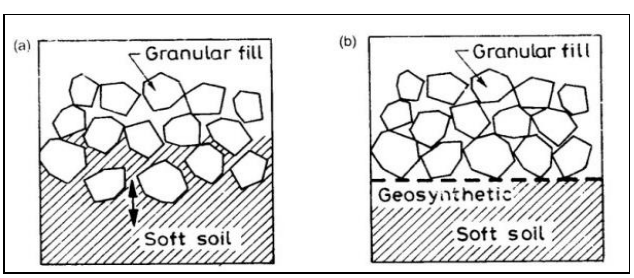

Fig 2

If the geosynthetic has to prevent intermixing of adjacent dissimilar soils and /or fill materials during construction and over a projected service life time of the application under consideration, it is said to perform separation function. Fig 2 shows that the geosynthetic layer prevents the intermixing of soft soil and granular fill, thereby keeping structural integrity and functioning of both materials intact. This function can be observed if a geotextile layer is provided at the soil sub grade level in pavements or railways tracks to prevent pumping of soil fines into the granular sub bases /base course and /or to prevent intrusion of granular particles into soil sub grade.

Figure 2 Basic Mechanism Involved In the Separation Function

(A) Granular Fill-Soft Soil System Without The Geosynthetic Separator
(B) Granular Fill-Soft Soil System With The Geosynthetic Separator

In many geosynthetic applications, especially in roads, railway tracks, shallow foundations, and embankments geosynthetic layer is placed at the interface of the soft foundation soil and overlying granular layer [Fig 3].

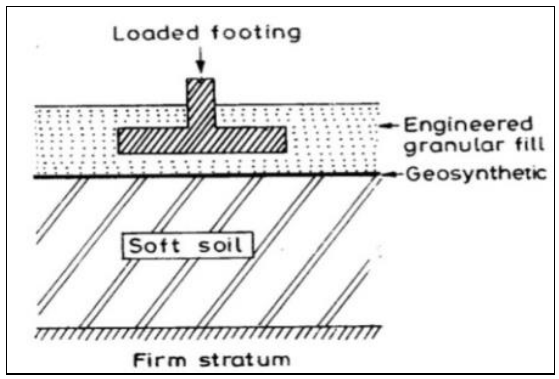

Fig 3: A Loaded Geosynhetic-Reinforced Granular Fill-Soft Soil System

Filtration

A geosynthetic may function as a filter that allows for adequate fluid flow with limited migration of soil particles across its plane over a projected service lifetime of the application under consideration. Fig 4 shows that a geosynthetic allows passage of water from a soil mass while preventing the uncontrolled migration of soil particles

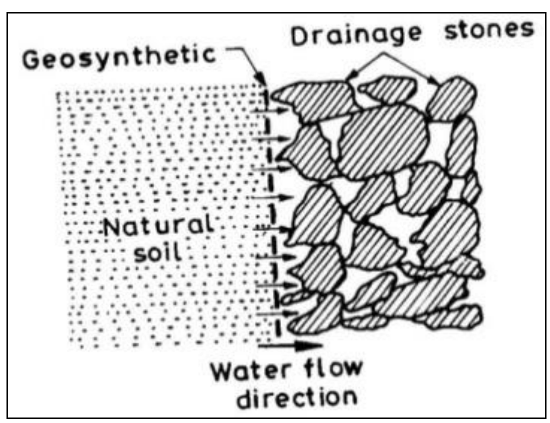

Fig 4: Basic Mechanism Involved In the Filtration Function

Drainage

If a geosynthetic allows for adequate fluid flow with limited migration of soil particles within its plane from surrounding soil mass to various outlets over a projected service lifetime of the application under consideration, it is said to perform the drainage function. Fig 5 shows that the geosynthetic layer adjacent to the retaining wall collects water from the backfill and transports it to the weep holes constructed in the retaining wall. While performing the filtration and drainage functions, a geosynthetic dissipates the excess pore water pressure by allowing flow of water in plane and across its plane.

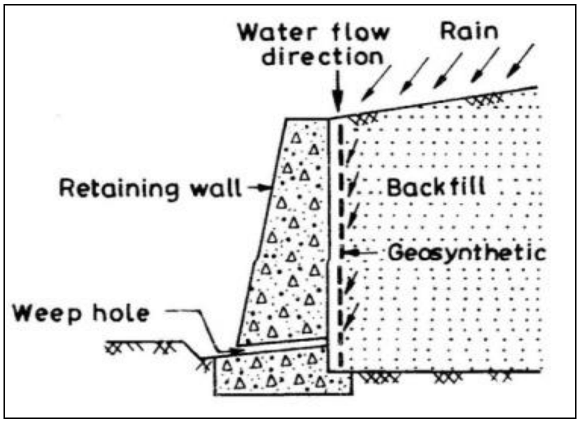

Fig 5: Basic Mechanisms Involved In the Drainage Function

Fluid barrier

A geosynthetic performs the fluid barrier function, if it acts like an almost impermeable membrane to prevent the passage of liquids or gases over a projected service lifetime of the application under consideration. Fig 6 shows that a geosynthetic layer, installed at the base of a pond, prevents the infiltration of liquid waste into the natural soil.

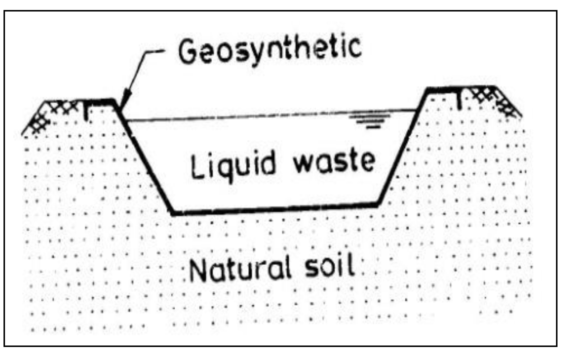

Fig 6: Basic Mechanisms Involved in the Fluid Barrier Function

- **Applications of geosynthetics**

Geosynthetics have established themselves as one of the versatile and feasible construction materials. The particular categories of the various geosynthetic applications are as follows:

- Geotechnical
- Transportation
- Hydraulic
- Geoenvironmental

The geosynthetics find their applications as briefed in the following articles.

- **Slopes**

One of the earliest uses of geosynthetics was to steepen soil slopes and embankments as shown in Fig.7Such soil masses can be made stable at essentially any angle by using horizontally placed layers of appropriately designed geogrids or geotextiles.

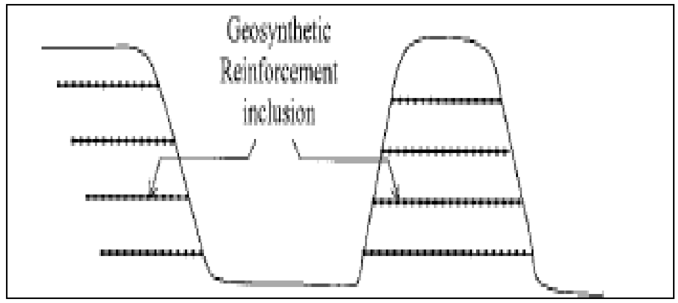

Fig 7: Soil Slope Reinforcement

- **Reinforced Walls**

A geosynthetic material (geotextile or geogrid) wrapped around layers of soil backfill can provide for a vertical wall. The reinforcement can be a geotextile, but is currently more often a geogrid. Fig 8 shows a geosynthetic reinforced wall made of facing elements which are anchored to the geosynthetic strips laid in compacted back fill material.

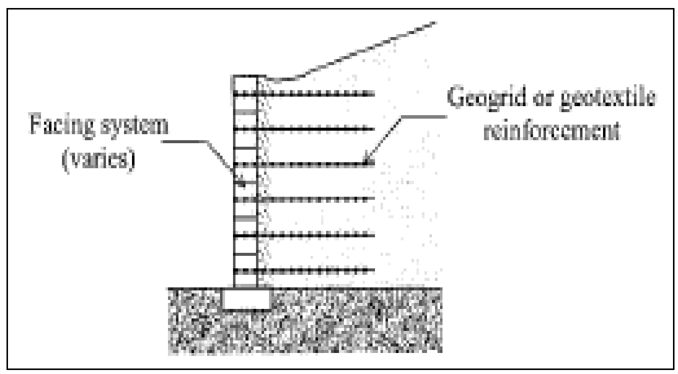

Fig 8: Geosynthetic Reinforced Wall

- **Concrete *Dam Waterproofing***

Geomembranes, placed directly on the upstream face of the dam, are a current application that provides a waterproofing barrier [Fig.10]

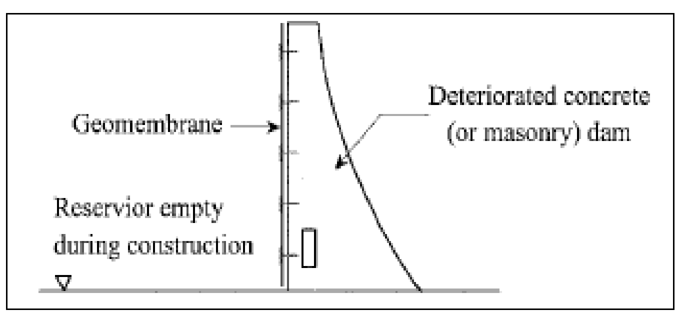

Fig 10: Geomembrane waterproofing of dams

- **Earth Dam Waterproofing**

The application of geomembranes and potentially geosynthetic clay liners on the upstream face of earth and earth/rock dams is an important application to minimize seepage of water through water retaining structure. Fig. 11(a), (b) & (c) illustrate dam water proofing using geosynthetics.

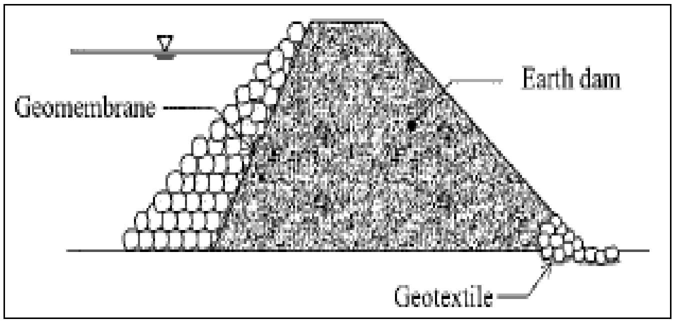

Fig 11(A): Geomembrane Waterproofing of Earth or Earth-Rock Dam Face

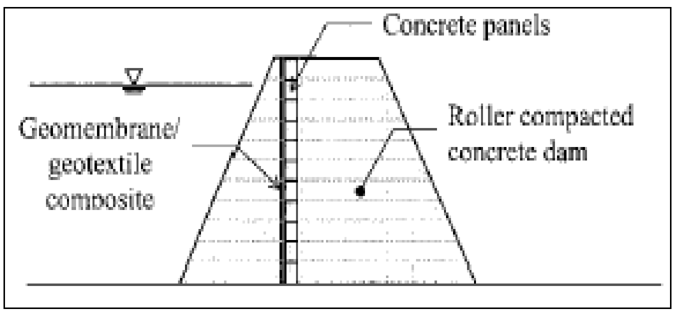

Fig 11(B): Geo*m*embrane Waterproofing Of Roller Compacted Concrete Dam

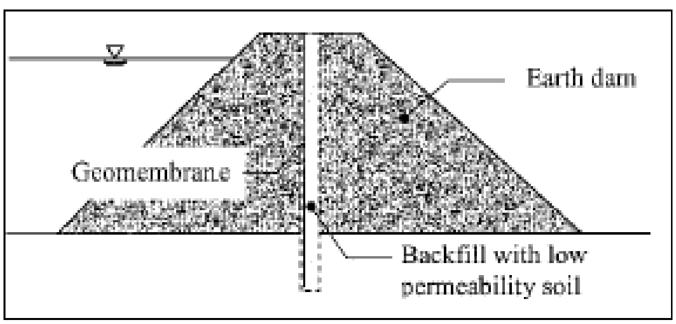

Fig 11(C): Geomembrane Waterproofing Of Existing Dam

- **Tunnel Waterproofing**

The use of waterproofing geomembranes placed in advance of liner plates or permanent concreting in tunnels is amicable solution for waterproofing [Fig 12]. When coupled with a thick, needle punched nonwoven geotextile, and a drainage outlet at the toe of the geotextile, a complete seepage control system can be established.

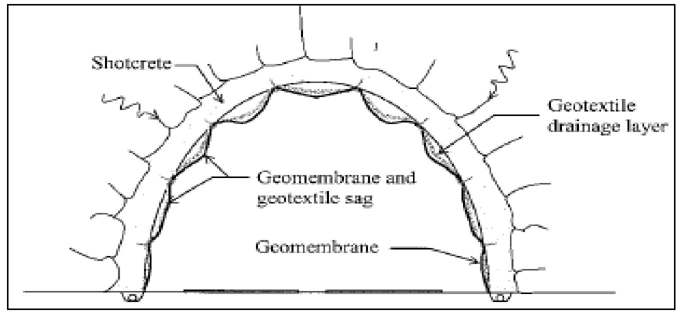

Fig 12: Tunnel Waterproofing

- **Erosion Control of Systems**

The loss of soil by water and/or wind erosion negatively affects land and farm use. In order to control, limit or altogether avoid soil erosion, suitable geosynthetic layer is laid over the sloping ground from where erosion is expected, pinned down and sometimes vegetation is grown. Fig.13 (a) & (b) depicts such an application for erosion control.

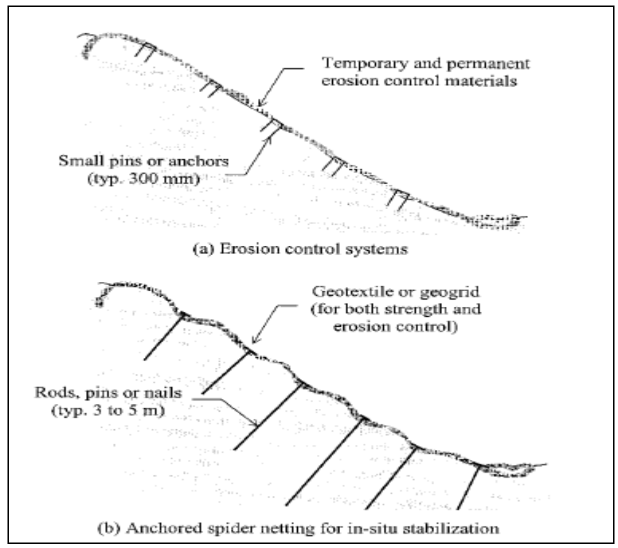

Fig 13: Geosynthetic for Erosion Control

- **Geoenvironmental applications**

Landfill Liner Systems: Landfill liner systems using geomembranesare being widely used. The different landfill liner systems can be

i) Double with leak detection capability
ii) Composite liners (geomembranes with underlying clay soils)
iii) Geosynthetic clay liners

Such systems have replaced all or part of the compacted clay soils, leading to the situation as shown in Fig.14 (a) & (b). These containment systems have indeed proven themselves to be extremely efficient in protecting the subsurface environment.

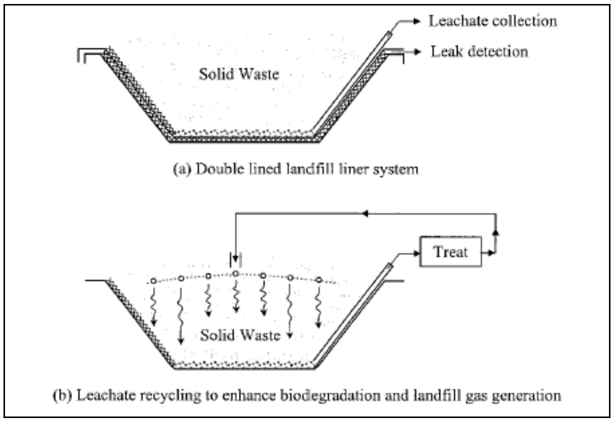

Fig 14: Geosynthetic for Landfill Liner System

- **Landfill Closure Systems**

Closely related to the liner systems beneath the waste mass in a landfill are the cover systems placed above the waste. Such systems usually consist of a composite barrier (i.e., geomembrane over a geosynthetic clay liner or compacted clay liner), with a drainage system placed above and a gas collection system placed below [Fig.15 a, b and c]

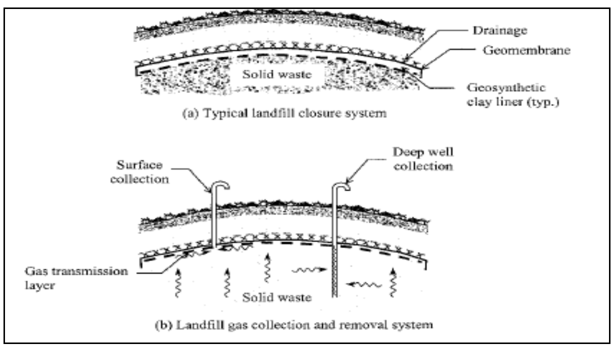

Fig 15: Geosynthetic for Landfill Closure Systems

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