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A REVIEW OF SOME SIGNIFICANT TRENDS IN GEOTEXTILES

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Abstract

The article comprehensively reviews some significant advances in the field of geotextiles. Geotextiles is an area of the enormous field of technical textiles. Technical textiles have the diverse range of products which will lead the future world market and the researchers from the various field of science and engineering will work together for the development of these textile materials. Among various types of technical textiles, geotextiles possess very important class due to its versatile applications in roads, dams and constructions industries. Geotextiles are the permeable textile materials which mainly used for filtration, drainage, separation, reinforcement and stabilization purposes. Geotextiles is the fastest growing industry and a promising field of technical textiles. Geo synthetics play an important role in many civil engineering applications, especially soil stabilization, railways, coastal structures and water resources. It is often used to achieve economic and technical benefits. Geotextile is one of the types of geo synthetics that is called in American Standards as “A permeable geosynthetic comprised solely of textiles”.

Keywords: Geotextiles, Geosynthetics, Marine Works, Fabrics, Filtration, Technical Textiles, Civil Works.

1. Introduction

Technical textiles are considered to an amazing field in the range of textile science and engineering which have diverse applications in all the sector of science and engineering. The modern age lead by the versatile products of technical textiles. Technical textile can be defined, according to the Textile Terms & Definitions, published by performance properties rather than their aesthetic or decorative to be the fastest growing sector of the textile industrial sector and the global technical textiles market is expected to reach USD 193.16 billion by 2022, according to a new report by Grand View Research, Inc. Global technical textile market demand was 26.58 million tons in 2014 and is expected to reach 35.47 million tons by 2022, growing at a CAGR of 3.7% from 2015 to 2022 [1, 2].

Geosynthetics are used in marine projects, roads, transportation, river embankment, etc. to strengthen and improve their efficiency. The main reasons behind the growth of the geosynthetics industry in recent decades are the development of its basic characteristics such as corrosion resistance, durability, flexibility, ease of storage and installation, environment friendly, resistance to biological and chemical degradation, etc. [3].

2. Exploration of the potential of geotextiles

The leading international trade exhibition for technical textiles, Techtextil (organized biennially since the late 1980s by Messe Frankfurt in Germany and also in Osaka, Japan), defines 12 main application areas such as agrotech (agriculture, aquaculture, horticulture and forestry), buildtech (building and construction), clothtech (technical components of footwear and clothing), geotech (geotextiles and civil engineering), hometech (technical components of furniture, household textiles and floorcoverings), indutech (filtration, conveying, cleaning and other industrial uses), medtech (hygiene and medical), mobitech (automobiles, shipping, railways and aerospace), oekotech (environmental protection), packtech (packaging), protech (personal and property protection) and sport tech (sport and leisure). Among these geotech or geotextiles has widely used all over the world and one of the essential products for civil and construction engineering sector [1]. Any textile materials used in the earth or soil for technical purpose is called geotextiels. The Textile Institute defined geotextiles in Textile Terms and Definitions drainage, separation, reinforcement and stabilization purposes as an integral part of civil engineering structures permeable textiles used in conjunction with soils or rock as an integral part of a manmade project. The economic and environmental merits of using textiles to reinforce, stabilize, separate, drain and filter have already well proven. It is basically employed for temporary roads and yards, permanent roads, repair of permanent roads, railway tracks, embankments in soft ground, drainage applications, sports field construction, retaining walls and erosion control [4-8]. Road construction was the largest application segment in 2015 accounting for over 40% of the market. Geotextiles are increasingly employed in the road construction industry due to their growing awareness of the advantages they provide. Geotextiles are used as a component of the foundation in laying roads, as they are suitable in strengthening soil by holding it together, thus resulting in a longer lifespan of roads. The needs of geotextiles are increasing day by day in developing countries such as China, Russia, India and Bangladesh among others, due to the strong infrastructural development in these countries [9-11].

2.1. Comparative study of natural and synthetic fibers for geotextile applications

In general, man-madefibers, such as polypropylene, polyester, polyethylene, polyamide etc., have lead the geotextile industry, although the advantages of natural fibers should not be ignoreddue to environment friendly, less costly, easily available and ecologically compatible as they are degraded within the soil [12]. Natural fibers are basically used for temporary reinforcements and erosion-control uses of geotextiles. For example, in slope stabilization, natural fibers such as jute, hemp or coir are needed for a relatively short period of time in order to form the root structures after which the geotextile is needed to be decomposed for visual aesthetic reasons. Several researchers have revealed the application of natural fibers including jute, coir, wood, flax and bamboo in various applications of geotextiles such as soil erosion control, vertical drains, road bases, bank protection and slope stabilization [13-23]. In addition, Ranganathan [24] has revealed the merits and possibility of jute-based geotextiles for new products and applications such as super-sod, temporary haul roads, reinforcement fabric in highway construction, wick drains etc. due to their high-water uptake and moisture absorption that builds them suitable materials for such uses. Likewise, the applications of a coir-based geotextile have exhibited a tremendous improvement in the vegetal growth. However, the coir geotextile is degraded because of the microbialaction in the soil in addition to the effect of rain and sun. Lekha has found that coir net retained only 22% of its initial tensile strength at the end of seven months after it was buried in the soil. Similar loss of strength in coir netting was reported by Balan and Venkatappa Rao [25]. Thus, in uses where natural fibres are exposed to microbiological agents and solar radiation, such fibers are seemed to have lost effectiveness [26]. Not only natural fibers but also synthetic fibers such as polypropylene have also showed poor resistance to UV radiation. Likewise, nylon with a higher tensile strength than polyester or polypropylene may tend to be degraded by weathering [27]. However, nylon can resist at least twice the level of abrasion in comparison to polyester or polypropylene fiber [28], but polyester has more abrasion resistance on exposure to UV light, whereas polypropylene fiber has a superior resistance to fatigue-flexing. In roofing uses where by the fabric is placed under higher tensile and flexural stresses and also subjected to abrasion or bursting stresses, polyester fibre with greater tenacity and lesser elongation is further suitable. Polyester fibre is also least affected by acidic conditions or changes in temperature that can occur due to seasonal variations. It can be mentioned that polyester fibre may be employed for tidal-barrage protective devices for the same reasons of resistance to solar radiation and mechanical stresses, in addition to resistance to salt solutions [29]. Besides, polypropylene fibre with lower density leading to better buoyancy characteristics is more suitable for tidal barrages, which are frequently subjected to battering. It can be abridged that fiber can be selected for geotextiles applications on the basis of constructions and environmental demand the difference in pore structure may be found by comparing cross-section photomicrographs. of a continuous filament geotextile and a staple fiber geotextile. The continuous filaments tend to have more order within the cross-section as opposed to the staple fibers, which are random throughout the geotextile. Staple fibers generally have a much tighter pore structure than continuous filaments [30].

2.2 Production of Geotextiles

Conventional fabric production methods are majorly used for manufacturing most of the geotextiles. Production techniques for the fabrication of geotextiles are apparently classified by Giroud into two classes, i.e. classical and special geotextiles. Typical products of textile industries such as woven, knitted, nonwoven fabrics etc. are used in classical geotextiles, but in special geotextiles there are similarities in appearance but not the exact products of typical industries. Net, mat, webbing etc. are applied in special geotextiles [31]. Classical geotextiles are manufactured in two steps, i.e. production of fibres, filaments, slit films (tapes) and yarns and converting these component materials into a fabric. Various procedures of manufacturing these constituent materials used in fabrication of geotextiles are as follows [31]:

2.3 Geotextile Functions

The crucial functions of geotextiles used for pavement applications have traditionally involved separation, filtration, drainage, and reinforcement. Nonetheless, different functions can be done by a certain geotextile product, conversely, various types of geotextile products can perform the same function.In addition to their basic function, geotextiles can perform one or more secondary functions these must also be considered when choosing the geotextile material for optimum performance. For instance, a geotextile can use for separation of two dissimilar soils (e.g., aggregate base and clay subgrade), but it may also use for filtration as a secondary function by reducing the build-up of excess pore water pressure in the soil beneath the separator. A general idea of functions typically done by geotextiles in pavement applications is briefly described below.

2.4 Separation

Between the two soil layers like coarse material and fine soil geotextile acts as a separator. It sets apart the different materials and prevent mixing under application of load. It can be said that preventing pebbles mixing with subgrade and penetrating the barrier is the function of geotextile [32]. Separation is the introduction of a flexible porous geotextile located between different materials so that the integrity and the functioning of both materials remains intact for the life of the structure or is enriched [33]. Application of geotextiles in constructing pavements, intermixing of two adjacent layers is prevented. For example, the major cause of roads and highways failure is constructing over insufficiently strong foundation which gradually gets contaminated by mixing of aggregate base layers with the adjacent soft underlayer subgrade soil. A geo textile is subjected between these two layers which minimizes the contamination of aggregate base by the subgrade, working as a separator

2.5 Filtration

Filtration is defined as the equilibrium of a geotextile-soil system that permits for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration. A common application showing the filtration function is the use of a geotextile in a pavement trench drain. The geosynthetic-soil system should achieve an equilibrium that allows for adequate liquid flow under conditions of consideration. As the flow of liquid is perpendicular to the plane of the geosynthetic, filtration refers to the cross plane hydraulic conductivity or permittivity. Another important property relevant to filtration is apparent opening size (AOS) - the opening size larger than 95% of the geotextile pores, which is compared to soil particle size characteristics. The coarser-sized particles eventually create a filter bridge, which in turn retains the finer-sized particles, building a stable upstream soil structure.

2.6 Drainage

Due to different reasons, liquid and gas can be stocked up gradually. A geotextile material can gather and redirect the liquid or gas towards the vent channel, i.e., the transmission of fluid is in the direction of in-plane flow of fabric without any loss of soil particles [34]. Any geotextile material exhibiting good filtration and permittivity properties can be used in drainage applications [35].

2.7 Reinforcement

When insufficient stability and strength of subgrade soil is complimented, geotextiles with higher tensile strength acts as reinforcement materials. The principle of employing geotextiles as reinforcement is to introduce the geotextiles into the soil structure that increase the cohesion between the grains [36]. This modifies the transmission of the load and the resulting composite is able to sustain higher loads. The forces exerted on the structure as a result of different loads are transferred into tensile stresses, which further influences other mechanical properties, such as puncture resistance [37]. The reinforcement is a complex phenomenon and results from the combined behavior of soil geotextile interactions [38-40]. Reinforcement is the synergistic improvement in pavement strength created by the introduction of a geotextile into a pavement layer. While the function of reinforcement in the U.S. has often been fulfilled by geogrids, geotextiles have been used extensively as reinforcement inclusions, particularly overseas, in transportation applications [41,42]. The reinforcement function can be developed primarily through the following three mechanisms [43]:
Subjecting a geotextile to act as a stress relief layer is referred to protection. Fluid barrier is the ability of a geotextile material to prevent the migration of fluid. Typically, geotextile materials are employed as a fluid barrier in roadways in two ways: when placed beneath a pavement overlay saturating with bituminous material and when placed adjacent to a finer material under unsaturated conditions.

Moreover, Giroud [31] has identified some other functions of geotextiles which are defined below. Surfacing A geotextile works as a surfacing when a smooth and flat ground surface is needed and preventing the soil particles to be eliminated from the soil surface. Solid barrier. A geotextile acts as a solid barrier when it prevents or ceases the motion of solids.

Container

A geotextile acts as a container when it holds or protects the materials such as sand, rocks, fresh concrete etc.

Tensioned membrane

A geotextile acts as a tensioned membrane when it is sandwiched between two materials having different pressures. The principle of using a geotextile is to even out the pressure difference by balancing with the tension of the geotextile.

Tie

A geotextile acts as a tie when it joins various pieces of a structure that is capable of moving apart.

Slip surface

A geotextile placed between two materials by minimising the frictional characteristics of thestructure.

Absorber

A geotextile acts as an absorber when it shares the stresses and strains transmitted to the material that is required to be protected.

2.8 Major Geotextile Applications

In more or less two decades in the construction of railway, highway, embankments and retaining walls, erosion control and drainage geotextiles or geosynthetics have been applied remarkably. Some of them are mentioned below

2.9 Temporary Roads

Maximum construction sites need access to the site through weak surface deposits. Temporary roads are constructed by spreading a carpet of coarse granular material (stone metal) over the soft subgrade to act as a load dispersing medium which retains the stresses on subgrade low. Nevertheless, extensive rutting occurs on the surface due to the granular fill getting lost into the soft subgrade under continuous pressure from the running vehicles. This provides rise to perennial maintenance problems. The problems can be lessened, if not overcome, by using a suitable layer of geotextile at the interface of the granular fill and the subgrade. This not only keeps the thickness of the granular fill intact but the tensile strength of geotextile allows reduction in thickness of the stone filling as well. Effective use of geotextiles has been made in a fabrication yard on soft dredged fill to make the area suitable for movement of heavy cranes for jacket fabrication [44]. A depth of 700 mm of stone aggregate was placed on the soft subgrade with geotextile at the interface. This not only allowed a saving of 200 mm of stone filling but enabled rapid construction of the fabrication yard.

2.10 Permanent Roads

In a permanent roadway application of textile materials not only reduces the thickness of pavement as well as reduces the chances of damage and maintenance necessity in long term use. Geotextile also prevents the stability reduction of the base subgrade by preventing the possibility of water constancy and intent to flow water into the side drains which saves subgrade layers from getting softened and loosen. Geotextiles also defend reflective cracking of the road surface when bituminous surface layer is cracked for maintenance.

A report was published on use of non-woven geotextiles as a pavement overlay to reduce reflective cracking in the runway of the Ahmedabad airport in Gujarat by Tiwari and Ranjan [45]. At the cracked location strips of fabric were placed on a V-shaped groove filled with a bituminous tack coat. Pressuring by heavy rollers a rigid contact was made between fabric and tuck coat. Comparative analysis shows that, in the treated area without geotextile fabric crack appeared within six months, on the other hand, in the fabricated area crack appeared after two years that too on a very minor scale.

In case of railway, to scatter the huge amount of load into the subgrade soil the rail lines are subjected on a gravel layer. For the regular load, the gravels get start to penetrate gradually which requires a regular inspection and replenishment as the same thing happens for the pavement on week subgrade. High performance geotextiles can be used for separating the gravels and equal load distribution on subgrade. As per estimation 2,400 km of track belonging to Indian Railways is founded on weak soil and approximately 300 km of rail track require strengthening every year [46]. Nonwoven geotextiles have been recommended for reinforcement of tracks in Indian Railways.

2.11 Embankments and Retaining Walls

Geotextile is more effectively used for reinforcement in construction of embankments and retaining walls in soft soil. By filling geotextiles horizontally at the base of embankment it is possible to attain an erect side slope and construction can be cost efficient. More importantly, in urban areas, project can be made cost efficient by reducing the land coverage on the both sides of the embankment. By the limit equilibrium methods and considering the fabric tension capacity the slope stability can be analyzed and applied the data to design. Nonwoven geotextiles have been used in Nava-Seva Port near Bombay to stabilize 9 m high guide bunds on soft marine clay [47]. The geotextile was laid on the marine clay at a water depth up to 6 m from a flat-decked barge.

It was covered with a rock mattress and earth filling was done in stages to build up the embankment. The use of geotextiles reduced the quantity of natural rock by 30% and the cost by 50% [48].

2.12 Erosion Control

Application of geotextiles in the erosion control sector is growing fast for attaining short term effects. In this sector the materials are applied in a bit different way that they are laid on the surface and bot buried in the soil. The main objective remains to control erosion and for making more efficient vegetation is established which can control erosion naturally. The geo textile is then residue to requirements and can fertilize the soil by degradation. Geotextile can intersect the running off soil particles and protect the unvegetated soil from natural force like sun, rain and wind. Weeds and newly plant trees can also be inhibited by them. Erosion control can be applied to riverbanks and coastlines to prevent undermining by the ebb and flow of the tide or just by wave motion.

2.13 Global Geotextiles Market

The global market for geotextiles is anticipated to grasp $8.24 billion by 2020, in keeping with a new study by Grand View Research Inc. increased concentration on geotextiles and its uses in roadways and erosion prevention is likely to be a key driver for the development of the market. Besides, increasing regulatory support in emerging countries including India, China, UAE and Brazil is also projected to enhance the demand for geotextiles over the forecast period. Road construction and erosion control were the leading applications of geotextiles together accounting for more than 60% of worldwide demand in 2013. Growing infrastructure spending in Asia Pacific, Middle East and Latin America are estimated to act as strategic features for driving geotextile demand for this use. Road construction is like wise projected to be the fastest rising fragment over the prediction period, at an estimated CAGR of over 9% from 2014 to 2020 [49-51].

Further significant outcomes from the research are stated below:

The world geotextiles demand is expected to reach 4,323 million square meters by 2020 increasing at a CAGR of 8.9% from 2014 to 2020. Asia Pacific was the biggest geotextile end user and is also expected to be the fastest growing regional market over the forecast period, at an expected CAGR of 9.1% from 2014 to 2020. North America is also estimated to observer momentous progress on account of repair and maintenance for the vast road network of the region. European geotextile market profits is estimated to touch USD 1.97 billion by 2020, increasing at a CAGR of 9.6% from 2014 to 2020.

Non-woven geotextiles were the most frequently used geotextiles in 2013, at an expected consumption of 1,561 million square meters. Low cost and extensive application scope make non-wovens the most desired among other geotextiles goods. Knitted geotextile demand is anticipated to reach 279.8 million square meters by 2020, growing at a CAGR of 7.1% from 2014 to 2020. The global geotextiles market is split with the top six companies catering to about 40% of international demand in 2013. Significant companies in the market include Royal Tencate, NAUE, Low & Bonar and Propex among others.

Technical textile products are now going essential for every sector of engineering as well as our practical life. Geotextiles has already been extensively used in various fields of constructions and civil engineering all over the world. The market demand of geotextiles are also increasing tremendously. Currently the product serves some functions such as separation, filtration, drainage, reinforcement and so on. But the range of functions of geotextiles can be enhanced and the product can be made more potential and versatility of applications. In this regard, more research has been required to enhance the performance of this valuable technical textile products.

Nanotechnology can be applied for this purpose and modification of both natural and synthetic fibers as well as novel finishing process can be performed to attain the best desired properties for the diverse and viable practical application of geotextiles.

2.14 Applications of geosynthetics in marine works

There are many types of geosynthetics used in several engineering applications such as; Geotextiles, Geogrids, Geomembranes, Geosynthetic clay liners, Geofoam, Geocells, Geocomposites, and Geonets. Due to the wide range of geosynthetics, they are selected according to the type of functions. Table -1 summarizes the different types of geosyntheticsand their functions to help engineers in selecting the appropriate type of geosynthetic for any project. It is also noted in Table -1 that geotextiles and geo composites cover most of the functions, so they are used in many applications.

Geosynthetics types	Types of applications
Geotextile	Filtration, Seperation, Reinforcement, Drainage, Protection,
Geocomposite	Filtration, Seperation, Reinforcement, Drainage, Containment
Geotextile tube	Protection, Erosion control
Geomembrane	Containment
Geogrid	Reinforcement
Geosynthetic clay liner	Containment
Geocells	Reinforcement, Drainage
Geofoam	Seperation
Geonets	Drainage
Natural fibre Geosynthetics	Filtration, Seperation, Reinforcement, Drainage

Moreover, when selecting geosynthetics, the engineer should be familiar with some of the properties of polymers as they are the main factor affecting the geo synthetics industry. Polyester is very high in tensile strength, unit weight, UV light, melting temperature and cost with low in strain only. Therefore, polyester geosynthetic is recommended for reinforcement applications. On the other side, polyethylene geosynthetic is recommended for separation and filtration applications. However, in the case of many geosynthetics that fulfil the minimum requirements for the required application, geosynthetic should be selected on a cost basis. The aim of this paper in general is to introduce the types of geosynthetics, their functions and important properties, then highlight the geotextile that is commonly used in marine works and summarize its functions, tests, properties, and the minimum requirements stated in the codes and standards that make engineers sufficiently qualified to specify and select geotextile properties that fit for purpose of a particular engineering problem.

3. Overview of Geotextiles

Geotextile is widely used in maritime structures such as breakwater, revetment and shore protection, etc. Generally, geotextile should allow water to flow while retaining the soil. Other coastal applications, such as soil bank reinforcement, depend on the high tensile strength of the geotextile [52].

CEM (2006) stated that the most common use of geotextiles in marine works is as a filter between fine material (e.g., sands or soils) and coarse material (e.g., gravel or small stone) that forms the first layer of coastal structures. For typical usage of geotextile in marine works see Figure -1. Both woven and nonwoven geotextiles are generally used for coastal applications, but woven monofilament geotextiles are highly preferred for coastal structures.

The Textile Institute in Manchester defined geotextiles as "Any permeable textile material used for filtration, drainage, separation, reinforcement and stabilization purpose as an integral part of civil engineering structures of earth, rock or other constructional materials" [53]. Geotextiles are made from either natural fibres or synthetic fibres. The important plant used in natural fibres are jute, sisal, flax, hemp, abaca, ramie and coir, while the raw materials used for synthetic fibres are the polymer families (i.e., polypropylene, polyester, polyamide and polyethylene) [54].

Using the natural fibres in various engineering applications have been investigated and described in many literatures [55-58]. Although the use of natural fibres in the geotextile industry has many advantages (such as; low cost, robustness, availability and environment friendly), its ability to biodegrade makes it used for short-term functions otherthan synthetic fibres [59]. Geotextiles are classified into the following classes based on the manufacturing process [60].

Woven geotextile: A geotextile produced by interlacing, usually at right angles, two or more sets of yarns (made of one or several fibers) using a conventional weaving process.
Nonwoven geotextile: A geotextile produced from directionally or randomly oriented fibers into a loose web by bonding with partial melting, needle punching, or chemical binding agents (i.e. glue, rubber, latex, cellulose derivative, etc.).
Knitted geotextile: A geotextile produced by inter looping one or more yarns together with a knitting machine.
Stitched geotextile: A geotextile in which fibers or yarns or both are interlocked/bonded by stitching or sewing.

The filter function in marine works can be achieved by using granular materials or geotextiles or a combination between them [1].For marine works, many researchers mentioned in their literature that the geotextile filter (either alone or in combination with granular filter) is preferred more than the granular filter alone for the following reasons:

- Easy to install;
- More economical;
- Ensures continuity and uniformity, whether above or below the water level;
- Easy to quality control.

However, it is usually recommended that a layer of aggregate (e.g., granular filter) be placed between the geotextile and the layer of rocks/concrete blocks to prevent geotextile degradation by ultraviolet and to protect it from damage caused by large rocks or blocks. Moreover, it will create a uniform pressure on the geotextile that ensures proper filtration.

3.1 Geotextile Properties and Tests

Most of values of geotextile properties are expressed as a Minimum Average Roll Value "MARV", except AOS. Statistically, MARV is equal to the average (μ) value minus two times the standard deviation Table -2 summarize the basic properties, functions and ASTM standards used to select and specify the geotextiles.

Table -2 summarize the basic properties, functions and ASTM standards used to select and specify the geotextiles.
Table – Geotextiles Properties, functions and standards

Properties	Functions	ASTM standard
Tensile strength	Seperation, Filtration, Reinforcement	D4595
Grab tensile strength and elongation	Seperation, Filtration, Reinforcement	D4632
Tear strength	Seperation, Protection, Reinforcement	D4533

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Puncture strength	Seperation, Protection, Reinforcement, Filtration	D6241
Apparent opening size	Separation, Drainage, Reinforcement, Filtration	
Permittivity	Separation, Drainage, Reinforcement, Filtration	D4491
UV Resistance	Separation, Protection	D4355

The tests for geotextiles include the following
a) Tensile strength test
b) Grab tensile test
c) Trapezoidal test
d) Puncture strength test
e) Bursting strength test
f) Permittivity test
g) Ultraviolet resistance test

3.2 Geotextile Requirements

The American Association of State Highway and Transportation Officials (AASHTO M288 Geotextile Specifications) classified the geotextile for the following three classes to assess the engineers during geotextile design and selection:

- Class 1: For more sever installation conditions.
- Class 2: When site conditions are unknown.
- Class 3: For less sever installation conditions.

Table -3 provides the classes required for some geotextile Applications

Table -3: Geotextile Applications and required Classes

Geotextile applications	Geotextile classes
Filtration applications in subsurface drainage	2
Seperation of soil subgrades	2
Stabilization of soft subgrades	
Permanent erosion control (for example, geotextiles beneath rock rip rap)	2 for woven
Monofilament	1 for all other
Geotextiles	

3.3 Future perspectives

In this paper, a geotextile for the marine works and their properties and functions was investigated and summarized from the standards, textbooks and literatures based on researchexperience in the field of ports and terminals. The study concluded the following:

a) It is noted that geotextile, as a type of geosynthetics, covers most of the functions and
applications of the marine works as shown in Table -1 (i.e., filtration, separation, reinforcement, drainage, containment, protection and erosion control). In the stage of geotextile selection, engineers should be familiar with the types of polymers and their properties that are the main factor in the geotextile industry. Moreover, the engineersshould be aware of the minimum requirements stated in the standards to qualify them to select geotextiles carefully.

b) It is worth mentioning that the minimum percentage of the retained tensile strength of ageotextile after UV test should not be less than 50%.

c) It is preferable to place a layer of aggregate between the geotextile and the rock layer toprevent it from degradation by UV as well as damage from large rocks. In addition, it will give uniform pressure on the geotextile, which ensures proper filtration.

d) When selecting a geotextile, it should be taken into account that the value of AOS or is less than for the soil.

e) It is noted that the pores in the woven geotextile are often uniform in their size and distribution. In general, nonwoven geotextiles display smaller pore size (i.e., “AOS” or “”) than woven.

f) Most of the geotextile properties are expressed in Minimum Average Roll Values (see equation-3), except AOS value as they are expressed as a Maximum Average Roll Values (see equation-4).

g) It is worth noting that excessive elongation will distort and enlarge the pores in the geotextile that leads to a change in the filtering characteristics as well as the loss of soil.
h) The tensile strength of the geotextile for tearing resistance is very important when geotextile is subjected to harsh conditions (e.g., high wave loads, currents, etc.), whether during installation or operation.
i) In general, woven geotextiles have elongation < 50 %, while non-woven geotextiles have ≥ 50% for each geotextile Class.
j) Woven fabrics have high tensile strength, high modulus and low strains while non-woven fabrics have high permeability and high strain. Therefore, woven geotextile is preferred to be used for reinforcement function while non-woven for filtration and drainage functions.
k) For rubble-mound structures, strong geotextile allows placement of larger stones directly on it, thus reducing the overall structure thickness and layers. However, if large voids occur in the overlying structure layers, soil pressure and hydrostatic pressure may rupture the geotextile material.
l) The bursting strength of the geotextile is greatly affected by the size of the stones used, as the bursting strength with large stones is greater than with small stones.
m) To reduce rehabilitation costs, it is recommended to use geotextiles that have a high “Burst strength” in order to continue to retain the soil for a long time.

4 Conclusion

Geotextiles is the fastest growing industry and a promising field of technical textiles. This paper presented the potential of geotextiles in civil and construction industries. Technical textiles and geotextiles have been discussed as a whole. Next, the raw materials such as natural and synthetic fibers used in it, the manufacturing process and functional requirements are explained. Finally, the functions and major applications of geotextiles has been presented. The global market of geotextiles has also been addressed here. Technical specifications have been provided about the effective properties, required tests, functions and minimum requirements that should be taken into account during selection of geotextiles. In addition, it defines the geotextiles minimum requirements stipulated in the codes and standards that make engineers qualified enough to specify and select geotextile that fit the purpose of use. The technical details and conclusions of this paper are highly useful for engineers working in the design and implementation of marine fields to be sufficiently qualified when identifying and selecting geotextiles to fit the purpose of use.

References

1. Horrocks, A. R., & Anand, S. C. (2000). Handbook of Technical Textiles. Woodhead Publishing Ltd, Cambridge, England.
2. http://www.grandviewresearch.com/press-release/global-technical-textiles-market (Access date: 13/10/2017).
3. Shukla, Sanjay Kumar & Yin, Jian-Hua, “Fundamentals of Geosynthetic Engineering”, Published by Taylor & Francis Group, London, UK, 2006. www.eBookstore.tandf.co.uk.
4. Ingold, T.S., & Miller, K. S. (1988). Geotextiles Handbook. Thomas Telford Ltd., London, United Kingdom.
5. Nizam, M. E. H., & Das, S. C. (2014). Geo Textile - A Tremendous Invention of Geo Technical Engineering. International Journal of Advanced Structures and Geotechnical Engineering, 3(3):221- 227.
6. Rawal, A., Shah, T., & Anand, S. (2010). Geotextiles: Production, Properties and Performance. Textile Progress, 42(3):181-226. Doi: http://dx.doi.org/10.1080/00405160903509803
7. Ingold, T. S. (2013). Geotextiles and Geomembranes Handbook, Elsevier, Amsterdam, The Netherlands.
8. Koerner, R. M. (2012). Designing with Geosynthetics, 6th Ed., Xlibris, Bloomington, Indiana. http://www.grandviewresearch.com/industry-analysis/geotextiles-industry(Access date: 13/10/2017)
9. Methacanona, P., Weerawatsophona, U., Sumransina, N., Prahsarna, C., &Bergadob, D. T. (2010). Properties and Potential Application of the Selected Natural Fibers as Limited Life Geotextiles. CarbohydrPolym, 82:1090 1096.
10. Sarsby, W. R. (2007). Geosynthetics in civil engineering. Woodhead Publishing, Abington, Cambridge.
11. Lekha, K.R. (2004). Field Instrumentation and Monitoring of Soil Erosion in Coir Geotextile Stabilised Slopes ACase Study. Geotextiles and Geomembranes, 22(5):399-413. Doi: https://doi.org/10.1016/j.geotexmem.2003.12.003.
12. Rawal, A. &Anandjiwala, R. D. (2007) Comparative Study between Needle punched Nonwoven Geotextile Structures Made from Flax and Polyester Fibres. Geotextiles and Geomembranes, 25(1):61 -65. Doi: https://doi.org/10.1016/j.geotexmem.2006.08.001
13. Ahn, T. B., Cho, S.D., & Yang, S. C. (2002) Stabilization of soil slope using geosynthetic mulching mat. Geotextiles and Geomembranes,20(2):135 146.Doi: https://doi.org/10.1016/S0266-1144(02)00002-X
14. Datye, K. R. &Gore, V. N. (1994) Application of natural geotextiles and related products. Geotextiles and Geomembranes,13(6-7):371 388.Doi: https://doi.org/10.1016/0266-1144(94)90003-5
15. Kaniraj, S. R. &Rao,G. V.(1994) Trends in the use of geotextiles in India,Geotextiles and Geomembranes,13(6-7):389 402.Doi: https://doi.org/10.1016/0266-1144(94)90004-
16. Lee, S. L., Karunaratne, G. P., Ramaswamy, S. D., Aziz, M. A., & Gupta, N.C. D. (1994) Natural Geosynthetic Drain for Soil Improvement. Geotextiles and Geomembranes,13(6-7):457 474.Doi: https://doi.org/10.1016/0266-1144(94)90008-6
17. Lekha, K. R., &Kavitha, V. (2006) Coir geotextile reinforced clay dykes for drainage of low-lying areas, Geotextiles and Geomembranes,24(1):38 51. Doi: https://doi.org/10.1016/j.geotexmem .2005.05.001

18. Rao, G. V., Kumar, J. P. S., &Banerjee, P. K. (2000) Characterization of a braided strip drain with coir and jute yarns, Geotextiles and Geomembranes,18(6):367 384.Doi: https://doi.org/10.1016/S0266- 1144(00)00006-6
19. Sanyal, T., &Chakraborty, K. (1994) Application of a bitumen-coated jute geotextile in bank-protection works in the Hooghly estuary. Geotextiles and Geomembranes, 13(2):127 132. Doi: https://doi.org/10.1016/0266-1144(94)90044-2
20. Slater, K. (2003). J. Text. I. 94:99 105.
21. Tan, S. A., Karunaratne, G. P., & Muhammad, N. (1993) The measurement of interface friction between a jute geotextile and a clay slurry. Geotextiles and Geomembranes,12(4):363 376.Doi: https://doi.org/10.1016/0266-1144(93)90010-L
22. Ranganathan, S. R. (1994) Development and potential of jute geotextiles, Geotextiles and Geomembranes13(6-7):421 433.Doi: https://doi.org/10.1016/0266-1144(94)90006-X.
23. Balan, K., & Rao, G. V. (1996) Erosion control with natural geotextiles, in Environmental Geotechnology with Geosynthetics, G.V. Rao and P.K. Banerjee, eds., The Asian Society ForEnvironmental Geotechnology and CBIP, New Delhi, 1996, pp. 317 325.
24. Wall, M. J., Frank, G. C., & Stevens, J. R. (1971). Textile Research Journal. 41:38 43.
25. Barnett, R. B., &Slater, K. (1991). J. Text. I. (82):417 425.
26. Ludewig, H. (1971). Polyester Fibers. Wiley, New York.
27. Corbman, B. P. (1975). Textile: Fiber to Fabric. McGraw-Hill, New York.
28. Bhatia, S.K., & Smith, J. L. (1996) Geotextile Characterization and Pore-Size Distribution: Part I. A Review of Manufacturing Processes, Geosynthetics International, 3(1):85-105.
29.Giroud, J. P. (1984) Geotextiles and geomembranes, Geotextiles and Geomembranes, 1(1):5 40. Doi: https://doi.org/10.1016/0266-1144(84)90003-7.
30. Fluet, J. E. (1984) J. Ind. Text., 14:53 64.
31. Koerner, R.M. (2005). Designing with Geosynthetics. 5th Edition. Upper Saddle River, NJ: Prentice Hall
32. Hwang, G. S., Lu, C. K., Lin, M. F., Hwu, B. L., &Hsing, W. H. (1999) Text. Res. J., 69:565 569.
33. Williams, N. D., &Luna, J. (1987) Selection of geotextiles for use with synthetic drainage products. Geotextile andGeomembranes, 5(1):45 61. Doi: https://doi.org/10.1016/0266-1144(87)90033-1Hwang, G. S., Lu, C. K., Lin, M. F., Hwu, B. L., &Hsing, W. H. (1999) Text. Res. J., 69:565 569.
34. Williams, N. D., &Luna, J. (1987) Selection of geotextiles for use with synthetic drainage products. Geotextile and Geomembranes, 5(1):45 61. Doi: https://doi.org/10.1016/0266-1144(87)90033-1
35. Wang, Y. (2001). J. Ind. Text. 30:289 302.
36. Ghosh, T. K. (1998) Puncture resistance of pre-strained geotextiles and its relation to uniaxial tensile strain at failure, Geotextile and Geomembranes, 16(5):293 302.Doi: https://doi.org/10.1016/S0266- 1144(98)00011-9
37. Adanur, S. &Liao, T. (1998). Computer Simulation of Mechanical Properties of Nonwoven Geotextiles in Soil-Fabric Interaction. Textile Research Journal, 68(3):155 162.Doi: https://doi.org/10.1177/004051759806800301
38. Liao, T., Adanur, S., &Drean, J. Y. (1997). Predicting the mechanical properties of nonwoven geotextiles with the finite element method. Textile Research Journal. 67(10):753 760. Doi: https://doi.org/10.1177/004051759706701008
39. Mogahzy, Y. E. E., Gowayed, Y. & Elton, D. (1994) Textile Research Journal. 64:744 755.
40. -Scale Retaining Wall Reinforced with Non- Slopes and Retaining StructuresUnder Seismic and Static Conditions. ASCE Geotechnical Special Publication No. 140, Gabr, Bowders, Elton, and Zornberg (Editors), January 2005, Austin, TX (CD-ROM).
41. Benjamim, C.V.S., Bueno, B., Zornberg, J.G. (2007). Field Monitoring Evaluation of Geotextile- Reinforced Soil Retaining Walls. Geosynthetics International Journal, April, Vol. 14, No.1.
42. Holtz, R.D., Christopher, B.R., Berg, R.R. (1998). Geosynthetic Design and Construction Guidelines. FHWA Technical Report No. FHWA-HI-95-038, Federal Highway Administration, Washington, D.C., updated April 1998, 460pp.
43. -Use of Geosynthetics in India: Experiences and Potential. Report No. 207, Central Board of Irrigation and Power, New Delhi, India, pp. 321-324.
44. Tiwari, A. B., &Rajan, V. S. (1989) Use of geotextiles overlay at Ahmedabad airport-A case study. In use of geosynthetics in India: Experiences and Potential. Report No. 207, Central Board of Irrigation and Power, New Delhi, India, pp. 393-399
45. polymer geogrids. In use of geosynthetics in India - Experiences and Potential. Report No. 209, Central Board of Irrigation and Power, New Delhi, India.
46. Conference on Geotextiles, Geomembrances and Related products, vol. 1, ed. G.D. Hock. Balkenma Publication, The Hague, p. 164.
47. http://www.indiantextilejournal.com/articles/FAdetails.asp?id=5752 (Access date: 13/10/2017)
48. Grand View Research Forecasts Global Geotextiles Market (https://www.estormwater.com/grandview- research-forecasts-global-geotextiles-market) (access date: 13/10/2017). Website: Global Market Insights. https://www.gminsights.com/industry-analysis/geotextile-market
(access date: 13/10/2017)
49. http://www.grandviewresearch.com/industry-analysis/geotextiles-industry(access date: 13/10/2017)

50. https://globenewswire.com/news-release/2015/08/06/758603/10145077/en/Geotextiles-Market- Revenue-Is-Expected-To-Grow-To-8-24-Billion-by-2020-Report-By-Grand-View-Research- Inc.html (access date: 13/10/2017)
51. https://www.futuremarketinsights.com/reports/geosynthetics-market(access date: 13/10/2017). Coastal Engineering Manual, "Materials and Construction Aspect", EM 1110-2-1100, Part VI, Change 3. U.S. Army Corps of Engineers, Washington, Sep. 2011.
52. M. J. Denton & P. N. Daniels, "Textile Terms and Definitions", 11th Edition, Manchester, UK: Textile Institute, 2002.
53. Das, Subrata; Paul, Debasree; Fahad, Mir; Islam, Tarikul& Nizam, Md. Eanamul Haque, "Geotextiles A Potential Technical Textile Product", JSAER, Nov. 2017, Vol. 4, PP. 337-350, ISSN: 2394-2630.
54. Rao, G. V., Kumar, J. P. S., &Banerjee, P. K., "Characterization of a braided strip drain with coir and jute yarns, Geotextiles and Geomembranes", 2000, Vol. 6, PP. 367-384, doi:
https://doi.org/10.1016/S0266- 1144(00)00006-6.
55. K.R. Lekha, "Field Instrumentation and Monitoring of Soil Erosion in Coir Geotextile Stabilised Slopes-a Case Study", Geotextiles and Geomembranes, 2004, Vol. 22, PP.399-413, doi: https://doi.org/10.1016/j.geotexmem.2003.12.003
56. K. R. Lekha, & V. Kavitha, "Coir geotextile reinforced clay dykes for drainage of low-lying areas", Geotextiles and Geomembranes, 2006, Vol. 24, PP. 38-51, Doi: https://doi.org/10.1016/j.geotexmem .2005.05.001.
57. A. Rawal & R. D. Anandjiwala, "Comparative Study between Needle punched Nonwoven Geotextile Structures Made from Flax and Polyester Fibres", Geotextiles and Geomembranes, 2007, Vol. 25, PP. 61- 65, doi: https://doi.org/10.1016/j.geotexmem.2006.08.001
58. S.K. Shukla, "Geosynthetics in civil engineering constructions", Employment News, New Delhi, India, March 2003, Vol. 1, No. 48, PP. 1–3.
59. Ahmed Abdelmawla, "Characterization of uniaxial geogrid pullout mechanism for calcareous sand backfill", M.Sc., April 2007, Cairo University, Egypt, doi: 10.13140/RG.2.2.26400.48642.
60. Hassan Salah, Technical specifications of geotextile and applications in
marine works, International Research Journal of Engineering and Technology, Volume: 07 Issue: 01 | Jan 2020, 385.