International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 04 | Apr 2023 www.irjet.net p-ISSN: 2395-0072

"Study of Geosynthetics and use of Non – Woven Green Geocomposite Blanket for Erosion Control and Slope Protection for Embankment"

Sanjiw Kumar

Student, M. Tech Transportation engineering, SRCEM (PALWAL) INDIA

Abstract – *Geosynthetics are versatile material made of either natural or artificial fibers like jute, coconut, hemp, coir or synthetic polymeric fibers. Geosynthetics have application in Geotechnical Engineering, Marine Engineering, and Environmental Engineering. Geosynthetic used with soil improve it strength by modifying its properties. In geotechnical, engineering Geosysthetics have a number of application like – soil reinforcement for MSE wall, Slope stabilization, and improve bearing capacity of weak sub – soil, drainage, Erosion Control, soil stabilization. Geotextile, Geogrids, Geocomposite, Geocells, Geonets, Geomembranes, Geofoam, Pre – Fabricated Vertical Drain are main eight type of Geosynthetics.*

The primary functions of a Geosynthetics are Reinforcement, Separation, Filtration, Drainage, Barrier Protection, and Surficial Erosion Control. However, in some cases the Geosynthetic have dual function. Geotextile, Geocell and Geocomposite blanket are mainly use for Erosion control element for Embankment of railway & highway and Landfilling side slope protection. Embankment slope erosion and failure due to rainfall & wind is one of the most difficult problem in Geotechnical Exposed soil surface of road embankments side slopes subjected to impact of raindrops and wind velocity that creates detachment of soil particles, this cause Erosion Therefore, we need to protect the soil and slope with environmental friendly and sustainable product.

Key Words: Geosynthetics, Geotextile, Geocells, Geocomposite, Erosion Control, Slope Stabilization, Reinforecement, Filtration, Separation.

1. INTRODUCTION

"Geosynthetics" are made of synthetic and natural fibers. It has high tensile strength, which is used to improve properties of soil in geotechnical engineering, Marine Engineering, and Environmental Engineering. Geosyntheic use with soil for modifying the engineering properties and improve strength of weak soil. Natural and artificial both type of fibers used for geosynthtics manufacturing. Coconut coir, hemp, jute are some natural product used for geosynthetic in India on wide level because India has huge production capacity. Natural geosynthetic like coconut coirmat, jute coirmat and other natural product used in india on large scale , these having application as reinforcement for low – volume road, erosion control element for embankment slope, act as barrier for small reservoir.

- Natural: Coir, Jute, Hemp (Cannabis sativa)
- Artificial: Polymeric and metallic.

The long and short-term properties of geosynthetics depends on the polymer, which is used to make geosynthetic.. Polyester and polypropylene are the most widely used synthetic polymers, followed by nylon and polyethylene.

Permeable geosynthetic made of textile materials is called geotextile. Geotextiles aremade by weaving together a variety of different types of fibers and threads to create flat, textile-like structures (Holtz et al, 1997). Staple fibers, which are shorter filaments, may be long filaments, very long thin type of a polymer, between 20 and 150 millimeters in length. In most geotextiles, nonwoven and woven materials make up the bulk of the material. Nonwoven textiles are made by continuously extruding, spinning, blowing, or otherwise depositing synthetic polymer strands or filaments on a moving belt. After the filaments have been mechanically entangled by a bed of needles or heat-bonded, the nonwoven mass is either needle-punched or heat-bonded.

It is possible to employ Geosynthetics for filtration and drainage as well as separation and strengthening. Geotextiles, which functioned as filtration layer in coastal and riverbank area, prevent soil from entering riprap and other armor materials. Low-permeability soils may drained using geotextiles or geocomposites as drainage medium. In order to keep the design thickness and integrity of the highway intact, geotextiles are employed as separators between the road foundation materials and the soft subgrade. As a structural material, geotextiles and geogrids may utilized to strengthen a soil matrix by increasing its tensile strength.

1.1 Types Of Geosynthetics:

Geosynthetics may categorized into many groups depending on manufacturing process. According to International Society of Geosynthetics, they are classified into following:

1. Geotextile
2. Geogrid

3. Geonet
4. Geomembrane
5. Geopipe
6. Geocell
7. Geofoam
8. Pre – Fabricated Vertical Drain
9. Geosynthetics Clay Liner
10. Geocomposite.

1. **GEOTEXTILE:** Geotextiles are the primary geosynthetic to be introduce into the engineering use along with the soils. Geotextile is a sheet like product, which are either natural or, artificial used for various purpose. Geotextile are permeable, allow to pass the water through, hence it act as separation & filtration layer. Other application are drainage, erosion control sheet for slope & sub soil and reinforcement. Synthetic fibers make them textiles in the conventional sense. Because of their inability to decompose, they have a longer expected useful life.
   Now a day very high strength geotextile are manufacture up to 700KN/m. Although the level to which geotextiles are permeable to liquid flow varies widely, all geotextiles are porous to some degree.

   The geotextile are available in GSM (Grams per square). There are two type of Geotextile:
   a. Woven Type Geotextile
   b. Non – Woven Geotextile

2. **GEOGRIDS:** Geogrids, which are polymers molded into an open, grid-like pattern, have large spaces between the machine's individual ribs and across the machine directions. The geogrid having large opening so, have excellent interlocking with aggregate media or soil when the geogird are sandwiched between these materials layer. Stiff polymer geogrids generate a mechanically stabilized layer inside the soil and thereby increase its load-bearing capacity. Vertical loading cause lateral shear that have prevented by the grid's apertures, which contain or confine aggregate or soil particles.
   Geogrid has classified as uniaxial and biaxial:-

   a. Uniaxial Geogrid – The plastic sheet stretched in longitudinal direction for production of uniaxial Geogrid. It possess high tensile strength in longitudinal direction, used mainly as reinforcement.
   b. Biaxial Geogrid – This geogrid possess equal tensile strength in both direction – longitudinal and transverse, because it stretched in both direction longitudinal and transverse. These are also use as reinforcement and erosion control system

3. **GEONETS:** Geonets are also a planner product and having structure like geogrid consist of filament in two direction longitudinal and transverse but their aperture openings are of shape like diamond. The filament of geonet is two directional and two planner. Geonets are also known as Geospace sometimes. These are used for liquid transport; the major function of a piping system is to drain into the in-plane drainage zone. The main application of Geonet are – Erosion Control and Drainage.

4. **GEOMEMBRANE: Geomembrane** is polymeric sheets that are impermeable to liquids, are often utilized as linings and coverings for storage facilities **i.e.** landfills, reservoirs, canals, and other containment structures. As a result, the fundamental role of the barrier is always one of containment. In addition to geo-environmental applications, the number of applications in geotechnical, transportation, and hydraulic engineering is steadily increasing.

5. **GEOPIPES:** Geopipes are polymeric pipes having a strong wall. It has wall of two type – solid and perforated based on requirement. Geopipe are used to drainage and transportation purpose of liquids or gas, oil and other liquid. A geotextile filter has be used to cover the perforated pipe in certain situations. The geopipe have huge application in wastewater transportation (Sewage transportation) because it is highly sustainable in chemical action of sewage.

6. **GEOCELL:** Geocells are three – dimensional structure it is manufactured by welding ultrasonically the perforated HDPE sheet hence when expanded in field this make honeycomb like structure act as cellular confinement system. This open honeycombed structure may be filled with soil /granular material, concrete ans other material make it as reinforced hence the bearing capacity and manoeuvre ability on loose or weak subsoil base increased. Geocell is also known as **Cellular Confinement Systems (CCS).**

   Geocell are made of HDPE sheet having thickness about 1 -1.2mm and 1 – 1.5mm for plain and textured type respectively, the welding is done through of height having interval of 300 mm – 450mm to get honeycomb like shape when expended.

   Geocell have applications in construction like canal lining, embankment reinforcement for highway & railway embankment and erosion protection system for slope surface, slope stability.

7. **GEOFOAM:** When a polymer expands, it creates "foam," which is made up of numerous closed, gas - filled cells. The unexpanded polymeric substance is what gives cell walls their skeletal structure. In most cases, the result is a stack of massive, but highly light, blocks that might use

as lightweight fill in a wide variety of situations. Polystyrene is the major type of used for manufacturing of geofoam.

8. **PRE – PERBRICATED VERTICAL DRAINS (PVD):** The prefabricated vertical drain having shape of long flat tube, it is made of a core inside surrounded by woven or non-woven Geotextile. In cross section of a pre-fabricated vertical drain consist of an outer core of a geotextile that acts as a filter and there is an inner core that acts like the drainage medium. In addition, this inner core could be made of in the simple PVDs, it could be just a corrugated plastic sheet, plastic core or in more complicated systems.

   For construction of structures on soft cohesive soil, strata require ground improvement. For this type of ground improvement our intention to prevent bearing capacity failure or to avoid excessive total and differential settlements for foundation. The soft soils with very low bearing capacity because of their lower shear strength, in this condition for improving the bearing capacity of soil and removing the excess water present inside the soil mass Pre – Fabricated Vertical drains is used. The PVD accelerates consolidation of soft soil. For construction of subgrade & foundation on very soft clay, cohesive soil, saturated soil PVD are used.

9. **GEOSYNTHETIC CLAY LINERS (GCL):** These are made by sandwiching the geomembrane with two geotextile at both side. Geosynthetic clay liners (GCL) are key material having primarily application in landfills. GCL are also of polymeric and natural according to their base component. Sometimes for GCL manufacturing bentonite is use in core surrounded by geotextile by help of chemical adhesives and needling.

10. **GEOCOMPOSITES :** "Geocomposite - Combination of two different type of Geosynthetics" Combining geotextiles and other materials in a prefabricated unit has known as geocomposite. An ideal geocomposite should be able to provide a range of services including containment as well as the ability to filter and drain water. Prefabricated vertical drain, Drainage composite is example of geocomposite, this consist of two part – inner core and outer filtration layer:

    a. Inner core – may be Geonet and other corrugated plastic sheet.
    b. Outer core – Geotextile.

1.2 Properties of Geosynthetics.

The performance and characteristics of geosynthetics depends in its application. , for different application have different function. The performance of geosynthetics depends on various factors - amount &rate of stress applied, temperature, duration to expose to sunlight.

The Geosynthetics tested for various properties. There are following properties of Geosynthetics:

a. Physical Properties
b. Mechanical Properties
c. Degradation Properties
d. Endurance Properties

The main objective of testing are:

a. For identification of product.
b. For selecting the suitable product as per design requirement and standard.
c. For quality control during manufacturing.
d. Quality assurance during application stage.

Properties of Geotextile: There are following properties of Geotextiles:

1. **Physical Properties**: Physical properties are fundamental properties. These are:-
   a. Specific Gravity
   b. Thickness
   c. Mass per unit area
   d. Stiffness.
2. **Mechanical Properties**: mechanical properties are basically strength of textile , these are:-
   a. Compressibility
   b. Tensile strength
   c. Burst strength
   d. Fatigue strength
   e. Tear test
   f. Impact test
   g. Puncture test
   h. Pullout test
   i. Friction behavior
   j. Impact test.
3. **Hydraulic Properties**: hydraulic properties are very important because of its application in drainage, filtration, and permeability. these are:-
   a. In – Plane Permeability

b. Cross – Plane Permeability
c. Long Term Permeability
d. Gradient Ratio
e. Apparent Opening Size.

Properties of Geogrids: There following physical and Mechanical properties:

1. Aperture opening & percent open area - This defines the interlocking Properties when have application as reinforcement with material like (earth & aggregate).
2. Thickness of ribs and junctions.
3. Numbers of ribs per meter length
4. Mas per unit area (unit weight).
5. Tensile strength – This is very important when geogrid used as reinforcement layer.

   Tensile strength = (Peak tensile load * no of ribs pert meter width)/ No. of ribs.
6. Interface frictional strength in shear and pullout.
7. Connection strength between facing blocks and Geogrids.

Properties of Geomembrane: Geomembranes having application in landfills and fluid flow barriers. There are following test has conducted on Geomembranes:-

1. Thickness.
2. Density
3. Tensile strength &elongation
4. Permeability
5. Peel test on seams
6. Shear test on seam

1.3 Functions of Geosynthetics.

The function of a geosynthetic in any given field application is a major factor in the choosing of the type. There are number of function of geosynthetics, are following:

1. R – Reinforcement
2. S – Separation
3. F – Filtration
4. D – Drainage
5. B - Barrier
6. P – Protection
7. E – Surficial Erosion Control

1. **Reinforcement**: Adding geosynthetics to a soil mass improves the soil's mechanical characteristics, which in turn enhances the reinforcing function. Reinforced soil is a composite material that has both strong compressive and tensile strength when it is coupled with soil. In order to keep the soil mass stable, the geosynthetic (mainly Geogrid) is used as soil reinforcement act as tension member attached to the soil/fill material counterbalance the tensile stress by frictional force and interlocking, or confinement.

   Reinforcing characteristics of Geosynthetics use for roads & railway embankment, road & airstrips pavements, roadside slopes, earthen retaining wall etc. The use of geosynthetic in India are for roads as well as water works departments in charge of embankment protection.

   The Government Agencies like - NHAI, PWD, BRO, Water Works Dept., etc. or the concessionaires/contractors suggesting the use of Geosynthetics in their designs.

2. **Separation**: Separation function is advised for geosynthetics in any application where nearby soil and/or fill materials need to be separated during construction and over its projected service life. Grain fill and soft soil cannot mixed together, and this is why geosynthetics are used. For keeping soil fines out of the granular sub-bases and tracks, a geotextile layer might utilized. It could also use to keep granular particles out of the soil subgrade. One of the most common uses of geosynthetics is to use a geotextile to provide separation of two layers with different soil properties.

   Separation is the placement of a flexible geosynthetic material, like a porous geotextile, between dissimilar materials so that the integrity and functioning of both the materials can remain undisturbed or even improved.

3. **Filtration:** Geosynthetic acts as a filtration layer to preventing intermixing and washing of material when subjected to water flow through. A geosynthetic may use as a filter to keep soil particles from moving over its plane during the application in condition, allowing for appropriate fluid flow.The filtering mechanism also aids in the separation of different substances. However, depending on the volume of fluid and the degree to which it affects geosynthetic selection, a difference may made between filtration and separation functions. However, if water seepage is not a problem, then the isolation becomes the most important feature.

4. **Drainage:** As long as the geosynthetic remains in place and does not enable soil particles to migrate across its plane to any of the application's many outputs, it is considered to be performing the drainage function. Water from the backfill is collected and transported to the retaining wall's weep holes by a geosynthetic layer

next to it. Allowing water to flow in and over the geosynthetic allows excess pore pressure to dissipate as it filters and drains.

5. **Fluid Barrier:** A geosynthetic acts as a nearly impermeable membrane to restrict the passage of liquids or gases form one place to another. Geomembrance, thin film Geotextile, Geocomposite, clay liners are used as fluid barrier.

6. **Protection:** The protection is normally provide by using thicker non-woven geotextiles, geocomposite clay liners. The protection function relates to including a protective geosynthetic for strength or resistance to surrounding conditions as part of a geocomposite in a situation where the material used to provide a major function. Geocomposites such as GCLs (Geosynthetic Clay Liner). Other key products catering to the protection function are Geotextile Tubes and Geobags for embankment protection from river/sea water, as well as Geonets and Polymer Gabions in retaining walls.

7. **Erosion Control:** The geosynthetic acts to reduce soil erosion caused by rainfall impact and surface water runoff. For example, temporary geosynthetic blankets and permanent lightweight geosynthetic mats has placed over the exposed soil surface on slopes. Geotextile silt fences has used to remove suspended particles from sediment-laden runoff water. Some erosion control mats are manufactured using biodegradable wood fibres.

2. EROSION CONTROL AND SLOPE PROTECTION OF EMBANKMENTS

Water, wind, and gravity all have a role in soil erosion, which is the process by which the soil's topsoil is lost to the environment. The two forms of soil loss, geological and rapid, are distinct. All terrain is subject to soil erosion, which is a normal. Exposed soil surface of road embankments side slopes subjected to impact of raindrops and wind velocity that creates detachment of soil particles. Therefore, we need to protect the soil and slope with environmental friendly and sustainable product.

The embankment of highway has provided with side slope of 1(V):2(H) or, 1(V):1.5(H) for stability of embankment. The slope are subject to erosion by various natural forces like rainfall, and Wind Strom. For stability of road structure, the control of soil and water is most important. Proper provision of drainage and landscape development IS require for erosion control; here we discuss the methodology for implementing for erosion control and slope protection work.

2.1 Erosion Control and slope protection with use of Non – Woven Green Geocomposite Blanket with Vegetation

Use of erosion control blanket made non-woven geo composite blanket from natural coconut fiber and reinforced with UV stabilized HDPE polymer net to control soil erosion & protect the slope of highway embankments.

Materials:

- Providing specially designed Non-Woven geo composite blanket made from natural coconut fibre (85%) reinforced with UV stabilized PP/HDPE polymer nettings (15%) with minimum opening of 2mm is suitable for performing all functions related to natural geo textile.
- Slope length greater than 10-mtr requires two side polymer netting blanket with minimum tensile strength of 7.5 kN/m in longitudinal direction and 1.5 kN/m in transverse direction.
- The minimum nominal weight of the blanket should be 650GSM and thickness 7-8 mm.
- Blanket shall supplied in a roll of width not less than 2m with a length suitable to slope length of the embankment.
- The product approximately contains 500-510gms of coconut fibre and 90-100gms of PP/HDPE per Sqm.
- 'GIU' shaped hook size 12"X3"X12" made of hardened spring steel with a diameter of 3.8mm to 4mm and skillfully sharpened on the edges.

Benefits of Erosion Control Green Geocomposite Blanket:

- Create favourable condition for growing plant & vegetation
- The coconut fibres are biodegradable, after decomposition adds organic material to insert soils which act as manure for growth of plant & vegetation.
- The fibres of blanket absorb water and maintained moisture in low rain areas.
- UV stabilized PP/HDPE polymer nettings provide high tensile strength as well as resistance to tear.
- The process for installation is easy, not require much skill labour and machinery.
- Degradation of blanket takes very long time (2 – 3 year), during this the plant creates a root system to control the erosion.

Non – Woven Green Geocomposite Blanket's Specification:

- 600GSM, with Brown PP thread netting stitched both sides with opening size of (9mm X 9mm).
- For slope length =< 10 mtr, minimum tensile strength of two sided polymer netting blanket is 4.0 kN/m in longitudinal direction and 1.0 kN/m in transverse direction.
- For slope length >10 mtr minimum tensile strength of two sided polymer netting blanket is 7.5 kN/m in longitudinal direction and 1.5 kN/m in transverse direction.
- Coconut Fiber Erosion Control Blanket Specification Sheet consist of:
  - 100% Coconut Fiber.
  - Polypropylene net.
  - Polypropylene Netting is Photodegradable.
  - Size of opening of PP netting – 9 mm x 9 mm Dimensions: width – 2.4 m, Length – 50m, Thickness – (7- 8cm), Mass – 590-620 gm.
- **Vegetation:** After Laying of Blanket Vegetation is very important – Vetiver grass is use, which have much potential for erosion control because of its complex root system. This Grass require lesser water, maintenance and any type of soil is suitable for its growth.

Installation Methodology:

There are Following Step for installation of Coirmat at site for Slope Protection work:

1. Purpose of providing green Blanket or Equivalent over embankment slopes of 1(V):2(H) is soil retention and enhancement of surface stability. Site dressing of slope shall carried out by removal of unwanted material & vegetation, slope surface dressing, outspread a layer of suitable soil mix with manure and add one kg /sqm of organic soil conditioner.
2. Marking of trenches of size 300mmx300mm or higher size on outer edge of embankment and top edge of the slope in which blanket anchored. The trench shall filled with soil of same specification to put weight over the blanket and rammed adequately. Length of the slope depends on the height, degree of inclination and properties soil all as directed in contract.
3. Laying of the Green composite blanket done with overlap of minimum 10mm and metallic hooks (J – hooks) of steel used, J – hook tie at every one-meter interval, the blanket over dressed slopes to hole the blanket.
4. Anchoring shall be done by providing GIU hook 1 No per sqm of size 12"X3"X12" made of hardened spring steel with a diameter of 3.8 mm to 4.00 mm and skillfully sharpened on the edges. Average 1 hook per sqm to hold the blanket shall be provided. 15% of an additional quantity of blanket or equivalent will be required for overlapping and anchoring while calculating the surface slope area for estimation.
5. A mix of hundred grams of native grass seeds like centrums seigneurs are broadcasted per square meter of slope area in two or three installments. Spreading of native seeds or plantation of shrubs, live cutting, grass or creepers if available in close proximity shall carried out during monsoon season.
6. Watering for around 3 months shall be carried out @ 5 ltrs/ Sqm. per day during monsoon season and 7 ltrs/ Sqm. per day in other seasons plantation of seeds. The way of watering shall be suitably engineered to minimize waste of water.
7. Provide total safety and security to the thread slope till vegetation sustains on its own. The treated site should be protected from cattle grazing, littering / toxic materials / inflammable items / throwing garbage and construction waste especially the post installation till vegetation develops.
8. The slope stabilization shall be carried out for five years to ensure growth of vegetation on entire surface of the green geotextile blanket. Any damage to the blanket during the currency of the maintenance period shall be rectified / replaced.

3. CONCLUSIONS

With the help of the above study and analysis the Geosynthetic is versatile material must used in Civil engineering projects. A geosynthetic is a sheet, strip, or three‐dimensional structure formed from a synthetic or natural polymer in geotechnical or civil engineering applications. Geosynthetics are most adaptable and cost-effective material for enhancing soil property. In terms of the services, they serve –

- Erosion control and surface protection.
- Drainage and filtration.
- Reinforcement and stability.
- Separation and surface erosion control.

Geotextiles application are effective treatment in the field of the civil engineer for improving the geotechnical properties of soil to solve geotechnical problems.

Use of Non – Woven Green Geocomposite Blanket:

- For Erosion control and slope protection, we have achieve our objective that develop a complex network of root system and vegetation cover on embankment slope after 1 – 2 year. The coir fibers protects steep surfaces from heavy rainfall, surface runoff with high tensile strength. Geotextiles have permeability property used for prevention of soil movement from migration, and maintaining the water flow without any obstruction.
- The Non- Woven Green Geocomposite Blanket (Coconut coir mat) is able to hold water and moisture for long time for the growth of plant, and it is biodegradable so, after decomposition it act as manure to soil for planation growth
- These are covers unstable slope soil against erosion and promote growth of vegetation for make protective ground covers. The hairy texture of coconut fibers helps hold the seeds and soil together. This having along life so, can It can support up to 3 years.
- The organic matter Promotes vegetation growth.
- Water absorption in low rain areas, hence suitable for the region with low precipitation.
- Vetiver has wide range application for any type of soil and any climatic conditions. It can survive in extreme dry weather after proper growth once, such as in dry areas in Rajasthan and other place. During flood, submergence it hold soil particle by extreme root system. Temperature range from - 22oC to 60oC is acceptable for vetiver.
- Easy to install for any contours and ground slope for soil surface.

REFERENCES

[1] Aditi Virupaksh Khurd, Nitin Ravindra More, Vishwajeet Vilas Narnawar, Darshana Rajendra Patil, Shruti Dilip Lokhande, "Soil stabilization using coconut coir", May 2021, DOI: 10.13140/RG.2.2.36178.89284 .

[2] G.S.Jadhav, S.S.Salunkhe, K.S.Patne, S.H.Khandekar, M.B.Ghorpade, "REVIEW PAPER ON-GEOSYNTHETICS", Oct. 2019, International Research Journal of Engineering and Technology (IRJET)Vol. 6.

[3] Office of the Textile Commissioner Ministry of Textile Government of India, "Study on Developing Measures to Promote the Use of Geosynthetics in India", Dec.2013

[4] ALAO, OLUKAYODE OLAWALE, "USE OF GEOSYNTHETICS IN ROAD CONSTRUCTION (CASE STUDY – GEOTEXTILE)", Sept.2011, DOI: 10.13140/RG.2.1.4259.1204.

[5] Hamed Niroumand, Khairul Anuar Kassim , Amin Ghafooripour , Ramli Nazir "The Role of Geosynthetics in Slope Stability" Article in Electronic Journal of Geotechnical Engineering , ,(2012). Vol. 17 [2012], Bund. R, (2740 – 2747)

[6] Prof. K. Rajagopal (Department of Civil Engineering IIT, Madras) NPTEL Lectures , "Geosynthetics and Reinforced Soil Structures:.