EXPERIMENTAL ANALYSIS OF GEOTEXTILES & GEOFIBERS COMPOSITES

Preface

In current geotechnical practice, the design of fiber reinforcement project requires testing of specific fiber-reinforced specimens, which may be time-consuming. The traditional design approach for fiber reinforced soil requires that tests be conducted on fiber-reinforced soil specimens. This has possibly discouraged the use of fiber-reinforcement technique in geotechnical practice. The material in the book is written for persons at a number of levels. Much of it is introductory for an engineer, but serves to link engineering principles with practical aspects. The book is not intended to be a traditional text. The most parts of this book provided to a make a balanced treatment between basic aspects and experimental concepts of the geotextiles and geofibers.

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CONTENTS

CHAPTER 1
Introduction

Content- Chapter 1

1.1. Geotextile (http://www.geofibers\The concepts of geotextiles.htm) is a synthetic permeable textile material applied with soil, rock, or any other geotechnical engineering related material. Textiles were first applied to roadways in the days of the Pharaohs. Even they struggled with unstable soils which rutted or washed away. They found that natural fibers, fabrics or vegetation improved road quality when mixed with soils, particularly unstable soils. Only recently, however, have textiles been used and evaluated for modern road construction. This fact sheet clarifies the confusion over terms and definitions of geotextiles, and discusses their common roadway and erosion control applications. In the 1920's the state of South Carolina used a cotton textile to reinforce the underlying materials on a road with poor quality soils. Evaluation several years later found the textile in good workable condition. They continued their work in the area of reinforcement and subsequently concluded that combining cotton and asphalt materials during construction reduced cracking, raveling, and failure or the pavement and the base course. When synthetic fibers became more available in the 1960's, textiles were considered more seriously for roadway construction and maintenance. As these new synthetic fabrics evolved, there was confusion over terms and definitions. Textiles and membranes now have reasonably well accepted definitions in the construction industry. It is produced by synthetic fibers made in a woven or loose nonwoven form. Geotextiles, also named as geosynthetics, are normally applicable to high-standard all-season roads, can also be used to low-standard logging roads. American Society for Testing and Materials (ASTM), describes geotextile as any permeable textile material applied with foundation, soil rock, earth or any other geotechnical engineering related material as an integral part of a: man-made project, structure or system. Geotextiles are mostly used for: Reinforcement of Unpaved Roadways, Paved Roadways, Separation applications in Unpaved Roadways, Paved Roadways, Sediment Control etc, as part of geo-composites. Geotextiles are existed with more than fifty year. Though, the development of market and research work put in to practice in early 1960s. Geotextiles are performing progressively in civil engineering construction and are still growing as an alternative, economically viable material. In recent years, the utilization of geotextiles in the world markets has grown at extraordinary rate. In India, geotextiles have been specially used in road and airport flexible pavements and in overlays. The growth of geotextiles in between 2000 and 2005 was grown at the rate of 4.6% annually, and during the next five years (i.e. up to 2012) it is predicted to 5.3 percent. The geotextile market is increasing in its growth rate, though these are now lower than previously forecasted and in compared to other applicators it has relatively little growth for end-user of textiles. In the quantity, geotextiles reported a little growth, more than 250,000 tons in 2000, merely 1.5 percent of the overall technical textile market. Furthermore, this sector with low unit values in small numbers gives a large margin. Geotextiles are mainly made from polyolefin, are light in weight and strong but cheap. These permeable woven geotextiles are generally used for filtration and impermeable membranes to hold out mud pumping. Certain fabrics provide high puncture resistance and offer a significant recognition in road and rail construction projects, or where the reliability of the sheet is required, as in landfill sites. It is noted that geotextiles have to be made in large quantities and that too cost-effectively, fibers for geotextiles are normally produced by melt-spinning. High Density Polyethylene

(HDPE) is applied to receive reinforcement needs. Even staple fibers, monofilaments, multifilament yarns and slit films are also applied. The polymers as they are actually made and applied for geotextile production are not available in their chemically pure form. For example, raw polyethylene in its colorless translucent form is rather subjected to light degradation; therefore, it is not applied as geotextiles applicants, but normally includes carbon black as ultraviolet (UV) light stabilizer. It is possibly the most light-resistant polymer in black form. Based on manufacturing process, geotextiles can be categorized as woven, nonwoven, or knitted. Woven fabrics are made by the traditional weaving method, giving a screen-like or mesh material with a variety of sizes of mesh openings and according to the tightness of weave. A woven fabric gives high tensile strength, high modulus, and low strains, but gives poor abrasion resistance and dimensional stability. While nonwoven fabrics have high permeability and high strain characteristics. They are produced in a number of geometric and polymeric compositions to satisfy a various applications. Many geotextiles are prepared by polypropylene. Fabric produced concrete revetment mats; silt filter fences, erosion control blankets, and fabric envelopes for pipe or mat under drains are the illustrations of common geotextile applications. A geotextiles long-term representation is due to the durability and creep characteristics of the polymer structure. The effect of ground, weather, sunlight, and aging conditions must be measured when applying a geotextile for a permanent base. Non-woven geotextiles are available in the form of polypropylene fibers and are needle punched. Nonwoven fabrics possess distinctive ability to lengthen locally to resist damage, superior permeability and frictional resistance, though their tensile strength is lower than that of woven fabrics. Knitted textiles exposed its fewer applications as geotextiles. Though, warp knitted fabrics are important for developed into reinforced soil applied for granular soil and are named as Directionally Structured Fibers (DSF). DSF directed to considerable economies in the application of polymer within the construction, in the form of its evidence for the absorption of tensile stresses. While examine, significantly less stress is to be found on weft element, then there is little grounds. Similarly Directionally Oriented Structures (DOS) are warp knitted fabrics with comparable sets of yarns put into the structure included by loop structures so that load is exactly put on the yarns to use their full potential.

Figure 1 Geotextile

Geosynthetics have been utilized in numerous civil and environmental engineering applications worldwide for more than 20 years to prevent seepage of liquids. Such seepage control applications as water containment and conveyance, structure waterproofing, and environmental protection make extensive use of geomembranes and geosynthetic clay liners (GCLs) along with other geosynthetics. The materials used for seepage control may be exposed, as with pond linings, or buried, as with landfill linings. They may be subject to significant stresses, as with a pond cover, or exposed to very aggressive environments, as with a chemical tank lining. The wide variety of potential exposure conditions is why there is such a wide variety of geosynthetic barrier materials.

1.2.Geofibers are usually polypropylene fibers blended into soils to create an ideal reinforcement system for the repair of slope failures, reinforcement of pavement subgrades, foundation stabilization, and improvement of retaining wall backfill. By synergistically meshing with the soil already on site, geofibers help create a soil reinforcement system with dramatically improved engineering properties.

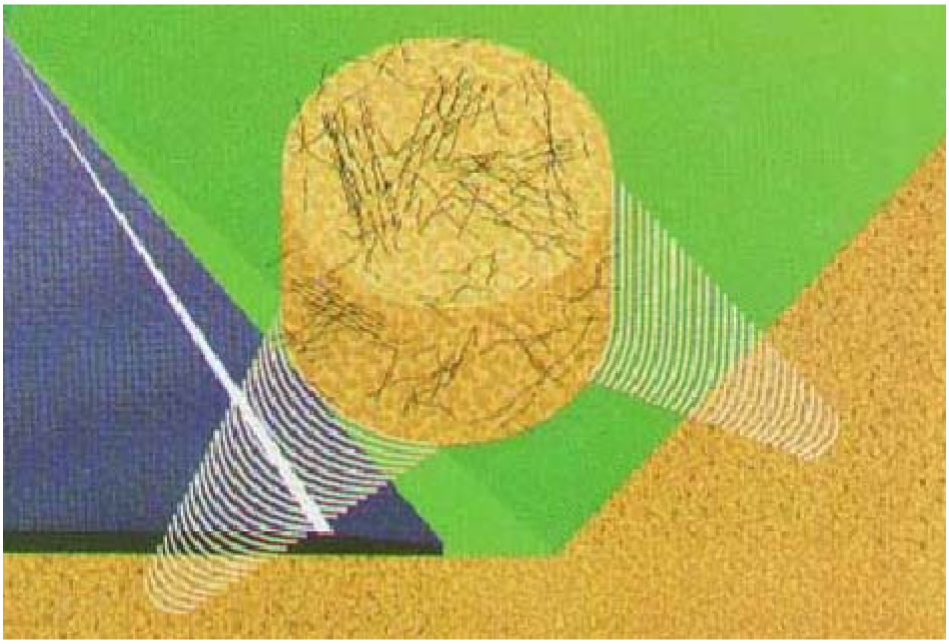

Figure 2 Geofiber

1.3.Types of Geotextiles

<u>1.3.1.Geomembranes</u>- Geomembranes stand for another form of geosynthetics and are applied mainly for linings and covers of liquid or solid-storage facilities. These are basically a resistant material, in the shape of manufactured sheet, which may be synthetic or bituminous. Therefore, the main task is as a liquid or vapor barrier and is also applicable for various applications. Applied for decorative water feature application and land design and recognized as flexible geomembranes as liners. This is because of the reality that the flexible geomembrane is cheap and flexible for many design ideas, besides having water containment capabilities. Geomembranes are

commonly used as barriers in waste containment facilities and landfills due to various benefits associated with their use and because of regulatory requirements. Geomembrane are also increasingly being used in reservoirs, ponds, lined canals and other geotechnical projects. Geotechnical engineers often characterize the shearing resistance along interface between geomembranes and soils using results from interface direct shear tests. The results of these tests are used in an analysis of stability against sliding along the given interface. Interface shear testing between soil and geosynthetics has now become an essential part of the design process in geotechnical and geo-environmental engineering.
Geomembranes are "impervious" thin sheets of rubber or polymeric material used primarily for linings and covers of liquid or solid waste containment facilities. Geomembranes represent the largest category (by cost), of geosynthetics products used in civil engineering applications. The growth in the use of geomembranes can be attributed to the various benefits associated with their application, their relative economy and increasingly stringent environmental regulations. The mechanism of diffusion in geomembrane is on molecular scale which is different from other porous media. Water molecules diffuse through narrow spaces between polymer molecular chains. Geomembranes cannot be regarded as totally impermeable as some amount of diffusion permeation is observed in geomembranes. A typical thermoplastic geomembrane will have diffusion permeability of the order of 10-11 to 10-13 cm/s. Because of their extremely low permeability, their primary function is as a liquid or vapour barriers.

-Calendered Geomembranes:
Calendered geomembranes are formed by working and flattening a molten viscous formulation between counterrotating rollers. Polyvinyl chloride (PVC), chlorosulfonated polyethylene (CSPE), chlorinated polyethylene (CPE), and, more recently, polypropylene (PP) are the most common calendered geomembranes. Specialty ethylene interpolymer alloy (EIA) geomembranes are used for unique applications. In most cases these engineered films are supported by a textile that provides tensile strength and enhances tear and puncture resistance.

- Extruded Geomembranes:
Extruded geomembranes are manufactured by melting polymer resin, or chips, and forcing the molten polymer through a die using a screw extruder. The sheet is formed either by a flat horizontal die or through a vertically oriented circular die to form either a flat wide sheet advanced on a conveyor belt, or cylindrical tube of "blown film", filled with air which is collapsed and pulled by nip rollers mounted high above the die. Blown film geomembranes must be slit prior to wind-up. Common extruded geomembranes include high-density polyethylene (HDPE) and various lower density, or very flexible, polyethylenes (VFPE). Polypropylene (PP) is a relatively new type of extruded (as well as calendered) geomembrane. Variations in the manufacturing of geomembranes include texturing to enhance the interface friction between the geomembrane and adjacent soils or other geosynthetics; coextruding different polymers into a single sheet to provide enhanced durability; and the availability of multiple thicknesses and sheet sizes.
Geomembranes are thin, two-dimensional sheets of material with very low permeability. This makes them ideal for forming waterproof or gas proof barriers between adjacent bodies of soil or soil and fluid. Some of their potential applications include sealing against fluid percolation along the coasts, river banks, reservoirs and

in water storage. They are also used as buffers against pollutants. The manufacturing of geomembranes begins with the production of raw materials. These are polymer resin, plasticizer accelerators or retarders, filters, and processing aids. The raw materials are blended together and compounded before being extruded in sheet or cylindrical form. Extruders both melt the above materials and homogenize them into a consistent fluid mass in a partial vacuum. The vacuum eliminates air bubbles in the final product.

1.3.2.Geogrids- Geogrids are polymeric structures rather than being a woven, nonwoven or knit textile fabric, in their unidirectional or bidirectional format. They are made in the form of manufactured sheet, including a regular network of integrally associated parts, which may be linked by extrusion, bonding or interlacing, whose openings are larger than the constituents, made into a extremely exposed, network like arrangement, i.e. they have large apertures. They work as reinforcement materials. Coated polyester geogrids have been broadly applied in soil stabilization and geotechnical reinforcement uses. Geogrids are single or multi-layer materials usually made from extruding and stretching high-density polyethylene or polypropylene or by weaving or knitting and coating high tenacity polyester yarns. The resulting grid structure possesses large openings (called apertures) that enhance interaction with the soil or aggregate.

Their physical structure can be categorized in to the following:

- Unidirectional geogrid: Having a great deal of tensile strength in one direction (longitudinal or transversal) than in the other direction.

- Bidirectional geogrid; Having identical strength in both longitudinal and transversal direction.

- Extruded geogrid: Created through stretching uniaxial or biaxial, an extruded integral structure.

- Bonded geogrid: Created through bonding, at right angles, two or more sets of strands.

- Woven geogrid: Created through interlacing, usually at right angles, two or more yarns, filaments or other elements.

1.3.3.Geonets- are normally made by uninterrupted extrusion of corresponding sets of polymeric ribs at acute angles to one another. When the ribs are opened, relatively large apertures are shaped into a netlike pattern. Their pattern work is mostly applicable in the drainage area. Geonets are made of stacked, criss-crossing polymer strands that provide in-plane drainage. Nearly all geonets are made of polyethylene. The molten polymer is extruded through slits in counter-rotating dies, forming a matrix, or “net” of closely spaced “stacked” strands. Two layers of strands are called “bi-planar”. Three layers are called “tri-planar”.
Geonets are the most recently introduced members of the geosynthetic family. They are grid-like materials, however, distinct, from geogrids by virtue of their function. They do have considerable strength but are used mostly for drainage purposes. All geonets are made of polyethylene. The specific gravity of most geonets is in the range

of 0.935 to 0.942. The only other materials in geonets are carbon black and a processing package. In manufacturing, the ingredients are mixed and passed through an extruder, which injects the melt into a die with slotted counter-rotating segments. Over these, the melt flows at angles forming discrete ribs in two planes. As pressure forces the semi-solid mass forward, it is pushed over an increasing diameter core, which forces the ribs apart and opens the net. Diamond-shaped apertures are formed that are typically 12mm long by 8mm wide. Geonets are typically 5.0 to 7.2mm thick. Thickness is a key factor in determining drainage capability. Adding a foam agent to the ingredients can increase thickness of geonets.

1.3.4.Geocomposites- A geocomposite comprises with a mixture of geotextile and geogrid; geogrid and geomembrane; geotextile; or any of these three materials with [another material (e.g. deformed plastic sheets, steel cables, or steel anchors). Geocomposites are accumulated materials, in the appearance of manufactured sheet or strip, compromising of at least one geosynthetic among the components.

1.3.5.Geomat **-** Geomat is available in the polymeric form, in the shape of a manufactured sheet, compromising of an irregular network of fibers, yarns, filaments, tapes or other elements (thermally or mechanically connected), whose openings are normally greater than the application of the constituents.

1.3.6.Geocell - Geocell is available in a polymeric cellular form including a regular open network of connected strips, linked by extrusion, adhesion or by other methods.

1.3.7.Biomat and Bionet **-** They are permeable, natural, and accepted as biodegradable polymeric materials, in the shape of a manufactured sheet. Normally biomat comprises with fibers (jute, coir, sisal, straw, or others) set aside collectively by one or two layers of synthetic or natural meshes and bionet comprises with a regular network of knotted or interlaced yarns, whose openings are normally greater than the constituents.

1.4.Natural forms of Geotextiles:

1.4.1.Jute **-**Jute is natural multi filament fiber, durable and simple to both produce and dispose. Biodegradable woven jute is accessible in a number of weave densities, initially anticipated as a geotextile to avoid land sliding and consequent to deforestation. Jute is available in India in large quantities at a cheaper rate. Jute geotextiles can perform a vital function in the control of soil erosion by revegetation and it has many uses, which are cheaper well as easy to accomplish. It has many benefits as geotextiles, because of its high water absorption capability, flexibility and drapability. It also mixed with other materials, such as in the construction of jute-sand-mat structures. The growth of jute based geotextiles is huge due to its various applications in infrastructure development. There were eight Indian jute mills which started production of jute on the base of 50 tons a day of geotextiles with open mesh structures in June 1998, and in the recent time production and uses of these types of jute geotextiles have improved drastically. The possible market for jute geotextiles is bigger; though it is not yet being completely utilized. In order to get benefits of the prospects presented, the jute industries must carry a more market driven approach, reacting to the requirement of customers and must develop standards for its products. Jute, one of the oldest surviving agro-industries in India, has been traditionally in use for flexible packaging, especially sacks. Its special physical attributes have opened up new avenues for diversification promoted mostly as a result of global concerns for environment. Jute geotextile is one such diversified product of jute which has proved to be highly effective in addressing a number of soil-related problems in civil engineering Functionally, Jute geotextile does not have any dissimilarity with man-made geotextiles commonly known as synthetic geotextiles - made of artificial fibers with various petro-chemical derivatives as their source. The functions are - separation, filtration, drainage and initial reinforcement. Besides, biodegradablility of geotextile helps in quick growth of vegetation by coalescing with the soil, increasing its permeability, retaining the appropriate humidity as "mulch" and creating a micro-climate that is conductive to vegetative growth. In fact, geotextile is the most acclaimed natural fabric that provides biotechnical solutions to vulnerable exposed soil. Biodegradability is considered by some as a disadvantage. This is to be borne in mind that all geotextiles act as catalyst in the process of improving engineering properties of soil. An effective life span of two season-cycles is found to be sufficient for natural consolidation of soil known as "filter cake" formation from extensive laboratory tests by leading academics and field trials. Biodegradability of geotextile is, therefore, not a discouraging.

1.4.2.Flax/coir - Coir is a natural insulation material produced from flax fibers, intertwined together into non-woven matting, which can then be set in lofts or put into wall cavities. Coir geotextiles are applied in areas of erosion control, soil conservation, and other civil and bioengineering applications. It also has the appropriate strength and toughness to protect the slopes from erosion while permitting vegetation to flourish. They can dissolve the energy of flowing water and absorb the extra solar radiation.

Figure 3 Coir geotextile

1.4.3.Coconut (Coir) Matting - Used or recycled goods of the coconut fibers from the post industrial waste can also be applied as the economical applicators. It gives low impact and reasonable result to the problems of soil erosion and land sliding on manmade slopes such as motorway and railway embankments.

1.4.4.Cotton - Cotton is mainly made from old clothes in the form recycled cotton or from the post consumer waste stream, is available in a broad variety of colorways, each having the feature of speckling due to the lack of discrimination during the recycling and sorting stages of production.

1.4.5.Hemp - These are available in a broad woven variety:

1.4.6.Straw - Produced by a mixer of straw and a loosely woven net of biodegradable string, gives a minimal influence and realistic answer to the problems of soil erosion and land sliding on manmade slopes such as motorway and railway embankments.

When we talk about natural geofiber composites we mean a composite material that is reinforced with geofibers from natural or renewable resources, in contrast to for example carbon fibers that have to be synthesized (with crude oil as origin). Natural geofibers may come from plants, animals or minerals. However, in the following discussion only cellulose based fibers from plants will be considered. The use of natural geofibers and natural geofiber composites are certainly not new to mankind. Bricks made from clay reinforced with straws have been used for thousands of years as building material. Textiles and ropes made from flax and hemp have been around for very long time and are still used today. Paper and cotton sheets impregnated with phenol- or melamine-formaldehyde resin were introduced in the early 1900 for electronic purposes. Natural geofibers in composites offer some interesting properties. Geofibers such as flax have relatively good specific properties, similar to those of glass fibers. Natural geofibers are environmental friendly and together with a thermoplastic matrix they are also recyclable. Economical aspects are of course important. The ever rising oil price has lead to an increased interest in the use of natural geofibers over the recent years. Drawbacks of natural fibers are sensitivity to moisture, low compatibility to non-polar polymers used as matrix and lack of well defined mechanical properties. The latter is because many parameters (geographic location, climate, soil condition etc.) affect the growth of plants and consequently their properties (may even vary a lot from different locations within the plant). Some typical mechanical data for different natural fibers are shown in Table 1 in comparison to synthetic man-made fibers.

Table 1- Mechanical properties of different natural and conventional fibers.

Fiber	Density (g/cm^3)	Young's modulus (GPa)	Tensile strength (MPa)	Elongation at break (%)
Cotton	1.5-1.6	5.5-12.6	287-597	7-8
Jute	1.3	26.5	393-773	1.5-1.8
Flax	1.5	27.6-46.9	345-1035	2.7-3.2
Ramie	-	61.4-128	400-938	3.6-3.8
Sisal	1.5	9.4-22	511-635	2-2.5
Softwood kraft (spruce)	1.5	18-40	1000	-
Hardwood kraft (birch)	1.2	37.9	-	-
E-glass	2.5	70	2000-3500	2.5
Aramide	1.4	63-67	3000-3150	3.3-3.7
Carbon	1.4	230-240	4000	1.4-1.8

1.5. Composite/synthetic materials for geotextiles :

1.5.1.Kevlar :Woven Kevlar textiles possess the structural dynamics and works better than steel, but with a fraction of its weight. Whether it is working in a plant, or handling sharp edge materials kelwar bring together high strength (5 times stronger than steel) with light weight, and comfort with protection. Kevlar is also made at low temperatures. They are applied as the reinforcement of cement concrete in the form of chopped fibers both for ordinary and autoclave cure types. Kevlar can also be used with other materials as a protective coating.

1.5.2.Polyester - Made from the post consumer waste such as bottles, fabrics, etc. in the composition of polyester ethylene terephthalate, and because of its superior strength and elasticity it is applicable to numbers of geotechnical applications.

1.5.3.Polypropylene - Polypropylene is a famous alternative for geo-grids or geo-matrices, as it is strong and chemically static. Polypropylene is accepted to carry out poor long-term creep behavior but is economical and light in weight.

1.5.4.Phenolic/jute composite - This composite is a strong and abundantly durable, made by the mixing of jute fibers with a phenol based resin binder. Bio-composites such as this one give substitute of making durable, high performance materials whilst applying as few non-renewable as probable. This material is extensively applicable within a range of furniture design applications.

Besides these, many other types of materials may be applied to make geotextiles, according to its applications. Geotextiles are more and more applied in civil engineering works and so their production has new openings to the textile industries. New and various types of geotextiles are made worldwide and are applied in a variety of applications. The majority of geo-fabrics are made from synthetic materials, but there are few uses that require biodegradable, natural materials such as coir or jute. Unlike synthetics, they can absorb and store moisture, their natural flexibility permits them to match directly to soil profile and their bulk provides great productive cover/weight ratio. As natural material, these are well-matched with surrounding vegetation and are easily available with an economical rate. Natural fibers are available in a large quantity in India. They are comparatively economical and can give a cost-effective solution to short span projects. In the coming years, all these factors show bright prospects for geotextiles worldwide.

In the most common reinforcement application, the geotextile interacts with soil through frictional or adhesion forces to resist tensile or shear forces. To provide reinforcement, a geotextile must have sufficient strength and embedment length to resist the tensile forces generated, and the strength must be developed at sufficiently small strains (i.e. high modulus) to prevent excessive movement of the reinforced structure. To reinforce embankments and retaining structures, a woven geotextile is recommended because it can provide high strength at small strains. Geotextiles can be used successfully in pavement rehabilitation projects.
Geotextile interlayers are used in two different capacities-the full-width and strip methods. The full-width method involves sealing cracks and joints and placing a nonwoven material across the entire width of the existing pavement.

Geotextiles have been used in construction of gravel roads and airfields over soft soils to solve these problems and either increase the life of the pavement or reduce the initial cost. The placement of a permeable geotextile between the soft subgrade and the granular material may provide one or more of the following functions, (1) a filter to allow water but not soil to pass through it, (2) a separator to prevent the mixing of the soft soil and the granular material, and (3) a reinforcement layer to resist the development of rutting. The reinforcement application is primarily for gravel surfaced pavements. The required thicknesses of gravel surfaced roads and airfields have been reduced because of the presence of the geotextile. There is no established criterion for designing gravel surfaced airfields containing a geotextile.

1.6. Advantages

Geosynthetics, including geotextiles, geomembranes, geonets, geogrids, geocomposites and geosynthetic clay liners, often used in combination with conventional materials, offer the following advantages over traditional materials:

- **Space Savings** - Sheet-like, geosynthetics 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. Geosynthetics on the other hand are relatively homogeneous because they are manufactured under tightly controlled conditions in a factory. They undergo rigorous quality control to minimize material variation.
- **Construction Quality Control** - Geosynthetics 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** - Geosynthetic materials are generally less costly to purchase, transport and install than soils and aggregates.
- **Technical Superiority** - Geosynthetics have been engineered for optimal performance in the desired application.
- **Construction Timing -** Geosynthetics 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 geosynthetics are deployed sequentially, but with a minimum of stagger between layers, allowing a single crew to efficiently deploy multiple geosynthetic layers.
- **Material Availability -** Numerous suppliers of most geosynthetics and ease of shipping insure competitive pricing and ready availability of materials.
- **Environmental Sensitivity** – Geosynthetic systems reduce the use of natural resources and the environmental damage associated quarrying, trucking, and other material handling activities.

1.7. Geotextile Polymers - Almost all geotextiles available in the United States are manufactured from either polyester or polypropylene. Polypropylene is lighter than water (specific gravity of 0.9), strong and very durable. Polypropylene filaments and staple fibers are used in manufacturing woven yarns and nonwoven geotextiles. High tenacity polyester fibers and yarns are also used in the manufacturing of geotextiles. Polyester is heavier than water, has excellent strength and creep properties, and is compatible with most common soil environments.

1.8. Geotextile Structures - There are two principal geotextile types, or structures: wovens and nonwovens. Other manufacturing techniques, for example knitting and stitch bonding, are occasionally used in the manufacture of specialty products.
Nonwovens:
Nonwoven geotextiles are manufactured from either staple fibers (staple fibers are short, usually 1 to 4 inches in length) or continuous filaments randomly distributed in layers onto a moving belt to form a felt-like "web". The web then passes through a needle loom and/or other bonding machine interlocking the fibers/filaments. Nonwoven geotextiles are highly desirable for subsurface drainage and erosion control applications as well as for road stabilization over wet moisture sensitive soils.
Wovens:
Weaving is a process of interlacing yarns to make a fabric. Woven geotextiles are made from weaving monofilament, multifilament, or slit film yarns. Slit film yarns can be further subdivided into flat tapes and fibrillated (or spider web-like) yarns. There are two steps in this process of making a woven geotextile: first, manufacture of the filaments or slitting the film to create yarns; and second, weaving the yarns to form the geotextile. Slit film fabrics are commonly used for sediment control, i.e. silt fence, and road stabilization applications but are poor choices for subsurface drainage and erosion control applications. Though the flat tape slit film yarns are quite strong, they form a fabric that has relatively poor permeability. Alternatively, fabrics made with fibrillated tape yarns have better permeability and more uniform openings than flat tape products.

Chapter 5
Geofiber for EPS concrete reinforcement

Chapter 6
Geotextile-reinforced asphalt pavement