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Use of Various Geosynthetics in Improving Engineering Properties of Soil

Tajamul Islam¹, Berjees Qadri², Syed Muntaha³

Assistant Professor, Department of Civil Engineering, SSM College of Engineering, Kashmir, India¹

B.E Student, Department of Civil Engineering, SSM College of Engineering, Kashmir, India²

B.E Student, Department of Civil Engineering, SSM College of Engineering, Kashmir, India³

ABSTRACT: This paper presents a research study on the concept of geosynthetics in civil engineering. This study is about geosynthetics and reinforced soil structures and it will cover the different concepts of the geosynthetics and the reinforced soil structures along with some case study examples. So the brief outline of this study is learning about some basic introductory remarks followed by the historical background of the geosynthetics and reinforced soil structures and then the different types of geosynthetics and their functions and their applications. The objective of this study was to investigate the use of geosynthetics in soil and to summarise its performance results compared to the unreinforced soil. The paper commences with a summary of applications of geosynthetics in day to day life. It was found that the soil Geotechnical industry is moving more and more towards the use of geosynthetics for civil, geotechnical, and environmental engineering applications. The duration of the service life of geosynthetics and their cost-effectiveness compared to other available alternatives are the main reasons for their alternatives are the main reasons for their use in geotechnical and environmental industries.

KEYWORDS: Geosynthetics, Reinforced soil, Polymers.

I. INTRODUCTION

A geosynthetic product could be either a natural product or an artificial product that is used along with soil in geotechnical constructions. Some of the natural materials are coir, jute, hemp and other similar products. India is especially very strong in producing jute products and the coir products, both of which are employed extensively in several parts of India especially for erosion control applications and for low volume road reinforcement and so on. The artificial materials are the manufactured geosynthetics or the polymeric or metallic type.

The question may arise why geosynthetics? Well these geosynthetics are recently introduced into the civil engineering field and the introduction of the geosynthetics have entirely changed the way the geotechnical engineering is practised. We can come out with very innovative solutions that could not have been done just a few years back even 20 or 30 years back and we can solve very difficult problems at a very economical cost and expediently at a very reasonable speed. These geosynthetics, they enable the use of local materials that is the local soil or some other local aggregate and local materials that lead to sustainable solutions and lead to more economical and more sustainable and faster solutions. The most important factor in the geosynthetics is we can use unskilled labour. For countries like India where we have very large labour force, this is actually a boon because the use of geosynthetics means that we don't require highly skilled labour and the installation of the geosynthetics also does not require any heavy machinery as we can do them with very light machinery or even sometimes just with manual means.

II. APPLICATIONS OF GEOSYNTHETICS

Coir is very widely used in India and probably India is the leading producer of coir geotextiles in the world. The coir is a very ideal material for promoting the vegetation growth because the coir being a natural product, it degrades with time and as it is degrading, it produces the nutrients that are necessary for the growth of vegetation. The other advantage is that whenever there is rainfall, the coir retains the moisture and it supplies the moisture to the plants for a very long time. So because of both the reasons, first the provision of moisture for a longer time and second the nutrition, the vegetation can take root very easily. One of the examples of the application of geosynthetics is for the rehabilitation of a coastline in Tithal, Gujarat near an ancient temple called Swaminarayan Temple. Because of the extreme ocean currents and the wave conditions, the coastline has come very close to the temple and no amount of treatment, be it using boulders or any other forms of treatment could stop the sea erosion. The final solution that was given was just simply lining the coastline using stones put in a rope net gabion and giving some training works at the

bottom so that the beats can build up. The main advantage that we gain is that just by encasing the boulders inside a rope net gabions which are all tied together, no amount of wave force or current force can dislodge them because about 200 to 300 meters stretch of this structure is monolithic making it very strong and stiff and able to survive the severe ocean environment. Let's take an example of the construction of a 22 metre high retaining wall using geosynthetics. This particular application is actually in the city of Vijayawada near a ghat road leading up to a temple and to the top of a hill. This ghat road is very narrow. When it was constructed about 50 to 60 years back, there was not much traffic as most people used to walk or go on bicycles and didn't require a very wide road. Now since everybody is driving cars, a wide road is required and the only way that this road can be widened is by filling up the entire area on the left with soil. As the construction of a normal reinforced concrete retaining wall is not possible because of the height being too much (22 metre), so the solution that is provided is by using geosynthetics. Another example of the application of geosynthetics is for the construction of a landfill to contain highly toxic jerosite waste in the city of Visakhapatnam. The length of this landfill is nearly 100 to 200 metres and the width ranges from 100 to 150 metres. This entire landfill was constructed using very innovative techniques. Normally the landfills are constructed below the ground level but in this case, the ground could not be excavated because of the rocky strata and had to be entirely built above the ground level. The material used for the construction of this embankment was the jerosite granules. The jerosite granules which are otherwise a waste product could be used for construction of this embankment by putting in some geosynthetic reinforcement.

All these examples that we saw could not have been possible just a few years back.

III. REINFORCED SOIL

The reinforced soil is nothing but the soil with reinforcement. Some of the ancient reinforcement products i.e. some 2000 to 3000 years back, people have used the reinforcement in the form of tree branches, grass reeds, straw, the roots of vegetation, bamboo, tree trunks and so on. In the ancient times, people even built very high towers and very tall structures using soil along with some form of reinforcement. Some of the modern reinforcement products are steel, polymeric materials, natural materials like coir and jute. The reason why we require to use the reinforcement in soil is that the soil is very strong in compression i.e. if we apply pure compression stress on the soil it can take any amount of compression but unfortunately because of the Poisson's ratio, if we apply compression in one direction, there is tension in the other direction. Hence the soil being very weak in tension, it starts failing and undergoes quick failure. Therefore the combined product of soil and reinforcement is a very good synergetic combination and has much better engineering properties than the individual constituents, thus being able to provide very strong and stiff soil so that we can build any structures using that type of material. The concept of reinforced soil is very similar to that of the reinforced concrete.

IV. HISTORICAL APPLICATIONS OF THE REINFORCED SOIL

Before we talk about the human beings, we require to talk about this wonderful animal called Beaver which is very common in North America and in some parts of Europe. It is actually a semi-aquatic rodent i.e. it moves on the land but likes to live below the water. Beaver has been building obstructions/dams across the river or across the small water bodies in order to build its dwelling at a very deep depth. It uses twigs and similar type of things and soil in an excellent engineering manner for building its nests strong enough to not get destroyed easily. Because of this, Beaver is thought about as the first civil engineer. In many countries they issue stamps with Beaver and many of the civil engineering societies have Beaver as their logo.

There are several historical places with a good evidence of the application of the soil reinforcement concepts in the ancient past. About 3000 years back, in the present day Iraq in Baghdad city, there was a very famous temple, Ziggurats of Mesopotamia, whose original height was said to be nearly 80 metres high and now it is at 40 metres high. This entire structure was built using clay bricks each of about 130 to 400mm high and interestingly it was reinforced with woven mats of Reed laid horizontally and a layer of sand and gravel at vertical spacing of about 0.5 to 2 metres. The concept is very similar to the concept of the reinforced soil structures that we employ now. These reeds were also used to form plated ropes approximately 100 mm diameter to encompass the entire structure as an enveloping thing to keep the entire structure together. So this could be thought about as one of the early applications of the reinforced soil.

In China we have this Great Wall of China that was built during the 7th century B.C to about as recent as 17th century. They had employed the soil reinforcement concept for constructing this tall structure.

Adobe bricks are very good examples of the use of reinforced soil concept. These bricks are mostly manufactured in North Africa in the rural areas where it is a traditional practice to mix some small fibres with the bricks. Similar bricks are also used by Incas and Aztecs in North America and South America. In rural India, it's very



common to see the use of bamboo mats and other things for construction of the mud walls, so it's another example of the application of reinforced soil for human habitation.

Basically, the word geosynthetic came into being only in the 1970's. But in the past 100 years, the geosynthetics have been employed. In the 1920's, in South Carolina where they have lots of forests, they used the car dry mats for constructing temporary access roads. Terzaghi himself has used filter fabrics for construction of filters. In Japan, polyvinyl bags were used instead of straw bags for construction of sea walls. In Netherlands, geotextile tubes have been used for construction of dykes to keep the sea water away from land. In Europe, polymer meshes/membranes have been used to contain industrial wastes.

INVENTION OF THE CONCEPT OF REINFORCED SOIL

The concept of the Reinforced soil or the Reinforced earth is attributed to a French engineer called Henry Vidal who actually reinvented the concept of Reinforced soil. The manner of its invention is very interesting; while playing with his children at a beach trying to construct a sandcastle, he noticed that on putting some small reeds and roots, he was able to build higher castle. This is how he got an idea that we can put in more permanent materials for construction of very high soil structures. He did a lot of pioneering research work in his laboratory using the steel strips as reinforcement product and some metallic sheets to contain the soil at the front and he took out a patent and he called it as Reinforced earth and he started his own company called Reinforced Earth which is very popular in several countries. This is how the reinforced soil concept has come into engineering being and is extensively used in almost all the countries in the world.

PRINCIPLE OF REINFORCED SOIL

When the soil is not confined, on applying some compression stress the soil undergoes tensile strength in the other direction but if we put in some internal reinforcement layers, because of the tensile strength that is mobilised in the reinforcement layers and the frictional force that is mobilised along the surfaces of the reinforcement layers, the soil gets confined and exhibits higher strength. In the absence of the internal reinforcement we require very stiff structure on the outside of the reinforced soil to provide some lateral confinement.

BRIEF IDEA ABOUT THE TYPES OF GEOSYNTHETICS

A lot of people have a misconception that the geosynthetics are nothing but geotextiles because originally when it started all the products were textile products and most of the applications are related to geotextiles and so all the products whether they are geomembranes or geogrids, they were all bunched under geotextiles and even the name of the International Society was "International Geotextile Society" when it started in the late 70s and early 80s. But then towards the late 80s and early 90s people started questioning about not having a more generic name because we have number of products like the geotextiles, geogrids, geonets, and geomembranes. Thus the name was changed to "International Geosynthetics Society".

The different type of geosynthetics have their own graphical symbols proposed by the International Geosynthetics Society. Starting from geotextiles indicated by dashed lines, the geomembranes by a solid line, the geogrid by a solid line with a number of dots, the geocomposite drain by two lines with hexagon all over, the geonet by a number of X marks, the geocomposite clay liner by two parallel dash headlines with hatches, the geosynthetic erosion control mat having a crimped surface, the geocell providing the 3D confinement with a number of vertical lines, the geomat with a crested and troughed surface, and then more recently we have the electro kinetic geosynthetics wherein we pass some electrical current to change the properties of the soil. Using these symbols makes it easier to identify any product.

DIFFERENT FUNCTIONS OF GEOSYNTHETICS

The letter symbols for different functions of geosynthetics:-

- B: - Barrier against the fluid flow.
- D: - Drainage that allows free flow of water through the geotextile or the geosynthetic material.
- E: - Surficial Erosion Control product.
- F: - Filtration allows the water to flow but not fine soil particles to escape.
- P: - Protection of geomembranes or some other materials.
- R: - Reinforcement.
- S: - Separation i.e. to separate out the different materials inside geotechnical structure.

Separation function in a pavement layer: - The aggregate layer is separated from the subgrade soil by a geotextile separator. The purpose of the separator is to prevent the intermixing of the aggregate material with the soft



soil below and to prevent the piping. Because of these two aspects the strength of the aggregate is preserved for a much longer time.

Filtration function of geosynthetics: - The placement of geotextile which has some specific openings in them allows the water to come out from the ground but it doesn't allow the fine soil particles to escape from the ground, thus preventing the piping of the fine soil particles and hence subgrade can retain the strength for a very long time even if there is a lot of moisture in the ground like in the form of rain or the surface water.

Surface erosion protection function of geosynthetics: - Wherever we have a slope and there is a rainfall, the surface soil starts getting eroded which can be prevented by slowing down the water and by reinforcing the soil using some surface erosion protection mats.

Drainage function of geosynthetics: - Drainage is the flow of water along the length of the geotextile or a geogrid or a geoproduct or through the thickness of a thick geosynthetic product like a geonet or a geotextile. The rainwater entering into the pavement can smoothly flow into the side drains without entering the subgrade. As the problem with the soil is that as long as the soil is dry, it will have a very good strength but once it is mixed with water, we have the problem of the pore pressure and the reduced effective stress reducing the strength of the soil. Being able to drain the water out from the pavement without the water entering into the subgrade with the help of geosynthetics, we get a stronger subgrade and a good road surface for a very long time.

DETAILED STUDY ABOUT THE TYPES OF GEOSYNTHETICS GEOTEXTILES

Once again we are listing the geotextiles first because there were the first engineering products that were introduced into the Civil Engineering. The geotextiles are engineered sheet like products made of natural or synthetic materials. These are of two types; one is the woven product and the other is the non-woven product. The woven product is similar to the textiles that we wear and similarly there are some other varieties which are known as non-woven products, for example, the carpet that we have in our house. Some of the examples of the applications of the geotextiles are separation, drainage, filtration, erosion control and reinforcement. Nowadays the geotextiles are made with very high strength of as high as 700 KN/m i.e. a metre wide geotextile product can support a weight of 700 KN or 70 tons.

Fig 1.1 shows the microscopic photographs of a woven product and the non-woven fabric. In the woven fabric, the weave pattern is clearly visible whereas in the non-woven fabric, the fibres are randomly oriented don't have any preferential direction.

Very thin geotextiles can be used as a separator or as a filter whereas the thick geotextiles (as thick as 10 mm to even 15 mm) are used for drainage purpose or as cushion especially when constructing a landfill with geomembranes. These landfills are to contain some hazardous industrial wastes or chemical wastes and as we don't want the plastic geomembrane to get punctured, so a thick geotextile is put below that geomembrane as a cushion. One of the examples of the application of geotextiles is Konkan railway where the tracks used to sink into the ground because of the heavy rainfall making the soil below the track very soft and because of the pumping action. When the trains go at a very high speed, they develop a lot of pore pressure and once the pore pressure builds up in the soil it comes out at a very high speed bringing along with it all the fine soil particles. Now if we line this soil surface with a geotextile, it not only provides strength to the track but also prevents all the fine soil particles from coming out of the ground and thus prevents the piping action. In fact, after the use of geotextile the train speed was increased in this particular section where the trains were run at a very low speed of 10 to 20 km/hr earlier because of the problems of the track but once the stretch was reinforced, the speed was brought back to the to the original design speed of about 100 km/hr.

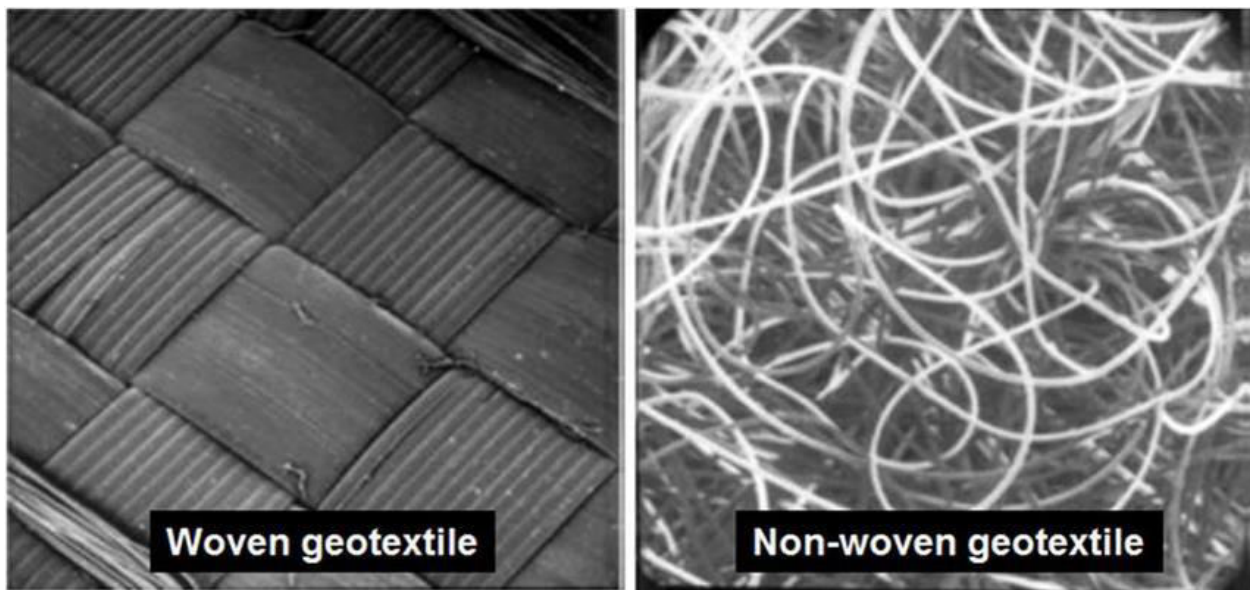


FIG 1.1

GEOGRIDS

The geogrids are also planar products but unlike the geotextiles, they have very large openings or apertures. Geogrids have excellent interlocking with the soil and aggregate. Typically, they can be made with very high tensile strength. Because of the open nature of the geogrids, they cannot be used as a filter layer or directly as a separator. They are mostly used as reinforcement products below the pavements or below the railway tracks or for construction of steep slopes and high retaining walls. These geogrids are of several varieties:-

Extruded Geogrids:- Geogrids having very low strength like the Netlon India Products that were made in the 80's

Stretched Geogrids:- Geogrids having very high strength and durability like the Tensar UK Products where they pioneered the polymeric technology for the manufacture of geogrids.

Recently there are other varieties of geogrids made by knitting process or welding process and so on.

In terms of the preferential strength directions there are:-

Uniaxial Products: - They are used as reinforcement layers where reinforcement is required only in one direction, for example, behind the retaining walls or for construction of steep soil slopes.

Biaxial Products:- They have almost equal strength in both the predominant directions, i.e. longitudinal and transverse directions and these products are used below the road bases or below the railway tracks or for general ground improvement.

One of the examples of application of a geogrid is for construction of the landfill at Hindustan Zink factory in Vizag, Visakhapatnam.

Now we have a new product that is just introduced in the market that is called as Triax. Triaxial products have strength in all the radial directions. As in case of biaxial products, there are only two preferential directions, one longitudinal and other lateral whereas the load may be distributed in some other directions also. In order to take care of that type of situation, we have the Triax grids.

Another example of application of very low strength geogrids is for coastal protection in Navi Mumbai near Vashi Railway Station where the land was subjected to erosion due to the ocean currents and the tidal actions. This is one of the earliest applications of geosynthetics in India using very low strength geogrids.

GEONETS

The geonets are also planar products and very similar to geogrids and also consist of ribs in two directions but their aperture openings are not square or rectangular in shape but they are more of diamond shaped. The major difference between the geonets and the geogrids is that the ribs in the two directions are in two different planes in case of geonets whereas both of them are in the same plane in case of geogrids. The thickness of a geonet is much larger than that of a geogrid because the function of a geonet is very much different from that of the geogrid. The geonets are sometimes also called as geospaces because we require to create some space in some situations so that there is a free flow of water.

The geonets are mainly used for erosion control because the ribs are very thick and act as small check dams to slow down the surface run off and once the rainwater surface run off is slowed down, it reduces the erosion potential of the



water, thereby reducing the surface erosion of the soil. The geonets can also be used as excellent drainage layers because due to the thickness of the geonet, the soil in between the small diamond shaped opening is not very highly compacted giving some path for the water to flow through. One of the examples of application of a geonet is the geonet made of polymeric row(boulder net) used in the Konkan Railway in the Western Ghats whose main function is to act as a boulder and as a guide for the loose boulders so that they don't fall into the railway track. As most of the Konkan railway is formed by cutting very deep gorges and the train passes through a very narrow gorge, when the boulders come loose during heavy rainfall, they fall into the railway track which has led to several accidents in the past few years. Thus, the purpose of the boulder nets is to guide the loose boulders to fall into a trap that is on both sides of the railway track.

GEOMEMBRANE

Geomembrane is very commonly used for construction of landfills or for lining the canals or some other water retaining structures. The geomembranes are thick impervious plastic sheets and typically their thickness can vary anywhere from 0.5 mm to almost 3 mm. The geomembranes are used to contain liquids or the gases. The geomembranes are of several varieties - A rough textured geomembrane and a smooth textured geomembrane

The geomembranes are used in landfill linings and as canal lining materials. They can also be used in the tunnels to prevent the rainwater from flowing through the tunnel or to prevent moisture from coming into the tunnel.

GEOSYNTHETIC CLAY LINERS

Geosynthetic clay liner is an additional protection member that we have in the landfills. They consist of a core of a bentonite clay that is sandwiched between two layers of thick non-woven geotextiles and this is applied below and above the geomembrane in a landfill. Because of the provision of the GCL, there could be a self-repair mechanism because when there is some damage in the geomembrane, the fluid starts flowing and once the dry bentonite powder that is placed in a geosynthetic clay liner comes in contact with the fluid, it expands. On expansion, it can close the openings and we call as self-repair mechanism.

GEOCELL

The geocell is different from all the other products. It has a three dimensional effect on the soil i.e. it can provide some confinement because it has number of openings. Geocell is more of a honeycomb structure wherein we take thin sheets of a plastic product similar to geomembrane and then weld it at several places along the length. These plastic sheets are ultrasonically welded and entire thing comes in a collapse form in small rolls. Once these rolls are taken to the site, they can be expanded and on expansion, pockets are formed. The pockets can be filled with soil to construct road base or several other things. When the geocells first came into the market, they were made of plain plastic sheets very similar to the geomembrane without any openings or any rough surface. The recent geocells are made either with a corrugated surface so that they have a very good interaction with the in filled soil or with some openings so that the geocell layer can also act as a drainage layer.

Some of the advantages of geocells are that these are easy to transport because they come in a collapsed form and don't occupy much volume. Once these geocells are taken to the site and expanded, we can cover very large area of as wide as about 4 metres and as long as about 10 metres. The second advantage is that we can use any fill material in the geocells. Also because of the all-round confinement that is given to the soil, it forms a semi rigid layer providing a very stiff support to the loads that we apply and spreading the load over a very wide area, thus reducing the pressures that are transmitted into the subgrade. Such good load dispersion reduces the settlements and the bearing capacity failure in the foundation soil. The geocell layer can also provide excellent support even under cyclic loading, for example, under railway tracks or under high speed highways. Some of the typical applications apart from the load carrying functions, it can also be used as an erosion control product or for the construction of steep slopes and retaining walls and as a sub-base support. It can be used in road bases or railway tracks or for the construction of the container yards. The main advantage of the geocells is that at a very low confining pressure, it provides excellent lateral support and because of that the soil behaves like a very stiff material.

GEOCOMPOSITES

Geocomposites are the combination of different types of geosynthetics taking advantage of the specific properties of each geosynthetic. These are of several varieties. The prefabricated vertical drain is an example of a geocomposite wherein we use a geotextile as an outer filter and inner core could be geonet or some other form of a corrugated plastic sheet. Taking an example of a geocomposite made by the combination of a geotextile and a geogrid, a geotextile has excellent separation and filter properties whereas the geogrid has excellent strength and stiffness, so combining both of them can provide the reinforcement action, drainage action, and the filter action. Therefore depending on the manufacturing process and on the materials that we use, geocomposites can be made to provide multiple functions.



GEO-OTHERS

There are several other geosynthetics that are known as geo-others.

I. Geodrains

Geodrains are plastic pipes with perforations. Once they are buried in soil, they can act as drains because through the perforations in the pipe, the rainwater or the water in the soil flows through the pipe and gets collected in some place from where it can either be pumped out or stored as a source of water.

II. Lightweight Fills

We have a number of varieties of lightweight fills, especially the lightweight fills made of polystyrene, expanded polystyrene and so on.

III. Geopipes

Geopipes are very similar to geodrains.

IV. Geotextile Bags

The geotextile bags can be used as soil encapsulation. For construction on a very soft soil, we can use very large geobags by putting in the aggregates or soil and encapsulating the soil. The entire thing can act as a rigid mat.

V. Gabions

The gabions can be either made of steel wire mesh or rope nets and so on.

VI. Geosynthetic Encased Stone Columns

The geosynthetic encased stone columns are of more recent origin and are used for forming stiff columns in soft clays. These are traditionally employed by geotechnical engineers for supporting the flexible structures like oil storage tanks or roadway embankments. If the stone columns are constructed in extremely soft clays, the main problem is that there is not sufficient confinement given by surrounding soft clay, because of which the column may not develop adequate strength to support the applied load. Also in most of the cases, the stone column acts as excellent drainage medium but when there is extremely soft clay all around the stone column, it can contaminate the stone column aggregate and clog all the openings in the stone column. When the aggregate materials, which otherwise have very good shear strength by their own, get contaminated, they will have very highly lubricated surfaces resulting in the loss of shear strength of the aggregate. Such problems can be easily overcome by encasing the stone column by a geosynthetic in the form of a geotextile or a geocomposite. The advantages that we gain is that some additional confinement to the stone column is provided, the contamination of the stone column material by the surrounding place is prevented and the formation of the stone column is made easier.

Also there are many other possibilities that are left to the imagination of engineers and every few months or few years, we see a new application of geosynthetics in a very innovative manner for construction in difficult soil conditions. Some of the latest trends that we have in the geosynthetics are the application of geosynthetics for vacuum consolidation of soft clay, encased stone columns, and electro kinetic geosynthetics.

POLYMERS IN GEOSYNTHETICS

All the geosynthetics except for the natural products (coir and jute) are made of polymers. The word polymer itself is derived from Greek language. "Poly" means many and "meros" means parts. So basically a polymer consists of several individual parts known as monomers which are all joined together to produce a polymer. The type of polymer differs in the way the monomers are linked together. The molecular weight of a polymer is the degree of polymerization i.e. the number of monomeric units packed into one unit of polymer, multiplied by the molecular weight of the monomeric units. The increase molecular weight results in higher tensile strength, higher impact strength, higher stress crack resistance and better heat resistance. So basically we can produce a geosynthetic with as much molecular weight as required to produce a geosynthetic that has sufficient strength. In other words, we can always design the required geosynthetic to have properties that are required for our field application. The polymers differ from each other by the manner in which the number of repeating units are linked together. There are nearly 50,000 varieties of commercially available polymers. The bonds within the polymer molecules are due to Van der Waal's forces or the permanent dipoles or hydrogen bonds. The bonds between the molecular chains are due to cross linking by covalent bonds. Based on the way the different monomers that linked together, the polymers are divided into two fundamental categories - Thermoplastic and Thermoset polymers

The thermoplastic polymer is the one which can be repeatedly heated to its softening point and made into desired shapes and cool to preserve the shape. We can repeat this process as many times as required whereas the thermoset polymer is the one which cannot be repeatedly heated. It can only be done once and if tried to reheat the thermoset polymer, it just simply degrades. Most of the geosynthetics are made of thermoplastic type of polymer. Some examples of the thermoplastic polymers are the polyethylene, polypropylene, and polyester and some examples of the thermoset polymers are butyl, nitrile, and EPDM.

MANUFACTURE OF GEOSYNTHETICS

The different polymers that are used for the manufacture of geosynthetics are all of thermoplastic variety including polyethylene, polypropylene, polyester, polyvinyl chloride, nylon, and polystyrene. The first two types are extensively used for manufacture of geogrids. In the early days, most of the geogrids of extruded and stretched type were made of polyethylene and polypropylene. The polyester is coming into being and is extensively used for manufacture of geotextiles and geomembranes. The PVS's are used for manufacture of the geopipes or geomembranes.

There are two quantities that are frequently used for indicating the quantity of material that is used-Denier and Tex. The Denier is the weight in grams of 9000 metres of yarn. The Tex is the weight in grams of 1000 metres of yarn.

GEOTEXTILES

The yarns are made into textiles using two different methods, one is the weaving process and the other is some type of bonding process. The geotextile that is made by weaving process is called as a Woven geotextile. Most of the high strength geotextiles are of woven type. There are different types of weaving patterns of the woven geotextiles: -

1. Plain weave: - This is the common weave that we find in textiles like in the form of shirts or pants, etc. These all have a plane wave pattern and are also called as one up and one down type of weave because continuous yarns are weaved together to fabricate the textile.
2. Basket weave: -Two or more warp are taken under filling yarns to fabricate this fabric.
3. Twill weave: - A diagonal yarn is introduced to get different shapes. This type of weave has a higher thickness because wherever there is a junction or intersection, the fabric used is slightly higher to bring a twill pattern.

The other types of geotextiles are known as Non-woven geotextiles. The fibres in case of nonwoven geotextiles are bonded together and this bonding happens in three different methods: -

1. Melt or heat bonded: - The fibres are spread on a roller and joined by melting at crossover points. We produce relatively stiff geotextiles by this process. When the polymeric fibres are heated, they melt and the bonding is established by melting. Calendaring process is done to achieve a smooth finish by passing the geotextile through hot rollers. The heat could be different for different type of polymers to achieve a smooth finish.
2. Resin bonded: - In case of the resin binding, we spray some acrylic resin to bind the fibres.
3. Needle punched: - In the needle punching process, a bunch of fibres are knit together to form the continuous mass. This process is used for fabricating non-woven textiles of large thickness and a large mass.

GEOGRIDS

Another class of geosynthetics that are extensively employed are the geogrids. The geogrids are manufactured by extrusion, weaving or welding process. The extruded products are made of polyethylene or polypropylene, usually having oriented molecules. The woven geogrids are made of polyester fibres and coated with PVC's, latex or bitumen to stabilise them against UV light and to protect the fibres against installation damage. The welded geogrids are made by attaching the strips of fibres at junctions.

Extruded and Stretched Geogrids

The extruded and stretched geogrids are manufactured by stretching a 4 mm to 6 mm thick polymeric sheet and punching holes at regular pattern. This sheet is drawn uniaxially or biaxially under controlled temperature and strain rate so that it does not rupture in the process of stretching. The draw or the stretch ratio could be different for different types of geogrids. For achieving geogrids of different strength we can vary the stretch ratio. The higher molecular orientation results in higher strength, higher stiffness and also better creep resistance.

GEOCELLS

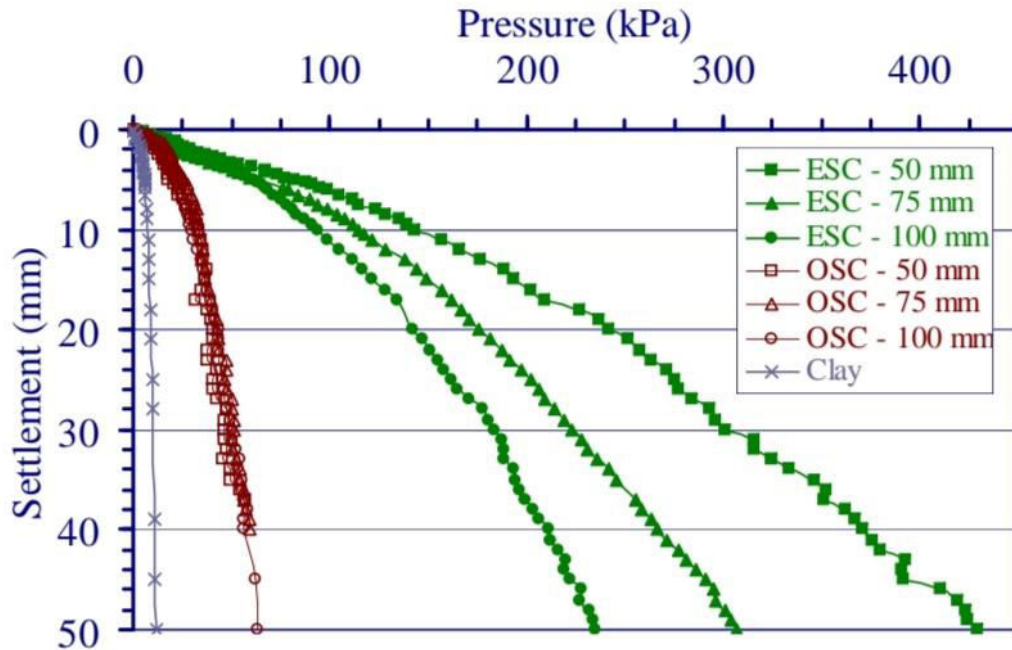
Geocells are manufactured by using plastic sheets usually HDPE sheets or sometimes even the sheets made of polyester compounds. 1 mm to 1.2 mm thick sheets are laid along the length and ultrasonically welded over the full height of the sheet at the distances of 300 to 400 mm so as to get a honeycomb type structure when the cells are opened. The number of strips controls the width of the geocells and the length of the strip controls the length of the geocells.

V. EXPERIMENTAL RESULTS

Here is the test data from the laboratory tests performed on the encased stone columns. It shows the pressure settlement data of the soft clay, the ordinary stone column and the encased stone columns. The soft clay failed at a very low pressure of the order of 10 to 15 KPa. On applying the ordinary stone column, the pressure capacity increased to



nearly 50 KPa. On encasing the stone column in a geotextile, the pressure capacity increased to as much as 400 KPa. Also, we see that as the diameter of the stone column increases, the influence of the geosynthetic reduces because of the reduction in the hoop tensile force reducing the additional confinement given by the geosynthetic.



VI. CONCLUSION

This paper presents the benefits of applying Geosynthetics in soil structures. Therefore, it was revealed that geosynthetic materials are commonly utilized for various dissimilar purposes including drainage, erosion control, filtration, separation, reinforcement, barrier etc. We also realised that geosynthetics is not a new concept but it has been into existence since very long. Only if we had known about their reinforcing action and other applications, the research industry would have been developed already many years ago. Many researches in the world have helped us learn about the significance of geosynthetics in the civil, geotechnical, and environmental engineering. This paper is an effort to give an overview of geosynthetics from every aspect of concern.

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