Use of Geo-Synthetics in Soil Reinforcement/Road constructions

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Abstract -*Geo-synthetics is a generic term for all synthetic materials used with soil, rock and/or any other civil engineering related material and become an integral part of a man-made construction and structure. From last few years geo-synthetics have joined the list of traditional civil engineering construction materials. In this paper we describe the use of geo-synthetics in soil reinforcement with special emphasis on road constructions.*

***Keywords*:** Geo-synthetics, reinforcement, road constructions, synthetic materials, construction materials.

1.INTRODUCTION

Geo-synthetics is a generic term for all synthetic materials used with soil, rock and/or any other civil engineering related material as an integral part of a man-made construction, structure. Natural or artificial product that is used along with soil in geo-technical and civil engineering constructions. Natural product like coir, jute, hemp etc. and artificial geo-synthetics product like polymeric or metallic. Geo-synthetics is also called by filter fabrics, plastic filter, engineering etc. The most common use of geo-synthetics is in road construction. Geo-textiles increasing stability and improve performance of weak sub grade soil primarily by separating the aggregate from the sub-grade.In only few years, geo-synthetics have joined the list of traditional civil engineering construction materials. Often the use of geo-synthetics can significantly increase the safety factor, improve performance, and reduce cost in comparison with conventional construction alternatives.

Sharma et al. (2014) investigated the application of geo-textiles in pavement drainage systems. They described that the geo-textiles are the permeable fabrics which, when used in association with soil have the ability to separate, filter, reinforce, protect, or drain. Typically made from polypropylene or polyester, geo-textile fabrics come in three basic forms: woven, needle punched, or heat bonded. The original and still sometimes used term for geo-textiles is filter fabrics. Geo-textiles have many applications and currently support many civil engineering applications including roads, airfields, embankments, retaining structures, reservoirs and construction site. Geo-textiles have a major role in construction of paved roads over areas having high ground water table. **NIZAM et al. (2014)** explained that the geo-textile as the tremendous invention of geo technical Engineering. Geo textiles are generally used with foundation soil, rock earth or different geotechnical engineering related material. Geo textile plays a significant part in modern technical textile. The use of geotextile in transportation application becomes more popular in modern civil engineering sector. Geotextiles are used in civil engineering earthworks to reinforce of soil, to construct firm bases for temporary and permanent roads and highways, to line ground drains, so that the soil filters itself and prevents soil from filling up the drainpipes and to prevent erosion. **Khalid et al. (2004)** explained the geo-textile in transportation applications and also explain the role of geo-textiles in modern pavement design and maintenance techniques. The main focus in their paper is on better understanding of this relatively new tool available to the transportation engineer. The paper provides an overview of the current geo-textile technologies and highlights the functions geo-textiles perform in enhancing the performance and extending the service life of paved roads. Three key application areas of geo-textiles, construction of pavements, in asphalt concrete overlays and for drainage systems along with impetus on the current design methodologies available in geo-textile design and selection are addressed. **Agrawal (2011)** described geo-textiles, a newly emerging field in the civil engineering and offer great potential in various areas of applications globally. Geo-textiles also play an important role in modern pavement design and maintenance techniques. The growth in their use worldwide for transportation applications in particular, has been nothing short of phenomenal. Geo-textiles are ideal materials for infrastructural works such as roads, harbors and many others.

2. Detailed Description of Geo-synthetics

Geo-synthetics can be categorizes as: geo-textiles, geo-grids, geo-nets, geo-membranes, geo-cells, geo-composites, geo-foam, geo-synthetics clay liner (GCL), pre-fabricated vertical drains (PVD). The important characteristics of geo-synthetics such as Physical properties includes specific gravity, weight, thickness, stiffness, density; Mechanical properties includes tensile modulus, bursting strength, drapability, compatibility, flexibility, tearing strength, frictional resistance; Hydraulic properties includes porosity, permeability, permittivity, transitivity, soil retention, filtration length; Degradation properties includes bio-degradation, hydrolytic degradation, photo degradation, chemical degradation, mechanical degradation; Endurance properties includes elongation, abrasion resistance.

Geo-textiles : It is a permeable, planar, polymeric textile product in the form of a flexible sheet. Geo-textiles were one of the first textile products in human history. Excavations of ancient Egyptian sites show the use of mats made of grass and linen. In other wards a geo-textiles is a permeable textile used with foundation, soil, rock, earth or any other geo-technical engineering-related materials as an integral part of a human made projects or construction. It is used for separation, drainage, filtration, erosion control and reinforcement.

Geo-textile is porous and allows flow of water through it and most used geo-synthetics.

Types of geo-textiles: (1) woven (2) non- woven (3) knitted (4) stitch-bonded.

Woven geo-textiles: they are made from yarns (made of one or several fibers) by conventional weaving process with regular textile structure. Large numbers of geo-synthetics are of woven type, which can be sub-divided into several categories based upon their method of manufacture. As their name implies, they are manufactured by adopting techniques which are similar to weaving usual clothing textiles. A geo-textiles produced by interlacing, usually at right angles, two or more sets of yarns (made of one or several fibers) or other elements using a conventional weaving process with a weaving loom.

It is uniform and regular interweaving of threads or yarns in two direction. it is regular and visible construction pattern. It is have high tensile strength and relatively low strain. These can be used to increase the load – carrying capacity of soil.

Non - Woven geo-textiles: They are made from directionally or randomly oriented fibers into a loose web by bonding with partial melting, needle punching or chemical binding agents (glue, rubber, latex, cellulose derivative, etc.). It's no visible thread pattern. They have high strain and stretch considerable under load.

Knitted geo-textiles: They are produced by inter looping one or more yarns together, with a knitting machine.

Stitch-bonded geo-textiles*:* They are formed by the stitching together of fibers or yarns. Geo-textiles in which fibers or yarns or both are interlocked/ bonded by stitching or sewing.

Functions: soil separation, reinforcement, load distribution, filtration, drainage, but non-woven is not used for reinforcement.

Geo-grid: geo-grids made by extrusion, weaving or welding process. Extrusion products (oriented geo-grids) are made of polyethylene or polypropylene (PP). Weaving geo-grids are made of polyester coated with PVC, latex or bitumen. Welded bonded geo-grids by attaching strips of fibers at junction. It is made of polymer materials, such as polyester, polyethylene or polypropylene.

Geo-grids are classified into the following two categories based on the direction of stretching during their manufacture: **uniaxial geo-grids**– they are made by longitudinal stretching of regularly punched polymer sheets and, therefore, possess a much higher tensile strength in the longitudinal direction than in the transverse direction. it is used as reinforcement layer as embankment and retaining wall.

Biaxial geo-grids– they are made by both longitudinal and t transverse stretching's of regularly punched polymer sheets and, therefore, possesses equal tensile strength in both the longitudinal and the transverse directions. It is used in road base, below rail way track and soil reinforcement.

Functions: soil separation, reinforcement, load distribution, filtration, drainage and erosion control. Geo-grids are commonly used to reinforce retaining walls, as well as sub bases or subsoil below roads or structure.

Geo-nets - Geo-netsare planar, polymeric product consisting of a regular dense network of integrally connected parallel sets of ribs overlying similar sets at various angles. At first glance, geo-nets appear similar to geo-grids; however, they are different from each other, not mainly in the material or their configuration, but in their functions. Consists of rib in two directions and apertures are of diamond shape. Thickness of geo-nets is longer than of geo-grids.

Functions: soil separation, reinforcement, filtration, drainage and erosion control.

Geo-membrane - Geo-membraneis a continuous membrane type barrier/liner composed of materials of low permeability to control fluid migration. The materials may be asphaltic or polymeric or a combination thereof. The term barrierapplies when the geo- membrane is used inside an earth mass. The term lineris usually reserved for the cases where the geo-membrane is used as an interface or a surface revetment. Thick impervious plastic sheets and thickness is 5 mm to 3 mm approximately. It is contain liquids and gases. It is made by polypropylene, polyethylene and PVC.

Functions: soil separation, protection (landfill lining, canal lining, tunnel lining) and erosion control.

Geo-synthetics clay liner (GCL): GCL are manufacture by sandwiching within bentonite within or layer it on geo-textile and/or geo-membrane bonding the layers with needling, stitching and/or chemical adhesives. Is a woven fabric-like material and it is primarily used for the lining of landfills. It's having similar behavior of geo-membrane and geo-synthetic, which incorporates a bentonite or other clay, which has a very low hydraulic conductivity. It is self repair mechanism.

Functions: soil separation, protection, reinfocement and erosion control.

Geo-foam: It is expanded polystyrene (EPS) or extruded polystyrene (XPS) manufactured into large lightweight blocks. The blocks vary in size but are often 2 m x 0.75 m x 0.75 m. The primary function of geo-foam is to provide a lightweight void fill below a highway, bridge approach, embankment or parking lot. EPS geo-foam minimizes settlement on underground utilities. It is also used in much broader applications, the major ones being as lightweight fill, green roof fill, compressible inclusions, thermal insulation.

Geo-cells: Geo-cells are also called Cellular confinement systems, or CCS's. It is used in civil engineering for roadway load support, walls and steep slopes, channel protection and erosion control. They are typically made from ultrasonically welded high density polyethylene strips and expanded on-site to form a honeycomb structure which is subsequently filled with sand, gravel, locally available soil, or concrete

Geo-composite: It is a term applied to the product that is assembled or manufactured in laminated or composite form from two or more materials, of which one at least is a geo-synthetic (geo-textile, geo-grid, geo-net, geo-membrane, or any other type), which, in combination, performs specific function(s) more effectively than when used separately.

Geo-natural: a product manufactured from natural fibers (jute, coir, cotton, wool, etc.) having a short life span when used with soil, rock and/or other civil engineering related materials.

Polymers in geo-synthetics: All geo-synthetics products except for the natural products are made of polymers. A polymer consists of many parts joined through links. Each part is called a monomer. The polymers generally used as raw materials for geo-synthetics are polyester (PET), polypropylene (PP), polyethylene (PE) (very low density polyethylene (VLDPE), medium density polyethylene (MDPE), and high density polyethylene (HDPE)), chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), poly-amid (PA), polyvinyl chloride (PVC), expanded polystyrene (EPS), extruded polystyrene (XPS), etc. It is increases molecular weight results in, higher tensile strength, higher impact strength. Based on cross-linking, polymers are divided into two categories: thermo plastic and thermo set.

Geo-synthetics were introduced to the Indian engineers by the Central Board of Irrigation and Power (CBIP), New Delhi in 1985 by organizing the first National Workshop on Geo-membranes and Geo-textiles.

Table: 1 Primary functions of geo-synthetics

Type of geo-synthetics (GS)	Separation	Reinforcement	Filtration	Drainage	Containment
Geo-textile(GT)	X	X	X	X	
Geo-grid (GG)		X			
Geo-net (GN) or geospacer(GR)				X	
Geo-membra					X

ne (GM)					
Geo-synthetic clay liner(GCL)					X
Geo-foam (GF)	X				
Geo-cells (GL)	X	X			
Geo-composite (GC)	X	X	X	X	X

3. APPLICATION/ ADVANTAGES/DISADVANTAGES OF GEO-SYNTHETICS

Geo-synthetics are versatile in use, adaptable to many field situations and can be combined with several traditional and new building materials such as

- Non-corrosiveness and highly inert to biological and chemical degradation.
- Long-term durability under soil cover, high flexibility, minimum volume, robustness and lightness.
- Factory-produced to have specific quality controlled standards and they do not exhibit the inherent variability of naturally occurring materials.
- Ease of storing, transportation, simplicity of installation, even by unskilled personnel and ease in control of execution.
- Rapid installation, even in adverse environmental conditions and thus speeding up the construction process useable, even with unsuitable soils.
- Replace soil/mineral construction materials – conserving scarce resources cause less wear and tear on equipment.
- Available in a wide range of products, in numerous configurations and weights, to perform a wide range of functions when placed in soils have capacity to solve even those problems which cannot be solved by traditional techniques.
- Make technically effective and economical solutions (the cost should be estimated to include the initial construction cost, continuing maintenance cost, cost related to production losses, in the case of roads as a result of their closure, etc.).
- Provide environment-friendly and energy-efficient solutions, thus allow for sustainable development.
- Improved performance of structure and provide good aesthetic look to structures.
- The manufactured quality control of geo-synthetics 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 low thickness of geo-synthetics, as compared to their natural soil counterparts, 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 geo-synthetic 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 from many publication sources as well as universities which teach stand-alone courses in geo-synthetics or have integrated geo-synthetics in traditional geotechnical, geo-environmental, and hydraulic engineering courses.
- When comparing geo-synthetic designs to alternative natural soil designs there are usually cost advantages and invariably sustainability (lower CO_2 footprint) advantages.
- Long-term performance of the particular formulated resin being used to make the geo-synthetic must be assured by using proper additives including antioxidants, ultraviolet screeners, and fillers.
- The exposed lifetime of geo-synthetics, being polymeric, is less than unexposed as when they are soil backfilled.
- Clogging of geo-textiles, geo-nets, geo-pipe and/or geo-composites is a challenging design for certain soil types or unusual situations. For example, loess soils, fine cohesion less 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 about which much has been written.

4. ANALYSIS

Geo-synthetics is use full for landfill, embankments, retaining wall, steep slopes, erosion control, sub-base support like roads base, rail ways tracks, container yard, sub-grade separations, base reinforcement, overlay stress absorption, overlay reinforcement. It is easy to transport, any fill material can be used, all round confinement to soil. Geo-synthetics in sub surface drainage: sub-grade dewatering, road base drainage and structure drainage. Geo-synthetics in erosion control and sediment control construction: slope protection, channel protection and coastal protection.The other way for soil stabilisation is by using conventional geo-synthetics e.g. geo-strips, geo-textile, geo-grid, etc. and natural fiber materials. However, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering.

In roadways, a separator keeps the base aggregate and the sub-grade from mixing. A geo-synthetic performs the reinforcement function when it contributes a tensile force within the soil mass. A geo-synthetic performs the cushion/protection function when it alleviates or distributes the stresses and strains transmitted to the material to be protected.

Textiles are not only clothing the human body but also our mother land in order to protect her. Extensive awareness should be created among the people about the application of geotextiles. Geotextiles are effective tools in the hands of the civil engineer that have proved to solve a myriad of geotechnical problems. To explore the potential of geotextile more researches are needed in this field.

5. CONCLUSION

Geo-synthetics can stabilize the road sub-grade and reinforce the road base aggregate by contributing two important functions: Membrane action- the ability of a geo-synthetic material to reduce and spread stress arising from the weak sub-grade and lateral restraint, sometimes called confinement - restraining lateral movement of both the aggregate and the sub-grade, improving the strength and stiffness of the road structure. In this case the geo-synthetic acts primarily as a separator between the soft sub-grade and the aggregate. A geo-synthetic that survives construction will work as a separator, base reinforcement with the addition of an appropriate geo-synthetic. Soil-Geo-synthetic-Aggregate (SGA) system gains stiffness via "confinement" of the aggregate, overlay stress absorption overlay reinforcement. While special asphalt mixes can be specified and thicker overlays improve performance, a geo-synthetic interlayer can be placed over the distressed pavement prior to the overlay to create an economical, long-lasting overlay system.

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