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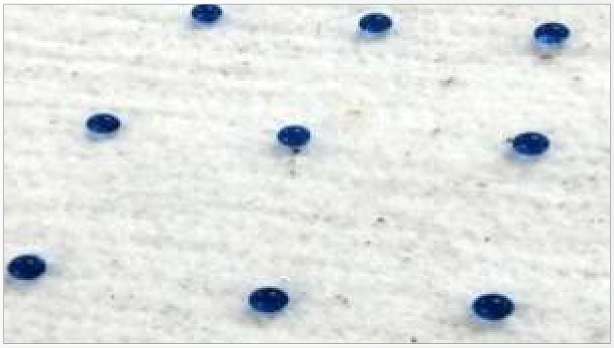

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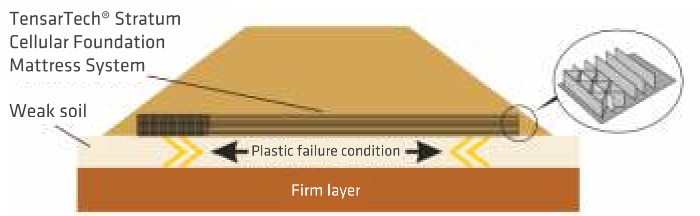

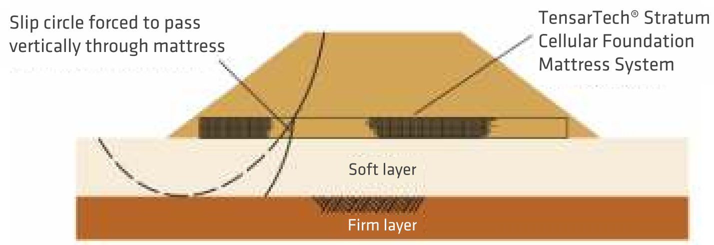

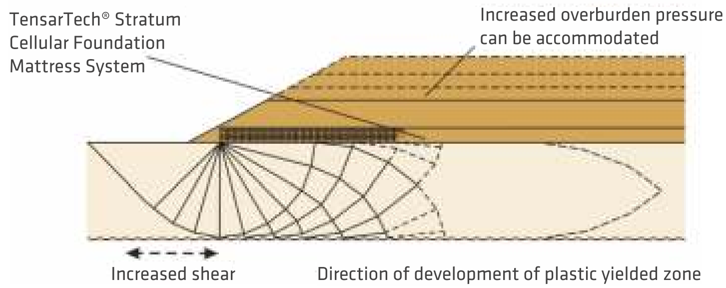

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info@tensar.in +91 (022) 6121 4982/84 tensarinternational.com

EDITOR'S DESK

Dear Readers,

Greetings!!

Research with persistent and focussed efforts lead to a positive result. Fostering research and providing a platform to publish quality research papers and related articles has been a continuous effort of BTRA Scan. In continuation to this effort, I am delighted to present to our readers the 50th Year Edition of BTRA SCAN. After a year, still we are struggling with the pandemic and facing many challenges. However, we have to focus on our progress accepting the challenges and difficulties.

This issue has papers from the different domains such as effluent treatment in textile industries, moisture management of fabric and developments in geosynthetics with their applications. Now we are open for authors from outside so researchers can send their original articles, case studies, research reviews or empirical contributions for publication in our journal.

I wish to assure you that we are on course of recovery and growth. The future is undoubtedly positive for our industry. I feel we will have a great time ahead after recovery." Hope, we all are following the safety practices to defeat the pandemic completely from our life soon.

Our sincere thanks to all the contributors for their support and interest.

Dr. T V Sreekumar
Director, BTRA

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Zero Liquid Discharge ETP – A Case Study (Part I)

Tanaji Kadam[1]*, A. Jeyakumar[2]

[1]Technical Services, BTRA Mumbai

[2] MD – Austro Water Technologies Pvt. Ltd., Tirupur

Abstract

Textile industry a major polluter of water, is passing through continuously increasing pressure from environmental regulations changing and updating time to time. We strongly feel that our textile processing industry should be able to take up these extra pressures about the environmental requirements and sustain our existence globally, some supportive activities are really needed. In this line , we at BTRA Mumbai and Austro water technologies pvt. Ltd have made an attempt to share some basic knowledge and know-how for Zero liquid discharge(ZLD) ETP plant. To share maximum information, we have divided this topic in two parts i.e. part-I compreses basic treatment scheme and inlet effluent characteristics, Part 2 details component of ZLD ETP and their functions to achieve the ZLD.

1.0 Introduction:

The textile industry is mainly concerned with 3 types of pollution viz water, air and soil or land. For every industry, it becomes an important thing to take major steps to minimize the pollution load of water, air and land for the survival of the next generation.

The textile processing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. As per one of the studies, it is estimated that the water consumption of the Indian textile industry alone is about 200-250 l/kg cotton cloth [1] of water in comparison to the global best of less than 100 l/kg cotton cloth. Textile dyeing and finishing is the most chemical usage intensive industry and the No. 1 polluter of clean water (after agriculture). More than 3600 individual textile dyes [2] are being manufactured by the Industry today and more than 8000 chemicals [2] in various processes of textile manufacture including dyeing and printing.

During our various studies for water conservation, shop floor audits, water balance and ETP audits, it observed that in a textile process processing house, 16-20 % of total water is consumed in dyeing and 8-10 % in printing. Specific water consumption for dyeing varies from 30 - 50 l/kg of cloth depending on the type of dye used. Dyeing contributes 15% - 20% of the total wastewater flow [2]. Water is also required for Washing of the dyed and printed fabric to achieve washing fastness and bright backgrounds. Washing agents like caustic soda-based soaps; enzymes etc. are used for the purpose. This removes the surplus color and paste from the substrate. Water is also needed for cleaning the printing machines to remove the loose color paste from printing blankets, printing screens & processing vessels. Wastewater from printing and dyeing units is often rich in color [3], containing residues of dyes andchemicals, such as complex components,many aerosols,high chroma,high COD and BODconcentration as well as to degrade materials. The toxic effects ofdyestuffs & other organic compounds, as well as acidic and alkaline contaminants, fromindustrial establishments on the general public, are widely known. Thus, in the form of water, the natural resource depletion is increasing due to increasing industrial demand.

To save and avoid the natural depletion of the water, textile industry should try to recycle the water within process as well as recover from waste water effluent and reach the level of zero liquid discharge (ZLD).

This article describes a typical module for ZLD in a textile plant. It is prepared for the complete treatment systems

*Corresponding author,
E-mail: tsd@btraindia.com

inclusive of effluent characteristics, volume generated and different treatment sections. Part 1 of the paper, discusses the inlet effluent characteristics and general treatment flow chart or scheme used for ZLD

2.0 Effluent characteristics & treatment steps:

2.1 Inlet effluent characteristics

The characteristics of the inlet composite effluent stream will be:

Table: 2.1 : Inlet effluent characteristics

S. No.	Parameter	Value	Unit
1	Colour	Lightly-medium colored	--
2	PH	9 - 11	--
3	Total dissolved solids	6000	mg/l
4	COD	3000	mg/l
5	BOD_5 at 20^0 C	1200	mg/l
6	Total suspended solids	100-200	mg/l
7	Total Hardness as $CaCO_3$	100-150	mg/l
8	Silica as SiO_2	10 - 15	mg/l
9	Chlorides as Cl	3000-4000	mg/l
10	Sulphate as SO4	500-1500	mg/l
11	Total Iron as Fe	1-2	mg/l

2.2 *Treatment steps are explained in the diagram with recovery in each stage:* *Kindly refer page no. 3 for the same*

3.0 Effluent Treatment Plant – Process description

The process selected is Anaerobic, color removal followed by Biological process (Activated sludge process with Diffused Aeration).

The effluent generated from the dyeing and washing sections is first collected in a collection tank through a Bar Screen which removes fibrous materials & solid particles. It is then into an Equalization tank with sufficient capacity for homogenization and cooling. The temperature of the effluent should be < 38°C.

The effluent, after proper mixing, homogenization & PH neutralization (7.5 to 8.0) is fed to an Anaerobic Digester, which has retention time of 48 hours. The reduction in COD & BOD expected is 60 -70 % and the color reduction up to: 70 - 80 %. (the remaining COD, BOD and the residual color are reduced in the subsequent Aerobic treatment).

The effluent, after Hybrid Anaerobic Digester is subjected to coagulation by the addition of a polymer-baseddecolourant CRP and PAC and poly electrolyte in mixing channel followed by flash mixture. The coagulated matters are allowed to settle in a primary clarifier having a hopper shaped bottom with a slow speed rack arm inside. Settled matter in the clarifier is sent to sludge drying beds/filter press for dewatering. The clear over flow effluent with an online acid injection for PH neutralization (7.5 to 8.0), is fed to Aeration tank for biological process (which reduces COD, BOD).

Aeration is done using energy efficient diffused aeration system, which results in compact layouts and reduces the power consumption. Air from the blower diffuses through the Diffuser grid. It consists of porous membranes of 12" dia disc type diffusers made of EPDM material. The diffusers are of non-buoyant type, which during shutdown condition contracts to prevent any back-flow.

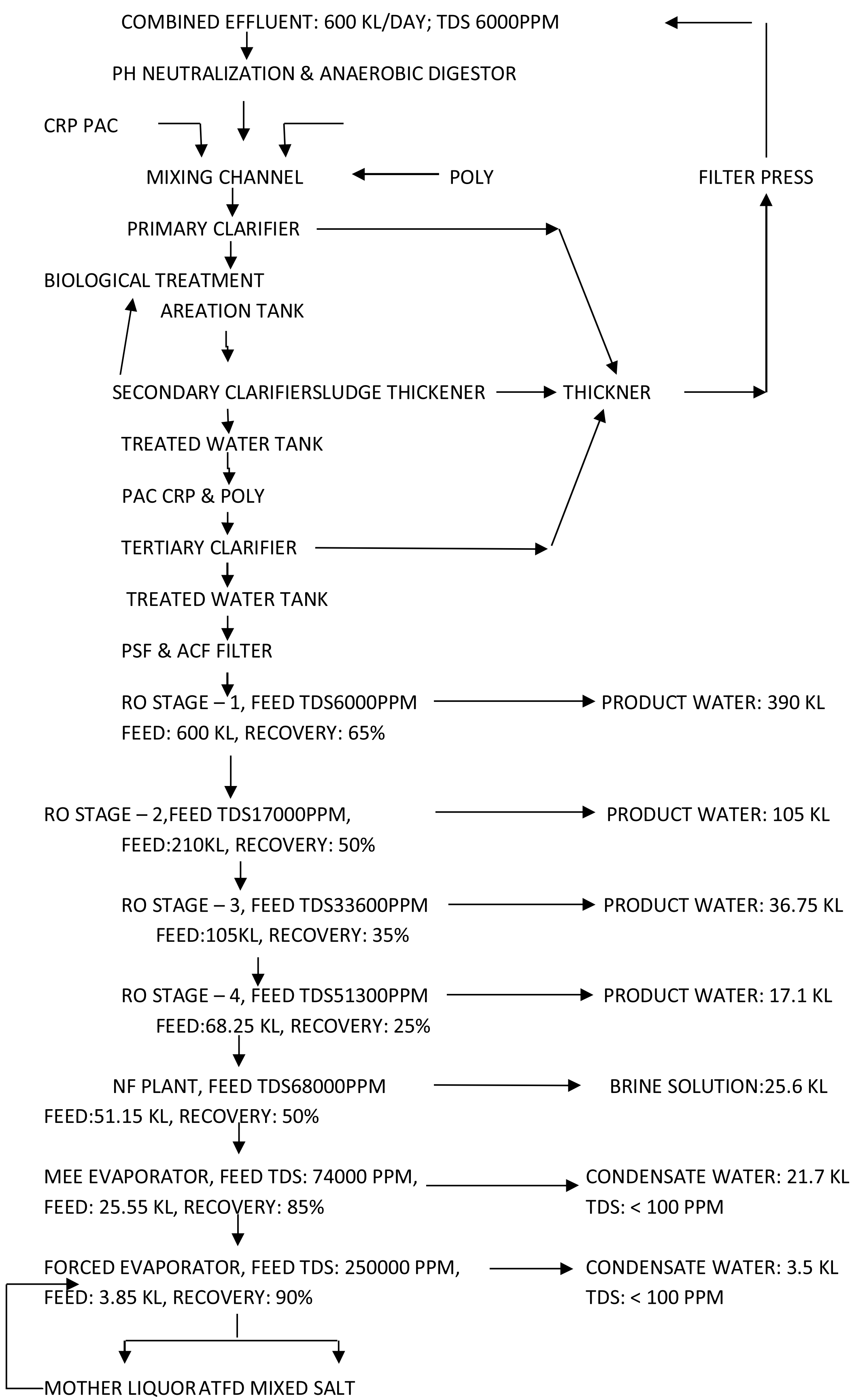
The diffuser is designed to ensure uniform permeability and to produce a flow of fine air bubbles which provides high contact area and more contact time due to slow rise of the bubbles. This makes the system very efficient in terms of oxygen transfer efficiency, less HP for the blower drive and hence loo operational cost.

After a residence of 27 hours in the aeration tank the treated effluent water and activated sludge flows to a secondary clarifier where the biomass is allowed to settle. The settled biomass in the clarifier is re-circulated back to the aeration tank to maintain the mixed liquor suspended solids (MLSS) up to the level of 2000-3000 mg/l suitable for the activated sludge process and the excess waste sludge is then sent to sludge drying beds and the dry sludge is used as manure for the plants. The COD & BOD reduction in the activated sludge process has been recorded up to 85%.

The over flow clear water from the clarifier is collected in another tank. This effluent may contain some residual color and fine suspended particles. Addition of CRP and PAC to this effluent will remove the residual color. Addition of these chemicals shall be done by gravity into a mixing channel. The chemical preparation tanks will have agitators.

The effluent is then let into a Tertiary clarifier, which is a circular type tank with a hopper shape bottom for sludge drain off. A low speed racked arm scraps the settled sludge to center of the clarifier and when the valve is opened all the accumulated sludge is drained. Settled matter in the clarifier is sent to sludge tank and filter press for dewatering or sludge drying beds.

2.2 Treatment steps are explained in the diagram with recovery in each stage:



The overflow from the clarifier is collected in a storage tank and passed through a Sand and Carbon filter and 4 stage RO Plants for water recovery. The RO reject is sent to NF Plant for Brine Solution Recovery. The NF reject is sent to MEE (Falling film & Forced Circulation) Evaporator for condensate recovery. The mother liquor from MEE collected is sent to ATFD and the mixed salt recovered is Stored in a closed shed.

It is now proposed to install a pre-treatment followed by MF Plant & 4 stage RO plant for maximum water recovery. To control and reduce the TDS level, there is a RO membrane filtration, which will be discussed in part-II of this paper.

Table 3.1 : Treated effluent characteristics after the media filter:

S. No	Parameter	Treated effluent	Unit
1	PH	6.5 – 7.5	-
2	Total suspended solids	2 – 5	ppm
3	Turbidity	2-5	ppm
4	Total dissolved solids	6000	ppm
5	Total Iron as Fe	< 0.1	ppm
6	BOD	<30	ppm
7	COD	< 100	ppm
8	Heavy metals	Nil	ppm

References:

1. PhilliaRstiani, Stockholm International Water Institute and Aparna Khandelwal, sustainability outlook, water governance mapping report: textile industry water use in India, 2016, P 12.
2. Rita Kant, Natural sience, Vol.4, No.1, 22-26 (2012), P23.
3. Zongping Wang, MiaomiaoXue, Kai Huang andZizheng Liu, Textile dyeing waste water treatment, Advances in treating textile effluent, ISBN: 978-953-307-704-8, P 91

The Effect of Weave Pattern on the Moisture Management Properties of 100% Cotton fabric

Archana Gangwar *

Nano Lab, The Bombay Textile Research Association, L. B. S. Marg, Ghatkopar(West), Mumbai 400086

Abstract

In this study, the effect of weave pattern on moisture management properties of 100% cotton differently woven fabrics have been assessed. The relation between fabric constructional parameters (such as fabric thickness, fabric weight, fabric bulk density, fabric cover factor, yarn count, yarn crimp and yarn twist per meter) and moisture management properties concerning the wetting time, spreading speed, demand absorbency capacity, maximum absorption rate, vertical wicking rate, air permeability and drying time were examined in accordance with different weave patterns (such as 1/1 plain, 3/1 satin and 2/1terry (both sided)). A general overview of the results showed that moisture management properties of cotton woven fabrics were affected by the weave patterns and constructional parameters.

Keywords

Cotton woven fabric, weave pattern, constructional parameters, moisture management

1.0 Introduction

Moisture transport properties of fabric in multi-dimensions are referred as moisture management properties. It significantly influences human perception of moisture sensation [1-5]. A new method and instrument called the moisture management tester (MMT) is developed to evaluate textile moisture management properties [4-5]. Moisture management of a fabric is its ability to absorb and transfer moisture through the fabric [6]. It is one of the key performance criteria in today's apparel industry which decides the comfort level of the fabric [5,7]. Comfort is a basic requirement in clothing selection in all conditions. However, the preference of people changes with the context: season, climate, age, type of work/activity and so on. Comfort can be defined as 'a pleasant state of psychological, physiological and physical harmony between a human being and the environment' [8,9]. The comfort properties of textiles are generally represented by its moisture transport and air permeability [10]. Wicking is the natural property of cotton fabric. It absorbs perspiration through capillary action from the body and evaporates the moisture from surface of fabric and keeps the body cool and dry [6]. Air permeability is the measurement of the ability to allow air flow through the fabric [6]. It is defined as the rate of air volume flowing through the fabric, when there is a pressure difference on both sides of the fabric. Air permeability is indirectly connected with moisture management, it provides the breathing and ventilation functions to the fabric. So it is also the main attribute of the moisture management performance. Drying time is also an important parameter. It is the length of time required to dry a garment. It is important to know the drying time during and after wear of garments, particularly for those engaged in outdoor activities such as tramping/hiking (e.g. a tramper may require a wet garment to dry overnight) [11]. Other fabrics such as upholstery items (curtains, covers, etc.), blankets and some highly absorbent fabrics such as towels, wipes and diapers are in a particular atmosphere.

The fabric should give comfort to wearer in terms of good perspiration absorbency and moisture management concerning parameters [6]. H. Özdemir concluded that both the fabric constructional parameter and the constituent fiber properties affect thermal comfort properties of fabrics [12].

This study aims at investigating the effect of weave pattern with constructional parameters on 100% cotton woven fabrics on the moisture management properties. Three types of cotton fabrics woven with different weaves

*Corresponding author,
E-mail :nanolab@btraindia.com

such as 1/1 plain, 3/1satin and 2/1terry (both sided)were studied. The effect on moisture management properties were measured and analyzed as wetting time, spreading speed, demand absorbency capacity (DAC), maximum absorption rate (MAR), vertical wicking rate, air permeability and drying time test.

2.0 Materials and methods of measurement

2.1 Materials

100% cotton woven fabrics with three types of weave patterns such as 1/1 plain, 3/1satin and 2/1 terry (both sided) were selected and purchased from a local market of Mumbai (India).

2.2 Methods of measurement

2.2.1 Measurement of fabric thickness

The thickness of fabric samples was measured as the distance between the reference plate and parallel presser foot of the thickness tester under a load of 1KPa. Standard procedure using MI- milestone thickness tester as per IS-7702- 2012 was used.

2.2.2 Measurement of GSM

Standard procedure for measuring GSM as per ISO-3801-1977 was followed. A measuring balance (SHIMADZU AX-200) capable of weighing to an accuracy of 0.1 gm was used to weigh the samples of size 10x10 cm^2.

2.2.3 Calculation of Fabric Bulk Density

Fabric bulk density (FBD) was calculated according to Equation (1) : [13,14]

FBD (g/cm^3) = Fabric unit weight (g/cm^2) / Fabric thickness (cm)………………………… (1)

2.2.4 Measurement of yarn count in fabric

The standard procedure IS- 3442-1980 RA 2014 was followed to measure the length and weight of yarns in fabrics and calculate the yarn count (Ne). A Torsion balance (50 mg) capable of weighing to an accuracy of 0.01 mg and a measuring balance (SHIMADZU AX-200) capable of weighing to an accuracy of 0.1 gm was used to weigh the yarns.

2.2.5 Measurement of thread density

Thread density (number of warp and weft threads per inch in woven fabric) in fabrics was calculated by the standard procedures IS-1963-2004 RA2014 and ASTM D 3775-2012.

2.2.6 Calculation of Fabric Cover Factor

For any fabric, there are two cover factors: warp cover factor (K_1) and weft cover factor (K_2). Calculations of the warp (K_1), weft (K_2) and fabric (Kf) cover factor are presented in Equations (2), (3) and (4), respectively [14,15]:

$K_1 = EPI/\sqrt{Ne_1}$………………………… (2)

$K_2 = PPI/\sqrt{Ne_2}$………………………… (3)

$Kf = K_1 + K_2 - (K_1K_2/28)$……………………..(4)

Where; EPI stands for number of warp threads per inch, PPI stands for the number of weft threads per inch of fabric. Ne_1 and Ne_2 are the warp and weft yarn count in Ne (English count) respectively.

2.2.7 Measurement of crimp % of yarns in fabrics

The crimp% of yarns in fabrics was measured and calculated by the standard procedure IS 3442-1980. The SASMIRA crimp tester was used to straighten the yarns and then measure the average length of yarns when straightened.

2.2.8 Measurement of twist in yarn

Twist per unit length was measured and calculated by the standard procedure using TPI analyzer- digital twist tester as per ASTM D 1422 M-13 and ASTM D 1423 M-16 was followed. However, the twist per unit length of the satin fabric air jet spun yarns (false twist) could not be measured.

2.2.9 *Moisture management (liquid absorbance and transport) properties*

Greenwood absorbency test system, model 3100, was used to measure the dynamic liquid absorbance and transport properties such as wetting time, spreading speed, demand absorbency capacity (DAC) and maximum absorption rate (MAR) in fabric samples. Total wetting time of 5.5 cm samples was recorded, then the DAC and MAR was calculated by standard test method ISO 9073-12: 2002 (E). Five tests on each sample were done and the mean value is reported.

2.2.10 Vertical wicking

Vertical wicking was measured by the standard test method AATCC-197-2013. The sample size was 15 ×2.5 cm used to measure the vertical wicking height (mm) and the relative wicking rates (mm/min) of woven fabrics obtained, for the 30min test period. Ten tests of the warp and weft side of each sample were carried out and the mean value was calculated.

2.2.11 Air permeability

Frazier® Air permeability tester was used to measure the air permeability by the test method IS-11056-2013.The opening area was 1-inch² and water column was 0.79 cm. Ten tests on each sample were carried out and the mean value was calculated.

2.2.12 Drying time

Drying time of samples was calculated by the standard test method AATCC TM 199. The samples were preconditioned at temperature25±2°C and 65±5% relative humidity, for 30 min before the testing was carried out. 100% wet pickup of fabric samples was recorded at the starting drying point. The samples were dried at temperature 25±2°C and 65±5 % relative humidity. However, this temperature is a nonstandard testing condition for drying samples. Ten tests on each sample were carried out and the mean value of moisture retention % after drying is reported.

Moisture retention (%) = $(W_2 - W_1 / W_2) \times 100$……….(5)

Where, W_2 is the weight of saturated fabric sample in grams and W_1 stands for the weight of dry fabric sample in grams.

3.0 Result and Discussion

Table 1. Constructional parameters of different weave patterns of fabric

Constructional parameters of fabric	**Plain woven fabric**	**Satin woven fabric**	**Terry woven fabric**
Fabric weight (gm/m²)	95.5	147.65	486.45
Thickness (mm)	0.38	0.39	2.5
Fabric bulk density (gm/cm³)	0.25	0.378	0.194
Yarn count Warp count (Ne 1) Weft count (Ne2)	 31.636 30.545	 61.09 84.36	 12.30 12.43
Thread density Ends per inch (EPI) Picks per inch(PPI)	 69 53	 205 210	 54 88
Warp cover factor Weft cover factor	12.267 9.589	26.228 22.864	15.39 24.96
Fabric cover factor	17.655	27.676	26.631
Yarn crimp% Warp yarn crimp% Weft yarn crimp%	 0.7 17.1	 1.7 8.1	 0.7 15.2
Warp yarn TPM Ply Type of twist Weft yarn TPM Ply Type of twist	881 1 Z 719 1 Z	- 1 False twist - 1 False twist	401 2 S 692 1 Z

3.1 Effect of weave pattern on moisture management (liquid absorbance and transport) properties of cotton fabrics

The dynamic liquid transport and absorbance properties are categorised under moisture management properties [3]. The relation of different woven fabrics between absorbency (a) and time (t), demand absorbency capacity and maximum absorption rate of different woven fabrics is shown in Figure A, B and C respectively. The fabric bulk density (Table 1) of differently woven fabrics showed the inverse relation with demand absorbency capacity and maximum absorption rate. It was also observed that the absorbency capacity had an inverse relation to the spreading speed (Table 2). While wetting time (total absorption time) was increased with the absorbency capacity of fabrics.

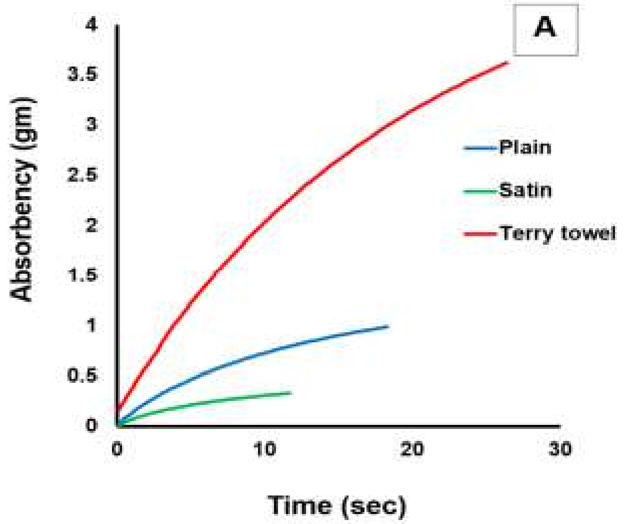


Figure A. Effect of weave pattern on wetting time (a/t curve)

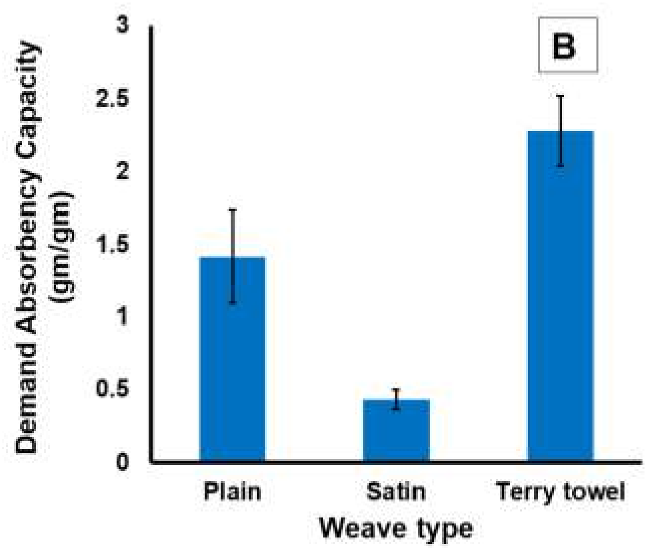


Figure B. Effect of weave pattern on demand absorbency capacity (DAC)

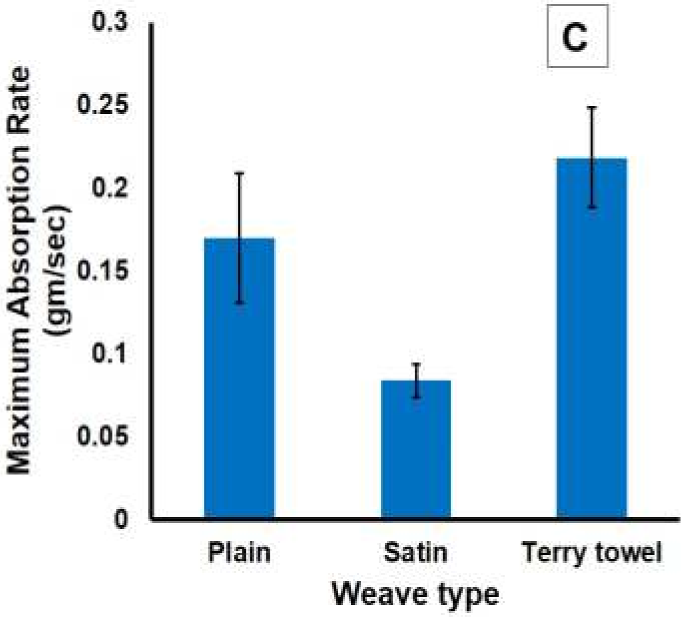


Figure C. Effect of weave pattern on maximum absorption rate (MAR)

Table 2. Moisture management performance properties such as demand absorbency capacity (DAC), maximum absorption rate (MAR) of differently woven fabrics

Parameters of moisture management	Plain woven fabric	Satin woven fabric	Terry woven fabric
Wetting time (sec)	18.3	11.7	26.4
Spreading speed (mm/sec)	3	4.7	2
DAC (gm/gm)	1.415	0.432	2.28
MAR (gm/sec)	0.17	0.084	0.218

In satin woven fabric, it was observed that the fabric had low wetting time (Table 2), less absorbency and high-water spreading speed due to the lengthier floats and fewer interlacing in its construction with its smooth surface. This fabric could absorb only 0.432 times its own weight. The lowest absorbency capacity (gm/gm) in the satin woven fabric may be due to fine yarns (high Ne), false twist (air jet spun) yarns and its high thread density and bulk density of the fabric. Fine yarns and high thread density would have small gaps (low pore size) and high surface area (highest cover factor shown in (Table 1) in its structure and more yarns would be on the surface of fabric due to fewer interlacements. So, water could rapidly move with the finest yarns with a less absorbency capacity of the fabric.

Plain woven fabric showed lower fabric bulk density and higher absorption rates than the satin woven fabric, but higher bulk density and lower absorption rates than the terry woven fabric. The plain-woven fabric had the lowest weight, thickness and thread density (Table 1). The water spreading speed on the surface with the yarns of plain-woven fabric was lower than satin woven fabric due to slightly rough surface, but it could absorb 1.415 times its own weight. The better absorbency capacity may be attributed due to interlacements of successive warp and weft yarns and lower thread density of better twisted yarns, as they can create the pores (spaces) in its structure. Those spaces can accommodate and transfer water. Hence the absorption capacity and the absorption rate of plain-woven fabric were higher than the satin woven fabric.

In terry woven fabric, demand absorbency capacity and maximum absorption rates were the highest and fabric bulk density was lowest. It could absorb 2.28 times of its own weight. This fabric had coarser yarns with low twist and highest thickness. So, it had the highest absorbency capacity, but there was the lowest water spreading speed with the low twist yarns. Coarser yarns and piles may provide more spaces to accommodate water in the fabric structure. This was due to the presence of capillary space and the availability of capillary pressure, that it could absorb and transfer water. But the spreading speed was lowest due to its highest absorbency capacity and lowest bulk density.

3.2 Effect of weave pattern on vertical wicking properties of cotton fabrics

Capillary transport of liquid water through fabrics was assessed and shown in Figure D as the vertical wicking of different woven fabrics in warp and weft directions. In vertical wicking, water transfer depends upon the capillary spaces with fibers, yarns and capillary pressure availability. This statement is in agreement with the work reported by Kissa that the wicking is a spontaneous flow of a liquid into porous substrate driven by capillary forces [16].

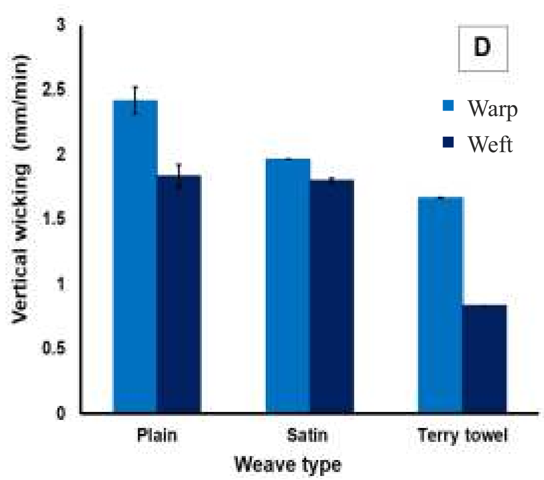


Figure D. Effect of weave pattern on vertical wicking rate

In this study, it is apparent that the wicking rates of plain woven fabric and satin woven fabric were higher than the terry woven fabric. Fabric weight per unit area and thickness showed the inverse relation with vertical wicking rates.

Satin woven fabric showed lower vertical wicking rates (mm/min) than the plain woven fabric because of its lower capillary flow due to its highest thread density, bulk density, weight per unit area and thickness (Table 1). While in plain woven fabric weight per unit area and thread density were lower than satin woven fabric but the twist in the yarn was higher. This fabric contained more spaces to absorb and transfer water therefore it showed highest vertical wicking rates.

In terry woven fabric, high thickness of low twist yarn and pile structure may attenuate the wicking process due to the formation of air pockets in low twist yarn. So the vertical wicking rates (mm/min) were low due to low capillary flow availability.

In all fabric samples vertical wicking rates were higher in warp direction than the weft direction. Because in these fabric structures warp yarns were straighter (low crimp shown in Table 1), so the overall length of yarn would be shorter in warp direction. The straighter yarns were found in the longitudinal direction of the test strips of warp. Therefore, in the warp direction less resistance of water would occur in the vertical wicking. Hence vertical wicking rates were higher in warp direction.

3.3 Effect of weave pattern on air permeability of cotton fabrics

Air permeability is the free passage of air in the fabric. The effect of air permeability in fabric samples was assessed in Figure E.

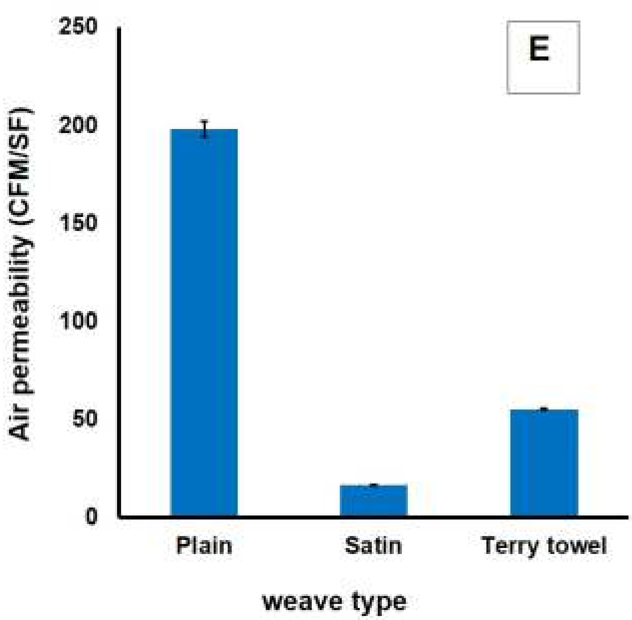


Figure E. Effect of weave pattern on air permeability

In this study, the satin fabric construction was compact (highest thread density) and contained finest yarns (high count) that may be woven tightly so the free spaces get reduced. Air permeability decreases as the weft density increases. Therefore, cover factor has a significant effect on air permeability. Air permeability of fabric samples decreased with an increase in fabric cover factor (Table 1).

Here the plain-woven fabric had very loose structure (lowest thread density), cover factor of fabric and weight of fabric was very low. Large pores could be seen in the structure. So air permeability was highest in plain woven fabric with lowest cover factor.

While terry woven fabric showed moderate air permeability, it may be due to its moderate fabric cover factor. The low tension warp is woven to form loops therefore it may increase fabric thickness and weight per unit area in the terry woven fabric. On the other hand, the fabric structure had a moderate thread density, coarser yarns (low Ne) and low fiber compactness in the yarns (low twist). So it may not be a compact structure but this fabric had the highest thickness and weight.

3.4 Effect of weave pattern on drying time of cotton fabrics

The length of time required to dry the samples was shown in Figure F. This study showed 100% moisture retention after drying in all samples. Highly twisted yarns in the fabric make the fabric dry easily. While low twist yarns in the fabric have better absorbency capacity and hence retard drying. The plain woven fabric showed the lowest drying time. This was due to its lowest weight per unit area and the maximum twist in its yarns. While the absorbency capacity of plain woven fabric was higher than the satin woven fabric, but here the wet pick up % was same for all fabric samples. The satin woven fabric dried slower than the plain woven fabric due its compact structure.

Drying time did not show a significant effect with the absorbency capacity of fabrics at 100% wet pickup. At this pick up %, plain woven fabric seemed slightly dry due to its low weight and high absorbency capacity. Satin woven fabric seemed saturated due to its high weight and low absorbency capacity. Hence drying time increased with increase in fabric weight.

In case of terry woven fabric, it was heavy, weight per unit area and thickness was highest in this fabric. Its structure had piles of low twisted yarns. This fabric showed good absorbency at same pickup % and took too long to dry due to its highest weight. It had low air permeability and lowest water spreading speed (inner and outer surface of the fabric). This may be the reason of its slowest drying capacity.

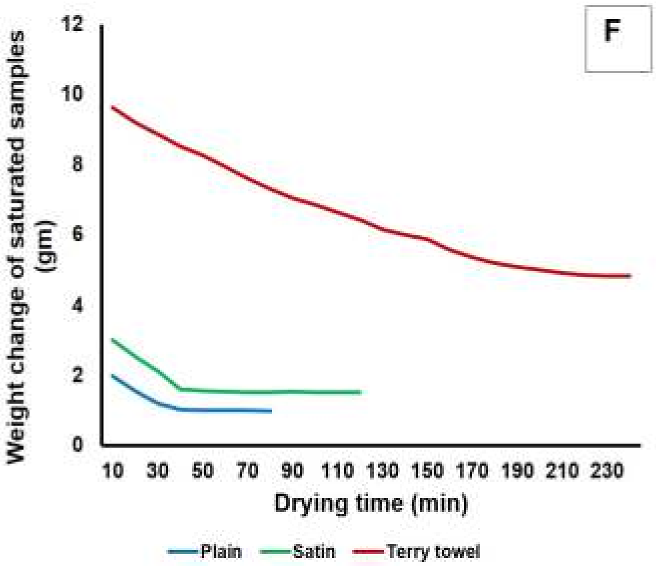


Figure F. Effect of weave pattern on drying time

4.0 Conclusions

The end use of fabrics can be rationalized according to their moisture management performance properties. In this study, different woven fabric structures have been found to show significant effect on moisture management performance properties such as wetting time, spreading speed, demand absorbency capacity, maximum absorption rate, vertical wicking rate, air permeability and drying time, particularly when the constructional parameters were different such as fabric weight, thickness, fabric bulk density, fabric cover factor, yarn count and yarn twist. The significant effects were found as, the absorbency capacity had an inverse relation to the spreading speed. The demand absorbency capacity of woven fabrics and the maximum absorption rate of woven fabrics were found to increase when the fabric bulk density decreased. The vertical wicking rate increased with decrease in fabric weight per unit area and thickness. The air permeability decreased with an increase in the fabric cover factor. The drying time had an inverse relation to the yarn twist (fiber compactness in the yarn) of fabric but it had increased with fabric weight per unit area. Therefore it can be concluded from this study that moisture management behavior of textile fabrics is dependent on variety of fabric constructional parameters and weave patterns. Each fabric can be recommended for different end uses. Textile manufacturers can make the right choice according to the performance and functionality of cotton fabrics.

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References

1. E. S. Namligoz, S.Coban, M. İ.Bahtiyari(2010). “Comparison of moisture transport properties of the various woven fabrics”,TekstilveKonfeksiyon, 2: 93-100.
2. Y. Gao, Y. Li, H. Tokura, T.K. Shingwong (2008).“Impact of Fabric Moisture Transport Properties on Physiological Responses when Wearing Protective Clothing”, Text Res J, 78(12):1057-1069.
3. B. Yao, Y. Li, J. Hu, Y. Kwok, K. Yeung(2006).“An improved test method for characterizing the dynamic liquid moisture transfer in porous polymeric materials”, Polym Test, 25(5): 677-689.
4. J. Hu, Y. Li, K.W. Yeung, A. S. W. Wong, and W. Xu (2005). “Moisture management tester: a method to characterize fabric liquid moisture management properties”, Text Res J, 75 (1): 57-62.
5. M. Basuk, M. Choudhari, S. Maiti, RV Adivarekar (2018). “Moisture Management Properties of Textiles and Its Evaluation”, Current Trends Fash. Tech & Text Eng, 3 (3): 50-55.
6. S. Ahmad, F. Ahmad, A. Afzal, A. Rasheed, M. Mohsin, N. Ahmad (2015). “Effect of weave structure on thermo-physiological properties of cotton fabrics”, Autex Res J, 15(1):30-34.
7. M. Maqsood, Y. Nawab, K. Shaker, M. Umair, M. Ashraf, D. M. Baitab, S. T. Ali Hamdani, S. Shahid (2016). “Modelling the effect of weave structure and fabric thread density on mechanical and comfort properties of woven fabrics”, Autex Res J, 16 (3):160-164.
8. A. Das and S. Ishtiaque (2004). “Comfort characteristics of fabrics containing twist-less and hollow fibrous assemblies in weft”, J of Text and Apparel, Tech and Management, 3 (4): 1-7.
9. L. Hunter, J. Fan (2015). “Improving the Comfort of Garments”, Textiles and Fashion, Cambridge (England): 739-761.
10. P. Santhilkumar, B. S. Dasaradan (2007).“Comfort properties of textiles”, J InstEng, TX, 88: 3-4.
11. R. M. Laing, C. A. Wilson, S. E. Gore and D. J. Carr, B. E. Niven (2007). “Determining the Drying Time of Apparel Fabrics”, Text Res J, 77(8): 583-590.
12. H. Özdemir (2017). “Thermal comfort properties of clothing fabrics woven with polyester/ cotton blend yarns”, Autex Res J, 17 (2): 135-141.
13. Y. L. Hsieh, (1995). “Liquid transport in fabric structures”, Text Res J, 65: 299-307.
14. K. Gizem, A. Mine (2018). “Effect of weft yarn fiber contents on the moisture management properties of Denim fabrics woven with differentconstructional parameters”, TekstilveKonfeksiyon, 28(2): 151-161.
15. M. Akgun, B. Becerir, H. R. Alpay (2010). “Assessing the relationship among fabric constructional parameters, fractional reflectances and cover factors of polyester fabrics by experimental and mathematical methods”, Fiber and Polym, 11 (2):291–302.
16. E. Kissa (1996). “Wetting and Wicking”, Text Res J, 66 (10):660-668.

Geosynthetics: An overview

Komal Kukreja*

The Bombay Textile Research Association, L.B.S. Marg, Ghatkopar(west), Mumbai 400086

Abstract

The paper provides an overview of history of geosynthetics, raw material, manufacturing, types, functions and applications. Usage of geosynthetics material goes way back when natural fibers were used as soil reinforcement in ancient structures. Different types of geosynthetic materials such as geotextiles, geomembranes, geogrids, geocomposites etc. are used in various functions of geotechnical and landfill engineering. These materials perform various functions of separation, filtration, drainage etc. The growth of geosynthetic market in the next few years and various developments taking place in this field is also summarized in this paper.

1.0 Introduction

Geosynthetics is an emerging field offering various applications globally. It refers to the planar products synthesized from polymeric materials used with geo materials like soil, earth, sand etc. for applications like transportation, hydraulics, roads, embankment, retaining walls, canals, erosion control, waste landfill, revetments etc. Geosynthetics have been increasingly used in geotechnical, environmental engineering and civil engineering replacing the use of conventional, restricted or expensive construction materials. These materials have long term durability, high strength and stiffness.

2.0 History of Geosynthetics

History of geosynthetics dates back to the time when linen, bamboo, reeds, timber, grass mats and other natural elements were found during excavation of ancient structures. Geotextiles made with natural fibers or vegetation was usually reinforced with soil to improve road stability.

The first use of woven fabrics as filter fabrics or construction fabrics was in 1950s and 1960s in coastal and hydraulic engineering in the Netherlands, Germany, and the United States. Carthage Mills' president along with the University of Florida developed a woven synthetic filter fabric to protect erosion from Florida storm in 1957.R.J.Barrettworkedon geotextiles for erosion control. He was recognized as a "father of filter fabrics". The Dutch used geotextiles in Delta Works flood protection scheme in the early 1960s which was honoured as one of the Seven Wonders of the Modern World by The American Society of Civil Engineers (ASCE). Since then in 1970s, there was emerging use of nonwoven fabrics in several European countries and woven fabrics in the United States. Many smaller textile companies like TenCate, Carthage-Mills and large chemical companies like ICI, Rhone-Poulenc, Enka/AKZO in Europe and DuPont, Phillips, in the United States drives this early technology. Carthage Mills and USACE participated in the construction of a full-scale embankment test section at Pinto Pass in Mobile, Alabama by which the first effective design criteria and construction techniques for "fabric-reinforced embankments on extremely soft soils" was developed [1,2].

The terms "geotextile" and "geosynthetics" were first coined by Dr. JP Giroud in a seminal paper and presentation at the First International Conference on Geosynthetics (1 ICG) in Paris in 1977 during his presentation the Valcros Dam in France. His early 1970s work, included the first use of a double-liner system, geotextile cushion with a geomembrane, and a geotextile for filtration and internal integrity of a dam embankment [1]. Prof. Heerten along with NAUE manufacturer in Germany worked for innovations in needle punched nonwoven geotextiles for advancement in geosynthetic clay liner materials [1,3].

*Corresponding author,
E-mail: geotech@btraindia.com

3.0 Raw Material for Geosynthetics

The selection of geosynthetic raw material depends on performance required in the field and its cost. On the basis of material used for manufacturing, geosynthetics is broadly classified into two

3.1 Usual Geosynthetics

These materials are adaptive to environment and provide long term functions such as high resistance to instantaneous loads, high initial strength retention etc. These are mainly produced from synthetic polymers [4].

3.2 Green Geosynthetics

These materials are made of eco-environmental biodegradable polymeric resins or natural materials that can degrade after service period and causes no harm to the soil and environment. These materials maintain their performance such as durability, design strength, hydraulic property etc. throughout the service period [4].

So, different fibres and polymers from both natural as well as synthetic category are used in geosynthetics for various applications.

3.3 Natural fibers

Earlier, natural fibers in fiber, yarn and knit form were used in geosynthetic products. With the development of non woven and woven type products, demand for natural geosynthetic products increased. Due to its quick biodegradability and small scale production it couldn't be used much. However, advantage of being eco-friendly materials, the utility of geosynthetic products in civil engineering as slope stabilization, erosion control, drainage, etc has recently begun to reappear. These materials are used in the form of paper strips, jute nets, wood shavings or wool mulch [5,6].

The raw materials of the products include cotton, jute, coir, straw, ramie, bamboo, coconut etc. Ramie possesses highest tenacity among all plant fibres. Jute has the ability to mix with the soil and serve as a nutrient for vegetation. Jute geotextile could be manufactured with specific properties treatment and blending. Its use as prevention of topsoil erosion and cracking is quite good. Jute geotextiles after degradation forms lignomass which enhances vegetative growth, soil organic content, fertility and stability of soil [5].

3.4 Synthetic polymers

The main synthetic polymers widely used as the raw material for geosynthetics are as follows

3.4.1. Polypropylene (PP)

It is one of the most widely used polymers for geosynthetic applications because of its low cost, acceptable tensile properties, and chemical inertness. Due to its low density it has extremely low cost per volume. The main disadvantage of polypropylene is its poor sensitivity to UV. In addition, at high temperature, its performance is easy to deteriorate, demonstrating poor creep characteristics due to low glass transition temperature [5].

3.4.2 Polyesters (PET)

The polymer in fiber form has high strength, modulus, creep resistance and general chemical inertness due to which it is more suitable for geotextiles. It possesses high resistance to ultraviolet radiations. Due to its high melting point, it can be used at high temperature. However, polyester can hydrolyse at pH above 10 [5].

3.4.3 Polyethylene (PE)

These polymers are mainly used in making geomembranes. Based on strength requirement, following three main groups of polyethylene are used, i.e, Low density polyethylene (LDPE, density 9.2-9.3 g/cc), Linear low density polyethylene (LLDPE, density 9.20-9.45 g/cc) and High density polyethylene (HDPE, density 9.40- 9.6 g/cc)

3.4.4 Polyamides (PA)

Nylon 6 and Nylon 6,6 are rarely used in geosynthetic applications. They have more strength but less modulus than polypropylene and polyester. They are also prone to hydrolysis.

3.4.5 Polyvinyl chloride (PVC)

Polyvinyl chloride is a hard plastic material. Flexible material can be made with the addition of plasticizers which is mainly used in geo membranes and thermo plastic coating materials.

3.4.6 Polystyrene (PS)

It is a light weight material of low density, mainly used in making of geofoams.

3.4.7 Ethylene copolymer Bitumen (ECB)

Ethylenecopolymer bitumen membrane has been used in civil engineering works as sealing materials.

3.4.8 Chlorinated Polyethylene (CPE)

Sealing membranes based on chlorinated poly ethylene are generally manufactured from CPE mixed with PVC or sometimes PE.

Additives such as antioxidant, UV absorbers, thermal stabilizers, flame retardents, antibacterial agents etc are generally added to enhance the performance of geosynthetics. Carbon black is mainly added for long term UV resistance and high strength.

Table 1 shows the types of polymers and their formulations for use in geosynthetics.

Table 1 : Type of polymers and their formulations

Type	Resin(%)	Plasticizer (%)	Fillers (%)	Carbon Black (%)	Additives (%)
Polypropylene	85-98	0	0	2-3	0.25-1
Polyester	98-99	0	0-10	0.5-1	2-5
Polyethylene	95-98	0	0	2-3	0.25-1
Polyvinyl Chloride	50-70	25-35	0-10	2-5	2-5
Polyamide	98-99	0	0	0.5-1	0.5-1
Polystyrene	98-99	0	0	0	1-2

4.0 Types of Geosynthetics

Fig 1 shows various types of geosynthetic material which are described as follows

4.1 Geotextiles

Geotextiles form one of the largest groups of geosynthetics. These are woven, non woven or knittedtextiles consisting of natural or synthetic fibers. These are flexible and permeable in nature.

4.2 Geomembranes

Geomembranes are the other largest group of geosynthetics. These are impervious sheets of polymer mainly used as fluid barriers. These are mainly made up of PVC and HDPE.

4.3 Geogrids

Geogrids represent a rapidly growing segment within geosynthetics. These are planar polymeric structures in grid form [7]. Cross over points is called junctions. Size of the aperture between individual ribs in the transverse and longitudinal directions varies as per the requirement. These are mainly used as a reinforcement material as it can interlock with soil or other earth material by its aperture. There are mainly three types of geogrids, uniaxial, biaxial and triaxial. In uniaxial geogrids, materials are stretched in one direction making it highly oriented in one direction having high strength in one direction only. In biaxial geogrids, materials are stretched in longitudinal as well as in transverse direction having tensile properties in both directions. Triaxial geogrids are triangular structure having multidimensional property. These materials have enhanced level of in-plane stiffness.

4.4 Geocomposites

Geocomposites are formed by the combination of geotextiles, geogrids, geonets or geomembranes for improved structures and enhanced functions.

4.5 Geonets/Geospacers

Geonets are net like structures similar to geogrids but flexible and thinner than that. In it, parallel sets of polymeric ribs are at acute angles to one another. These are also known as Geospacers. There are three types of geonets, biplanar, triplanar and box geonets. Biplanar geonets consists of two sets of intersecting ribs at different angles and spacing of different sizes and shapes. Triplanar geonets have parallel central ribs with smaller sets of ribs above and beneath mainly for geometric stability. Box geonets structures have either box shaped channels or protruding columns from an underlying support network.

4.6 Geosynthetic clay liners

Geosynthetic clay liners are geocomposites formed by sandwiching bentonite clay between two geotextiles or bonded to a geomembranes. Bentonite is clay that swells after absorbing water.

4.7 Prefabricated Vertical Drains (PVDs)

It is also a geocomposite consisting of plastic core and surrounded by non woven. These are held vertically in soils for drainage. Plastic core forms a channel for water movement, while outer geotextile fabric helps in filtation.

4.8 Geocells

Geocells are three dimensional honeycomb structure made by expanding parallel layers of welded polymeric strips. These are textured or perforated cellular mattress in which soil can be filled. Thus the movement of the soil confines to the cell of the structure, thereby known as Cellular Confinement Systems. These structures help in distributing loads over a wider area.

4.9 Geofoam

Geofoam is a light weight, block like polymeric material prepared by processing polystyrene into foam consisting of closed cells filled with air or gases.

4.10 Geocuspates

Geocuspates are used to provide a void space for the passage of either a liquid or a gas commonly used as a component in a Geocomposite. It is used in conjunction with a geotextile filter which helps in maintaining the void space. The secondary textile on the underside, is to improve the interface friction between the geocomposite and the materials that it is in contact with (often a geomembrane barrier/or a geosynthetic clay liner).

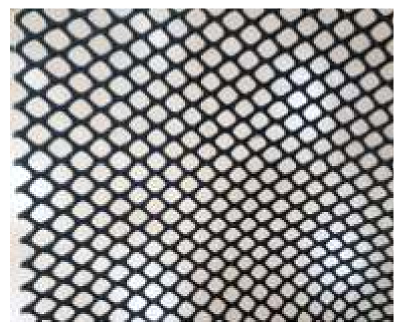
		
Woven Geotextile	Non Woven Geotextile	Geomembrane
		
Geogrid	Geocomposite	Geonet
		
PVDs	Geocell	Geocuspates

Fig 1 Different types of Geosynthetics

5.0 Manufacturing Process of Geosynthetics

5.1. Extrusion

During extrusion process, polymer chips in granular form and additives are fed to the hopper, which passes through the extruder. In extruder, polymer melts at high temp and mixes with additives. Molten polymer is then passed through a spinneret for yarn formation for geotextile materials or through die of desired cross section for making sheet for membranes or grids. Materials are often drawn to impart strength through molecular orientation.

5.2. Manufacturing of Geotextiles

5.2.1. Non woven geotextiles

A nonwoven geotextile is made of directionally or randomly orientated fibres. Fibers are laid down in the form of a web with two principal methods. First one is dry laid or carded webs in which staple fibres are carded and then cross lapped (folded) for web formation and other is polymer laid or spunlaid webs in which fibers from extrusion spinning process are directly collected to form a web. Laid fibers are then mechanically or thermally bonded. In mechanical bonding, fibre entanglement via water jets, needle punching and stitch-bonding techniques are used. In thermal bonding, a thermoplastic component in the form of a homofil fibre, powder, film, or as a sheath part of a bi-component fibre is present in the web which melts forms the bonding region with the application of heat. Finishing of fabric is done by thermal calendaring process in which the nonwoven web is passed continuously between two heated cylinders under pressure.

5.2.2. Woven Geotextiles

In it, two parallel set of materials such as film tape, extruded flat tape, multifilament yarn, monofliament yarn, tape yarn are interlaced at right angle to form a structure. The properties of the geotextile will depend upon the material used and weave pattern.

5.2.3 Knitted Geotextiles

In it, a fabric is formed by a series of interlocking loops of yarn by warp or weft knitted technique.

5.3. Manufacturing of Geogrids

5.3.1. Integral Junction Geogrids

In it, apertures are created by making holes in the extruded sheet of polymers. Sheets are then drawn either in one or multi direction to form a high strength and stiff structure. There are generally two methods for creating holes in the sheet, one in which flat sheet is punched and other is made on circular die with a piston creating the holes.

5.3.2. Fused Junction Geogrids

In it, strips of high tenacity polyester coated with polypropylene for durability are used. The machine and cross machine elements are bonded together by sonic welding.

5.3.3. Woven Junction Geogrids

In it, strips of high tenacity polyester is coated with polypropylene or PVC for protection against environmental exposure. The machine and cross machine elements are interweaved at multiple levels.

5.4. Manufacturing of Geonets

Geonets are manufactured by using a counter rotating die which consists of an inner circular die mounted inside a tubular sleeve. The outer sleeve has longitudinal slots on the inside while the inner tubular section has slots on the outside. Both the sleeve and the tubular section counter rotate, the strands of polymer cross over between 60° to 80° forming diamond shaped aperture and junctions. The net is extruded as a tube which is cut and drawn to create a flat rolled product.

5.5. Manufacturing of Geomembranes

Geomembranes are made of extruded polymer sheets either flat or as a tube that is split in the machine direction. These sheets are then processed by calendaring and/or spread coating. However, they can also be made by impregnating a geotextile with asphalt, or as multi-layer bitumen composites. The raw material can be a plastic (e.g. PVC, HDPE, LLDPE), a rubber (e.g. EPDM, EVA) or a combination of the two.

5.6. Manufacturing of Geocuspates

In it, an extruded sheet is formed into either cups or studs, with a variety of heights and spacing which determine the size and area of the void. There are two methods of forming voids. First one is using vacuum in which a semi molten sheet of polymer is stretched and forced against the mould by vacuum and the other is roller forming in which a semi molten sheet of polymer is passed through two roller having mould design.

5.7. Manufacturing of GCL's

In it, a uniform layer of sodium bentonite is bonded with upper and lower layer of geotextile by an inert adhesive, stitching or by the needle punching process. There should be no pockets or voids that could conduct liquids.

5.8. Manufacturing of Geocomposites

There are generally three methods for combining materials to produce a geocomposite.

5.8.1. Adhesive Bonding

In it, an adhesive is applied to materials by spray, bath or roller to bond them together. The short term and long term properties of the finished composite is determined by the quality of adhesive used.

5.8.2 Heat Lamination

In it, a thin layer of molten polymer is pressed against the other material and pressed to form a composite.

5.8.3 Stitching

In it, components are stitched together using high strength yarns. This is an effective way of combining materials. However it is a time consuming process.

5.8.4 Welding

In it, welding of two materials is done by high frequency ultrasonic acoustic vibrations under pressure. The strength of welded section can be close to the strength of material if done effectively.

6.0 Functions of Geosynthetics

6.1 Separation

Geosynthetic material can separate different type two kinds of materials allow the free passage of liquids/gasses. Commonly used in between subbase/subgrade and around drainage materials.

6.2 Filteration

Geosynthetic materials which are permeable in nature can allow water and liquids to pass though while restraining soil particles when flow is perpendicular to the material. This helps in prevention of soil, sand and other small particles.

6.3 Drainage

Fluids and gases flows along the plane of geosynthetic material acts as a drainage channel. Geotextile material can collect water and discharge slowly along the geotextile.

6.4 Reinforcement

The reinforcement function of geosynthetic material is most commonly used in geotechnical engineering. Tensile modulus, tensile strength, and surface friction are the three important properties of material used in geosynthetic application. It forms a reinforced composite soil when placed in the soil as a reinforcing material. The strength and deformation performance of the reinforced composite soils are improved and enable steep slopes and soil structures to be constructed over weak and variables soils. It also prevents soil erosion.

6.5 Protection

Geosynthetic materials protect the environmental soil from being erosion when used with the soil.

6.6 Containment

Geosynthetic materials help in isolating one material from another. This function is mainly used in landfill where geomembrane lining is placed to prevent the surrounding soil from being contaminated by inner waste.

6.7 Barrier

Geosynthetic materials act as a barrier between two kinds of materials as in GCLs when hydrated sodium bentonite swells 10 times its original weight and becomes effective barrier for liquid or gas.

6.8 Vibrational Energy Absorber

Geosynthetic materials placed as a lining under construction of roads, railways and building helps in absorbing energy caused during road traffic, running rails or during earthquake.

6.9 Thermal Insulation

Geosynthetic mainly as geoforms are used as a thermal insulation materials in building construction.

Different types of geosynthetic materials used in different applications are shown in Table 2.

Table 2 Types of geosynthetic and function

Type	Separation	Filtration	Drainage	Reinforc ement	Protection	Contain ment	Barrier	Vibrational Energy Absorber	Thermal Insulation
Geotextile	√	√	√	√	√	√	√	√	
Geomembrane					√	√			
Geogrid				√					
Geocomposites	√	√	√	√	√	√	√	√	
Geonets			√	√					
GCLs							√		
PVD			√						
Geofoams								√	√
Geocuspates			√						

7.0 Application of Geosynthetics

Geosynthetic materials are used in various applications. Some of them are listed herewith

- Landfill Engineering
- Geotechnical Engineering
- Coastal Protection
- Rockfall Protection
- Canal Lining
- Flood Control
- Drainage system
- Infrastructure

8.0 Market Survey of Geosynthetics

In 2019, the global geosynthetics market size was valued at USD 13.96 billion and is expected to grow at a compound annual growth rate (CAGR) of 5.6% from 2020 to 2027. Lockdown measures imposed by the governing authorities to contain the spread of coronavirus is expected to create uncertainty regarding the growth of the market in the next couple of years.Strict government compliance such as mandate use of Geosynthetics by U.S. EPA in landfills under the Resource Conservation and Recovery Act (RCRA) and infrastructural development in India and Brazil is anticipated to contribute the market growth due to over the forecast period.

8.1 Productwise market share of geosynthetics

The geotextile product segment led the market and accounted for a 48.86% share of the global revenue in 2019. Geomembranes are estimated to expand at a CAGR of 4.4% in terms of revenue from 2020 to 2027 for application as floating covers for reservoirs to control evaporation, reduce the Volatile Organic Compounds (VOCs) emission, and minimize the demand for drainage and cleaning. Percentage wise distribution of geosynthetic product consumption is given in Fig 2.

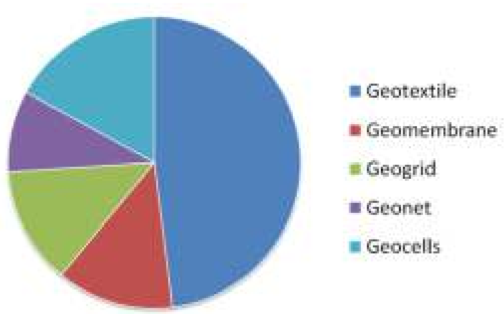


Figure 2 : Global geosynthetics market share by product 2019 (%)

8.2 Regionwise market share by geosynthetics

Asia Pacific led the market and accounted for over 41.0% share of the global revenue in 2019. Developing economies like China and India is expected to drive the regional market over the forecast period due to rising demand for oil reinforcement in the foundation work of residential buildings.

Europe accounted for over 20.0% share of the global revenue in 2019 due to various construction directives, such as 89/106/EEC and M/107 European Union, which has mandated the application of geosynthetics for infrastructure projects. Also, the German government imposed stringent regulations related to waste management practices in the municipal and industrial sectors.

Central and South America, including Brazil are likely to increase the use of geosynthetics due to increase in infrastructural activities in the coming years. Offshore oil and gas sector in Argentina, Venezuela, and Brazil is likely to drive the regional market. Increasing civil and commercial construction activities in the region of Middle East and Africa are likely to increase the demand of geosynthetics, over the forecast period.

9.0 Recent Developments in Geosynthetics

9.1 PLA based green geosynthetics

Green revolution is rapidly increasing in every construction sites in the world e.g., green such area structure, green installation, green industry and has led to development in green geosynthetics. PLA based geosynthetic materials is one such for researchers and to improve its biodegradability it is blended with PBAT (poly (butylene adipate-co- terephthalate) [13].

9.2 Smart Geosynthetics

Smart geogrids embedded with fiber Bragg grating (FBG) for reinforcement as well as the measurement of geotechnical structures have been developed. A paper studied the application of a distributed monitoring system to monitor a laboratory model slope reinforced with smart geogrids, in which the coherent optical frequency domain reflectometry technology (C-OFDR) was used to continuously monitor the geogrid deformations under different surcharge loadings [14].

9.3 Developments in Air Biaxial Tension Tests

Load-strain properties of geosynthetics determined from wide-width uniaxial tension tests are unable to account for stiffer load response due to biaxial loading. It is generally regarded as an index test. A paper presents the development of a biaxial testing procedure to provide load-strain response data necessary to determine in-plane linear elastic tensile properties of geosynthetics. In this, the load is applied in two principal directions and properties studied are two elastic moduli, two dependent in-plane Poisson's ratios and an in-plane shear modulus [15].

9.4 Electro kinetic geosynthetics

Geosynthetics have been identified to play an active role in initiating biological, chemical or physical change to the matrix in which it is installed. This can be done by combining the electro kinetic phenomena of electro osmosis, electrophoresis and associated electro kinetic functions such as electrolysis with the traditional functions of Geosynthetics. In a paper, a set of experimental and software analysis is done on expansive soils under various condition non saturated and fully saturated. Soil samples are tested by using prototype of cyclic loading disk (CLD). This copper is used as anode, aluminium as cathode and perforated PVC tube as drain system. Results show good improvements from lateral sliding and shear strength parameters [16].

9.5 Tri axial testing of multiple layer reinforced geogrids and geotextiles

In a research [17]shear properties and reinforced characteristics of multiple layer reinforced geosynthetic material were evaluated bytriaxial compression tests. Result shows that the geogrid stress–strain curves have hardening characteristics, while the geotextile stress–strain curves have strain-softening properties. With increase in reinforced layers, there is an increase in hardening or softening characteristics. However the reinforcement effect is more significant at a low confining pressure than at a high confining pressure.

9.6 Design of water retaining embankment using geosynthetics

In a study the author has proposed two alternative designs of water retaining embankment with internal drainage system with the objective of minimizing the use of sand by using geosynthetics.One is water retaining embankment with vertical drainage composite and other is water retaining embankment with horizontal drainage composite. Geosynthetics materials used are geotextile, drainage composite (geonet sandwiched by geotextile) and perforated pipe for filtration and drainage function [18] .

9.7 Improvement in shear strength of textured geomembrane (GMB) and nonwoven geotextile (GTX) in landfills

Textured geomembrane (GMB) and nonwoven geotextile (GTX) are usually used together in landfills, but during earthquake the stability of landfills are detrimental due to low shear strength of GMB/GTX interface. In a research[19], a series of displacement-controlled cyclic direct shear tests are conducted in dry and hydrated conditions with a large-scale direct shear machine to study the dynamic shear strength of the GMB/GTX interface. They showed that shear deformation develops along the GMB/GTX interface when specimens are fully hydrated, while the internal failure of GTX is induced in dry condition. A positive correlation is summarized between the shear strength and displacement rate of the interface.

9.8 Geosynthetic clay liners in the Antarctic environment

In a research [20], hydration/dehydration behaviour of geosynthetic clay liner (GCL) under polar conditions for four simulated conditions in Antarcticaviz; (a) hydration during summer, (b) dehydration during a winter-summer cycle, (c) hydration through a fine Antarctic soil, and (d) hydration through a coarse Antarctic soil were studied. Hydration in GCL during the summer is found to occur if there is direct contact with the water table. However dehydration occurs if there is low relative humidity of the environment. Hydration from either fine or coarse Antarctica soil depends on the original gravimetric water content of the subgrade soil, its grain size distribution, low relative humidity prevailing in Antarctica.

10.0 Conclusion

Geosynthetic materials are widely used in various applications and its global market demand is continuously growing. It provides cost-effective solutions for several engineering problems. This paper summarises different types of geosynthetic products, its manufacturing, functions, applications, its market survey and recent developments in geosynthetic products. Innovations in products, types and properties will continue to take place, adding to the already vast range of applications of these materials.

REFERENCES

1. C. Kelsey, “A Brief History of Geotextiles: A 40-Year Update”, *Land and Water*, (2014), URL- https://docplayer.net/50741230-A-brief-history-of-geotextiles.html
2. R. M. Koerner, “Early background and history of geotextiles”, *Geotextiles*, (2016): 3-15, https://doi.org/10.1016/B978-0-08-100221-6.00001-2
3. G. Heerten, “Geotextiles in coastal engineering—25 years experience”, *Geotextiles and Geomembranes*, 1.2 (1984):119-141
4. H. Y. Jeon, “Review of Sustainable Geosynthetic Development Trend with Environmental Adaptive and Eco-Environmental Performances Point of View”, *IntechOpen*, (2019), DOI- 10.5772/intechopen.90336
5. B. J. Agrawal, “Geotextile: It's application to civil engineering-Overview”, *National Conference on Recent Trends in Engineering & Technology*, (2011)
6. S. Jakhar, R. Charkhiya, M. Hooda, ”An Introduction to Geosynthetics Material”, *International Journal of Engineering Research & Technology*, 3.10 (2015)
7. P. G. Nicholson, “Soil Improvement and Ground Modification Methods”, *Elsevier,* (2015): 189-207
8. A. Patel, “Geotechnical Investigations and Improvement of Ground Conditions”, *Woodhead Publishing*, (2019): 61-76

9. H. Y. Jeon "Polymeric Synthetic Fabrics to Improve Stability of Ground Structure in Civil Engineering Circumstance", *IntechOpen*, (2018), DOI- 10.5772/intechopen.81246
10. "High Performance Geosynthetics", URL- https://www.geofabrics.com/app/uploads/download-manager-files/Introduction%20to %20Geosynthetics.pdf
11. N. Touze "Healing the world: a geosynthetics solution", *Geosynthetics International*, 28.1 (2021): 1-31
12. "Geosynthetics Market Size, Share & Trends Analysis Report By Product (Geotextiles, Geomembranes, Geogrids, Geonets, Geocells), By Region (North America, Europe, APAC, MEA), And Segment Forecasts, 2020 – 2027", 978-1-68038-501-4, *Grand View Research*, (2020), URL- https://www.grandviewresearch.com/industry-analysis/geosynthetics-market
13. H. Y. Jeon "Review of Green Geosynthetics by Using Biodegradable Resins for Civil Engineering Application as Tailor-Made Materials", *Juniper Online Journal Material Science*, 1.5 (2017), DOI- 10.19080/JOJMS.2017.01.555571
14. Y. Sun, S. Cao, H. Xu, X. Z "Application of Distributed Fiber Optic Sensing Technique to Monitor Stability of a Geogrid-Reinforced Model Slope", *International Journal of Geosynthetics and Ground Engineering*, (2020): 6-29, https://doi.org/10.1007/s40891-020-00209-y
15. S.W. Perkins, H.N. Haselton, E.C. Newma, "In-Plane Elastic Properties of Geosynthetics from In-Air Biaxial Tension Tests", *Geosynthetics International*, (2020), https://doi.org/10.1680/jgein.20.00044
16. S. Babu, R. Thirumalai, V. Naveen Nayak, S. Gopinath, "Experimental investigation on expansive soils using electro kinetic geosynthetics (EKG) under cyclic loading", *Materials Today: Proceedings,* 37.2 (2021): 1146-1153
17. F. Yi, C. Du, "Triaxial Testing of Geosynthetics Reinforced Tailings with Different Reinforced Layers", *Materials*, 13.8 (2020): 1943
18. S. Soni, A. Prashant, "Design of Water Retaining Embankment Using Geosynthetics for Hydraulic Conditions", Advances in Computer Methods and Geomechanics, *Springer* (2020): 329-342
19. J. Y. Chang, S. J. Feng, "Dynamic shear behaviors of textured geomembrane/nonwoven geotextile interface under cyclic loading", *Geotextiles and Geomembranes*, 49.2 (2021): 388-398
20. G. G. C. Guzman, A. Bouazza, W. P. Gates, R. K. Rowe, R. McWatters, "Hydration/dehydration behaviour of geosynthetic clay liners in the Antarctic environment", *Geotextiles and Geomembranes*, 49.1 (2021): 196-209

Electrospinning Facility at BTRA

The nanofiber spinning machine at BTRA is a needle less solution spinning system from ELMARCO. The electrodes in the machine are wire type. Maximum width of the deposition is 50cm. Using this machine, we can spin continuously roll to roll. Paper, woven, nonwoven and knitted fabric can be used as substrate in the form of roll of 50cm wide. Maximum deposition time is 1min based on the minimum speed of the machine but we can increase the deposition thickness by passing the substrate multiple times. Variable spinning parameters are voltage 1-80kV, distance between the electrodes 80-180mm, relative humidity 45-80% and temperature 23-27°C. We have successfully spun PVA, PAN, Nylon 6, PLA. GSM of the deposited nanofiber can be adjusted by changing the substrate speed.

For more information, contact:

The Bombay Textile Research Association

L.B.S. Marg, Ghatkopar(W),
Mumbai 400086

Tel. : 022-62023636, 62023600

Email : info@btraindia.com
mktg@btraindia.com

Website : www.btraindia.com

ABSTARCT

1. Performance of polypropylene textile encased stone columns

D. Rathod, M.S. Abid, S. K. Vanapalli

Geotextiles and Geomembranes, Volume 49, Issue 1, February 2021, Pages 222-242

This paper explores the potential use of a woven polypropylene textile for encapsulating stone columns and improving performance of a local soft soil in Warangal city of India. A series of axial load tests were performed on stone columns of various diameters and under various encapsulation conditions that include single and double layers and other combinations. Load carrying capacity of stone column increased twice its original capacity when encapsulated with different geofabric materials. Performance enhancement strongly correlated to the tensile strength of encasement material and encapsulation condition. In addition, the influence of lateral thrust on group of stone columns arranged in square and triangular patterns were investigated. Irrespective of the material used, lateral displacement reduced by half for encased stone columns. Apart from tensile strength of encasing material, the amount of material used for encasement in the form of additional encasement layer was found to be crucial. The cost of using the polypropylene encasing material is only a third of the commercial geotextiles; however, the performance is inferior to woven geotextiles but far superior to non-woven geotextiles.

2. Preparation of flexible microwave interactive fabric for 8.2 to 18.0 GHz frequency: Functional evaluation and validation

Krishna Kumar Gupta, Ashutosh C Abhyankar, Anurag Srivastava, Sayad Mohammed Abba

Journal of Industrial Textile, 50(6), 2021, 847–869

In this study, for the first time, coating formulation based on milled carbon fibre has been applied on textile substrate to prepare flexible covering material for microwave protection. Cotton fabric with its inherent high dielectric property and finite length with close network of carbon milled fibre has synergised to generate highly conducting surface (s = 96.22 S/m). The samples are prepared by coating of milled carbon fibre in various concentrations with polyurethane as binder on cotton fabric. Polyurethane contains hydroxyl and hexamethylene diisocynate groups which are polar under external electric field (dielectric constant 3.2–6.5) and also contribute high dielectric properties in coated fabric. Samples were evaluated for surface resistivity and microwave properties, i.e. permittivity, scattering parameters, reflection, transmission, absorption and reflection loss. Permittivity of high level ("0: 21–31, "00: 60–84) and attenuation of high order (a = 1971–2354 Np/m) are achieved. The sample coated with milled carbon fibre and polyurethane in ratio of 1: 1.67 on weight basis has shown 67–70% reflection, 28–30% absorption, 0.1–0.5% transmission, and EMI shielding of 28–30 dB in X (8.2–12.4 GHz) and Ku (12.4–8 GHz) frequency band. The results were further analysed theoretically and correlated with the scattering parameters and other microwave properties.

3. Aerodynamic performance of the supersonic parachute with material permeability

X. Yang, L. Yu, S. Nie, S. Zhang

Journal of Industrial Textiles, 50(6), 2021, 812-829

A new flow field model was established to simulate compressible flow around porous canopy. The compressible Ergun equation was introduced into the source term of momentum equations for the first time to study the influence of material permeability on aerodynamic performance of supersonic parachutes. By using this method, the dynamic variations of related flow field results such as flow structure, drag performance and shock wave standoff distance were obtained. Numerical results including shock wave shape and the average value of drag coefficient are in accordance with the wind tunnel test results. The numerical results show that the velocity-penetrating fabric makes the wake vortex area become narrower and move backward. With the increase of material permeability, the oscillation amplitude and the average value of drag coefficient decrease. This new method can be a good supplement in parachute design and research. It also instructs how to choose fabric for supersonic parachutes.

4. The characterisation of geosynthetic interface friction by means of the inclined plane test

P. Pavanello, P. Carubba, N. Moraci

Geotextiles and Geomembranes, Volume 49, Issue 1, February 2021, Pages 257-275

The paper focuses on the evaluation of the shear strength in conditions of low normal stress of various geosynthetic-geosynthetic interfaces, which are typical of landfill cover systems, by means of the inclined plane test, with the aim of studying the friction mobilisation in relation to various kinematic behaviours. The results of three different methods to evaluate the angle of friction were analysed, together with the sensitivity of the in-terfaces in relation to the wear effect and the influence of the state of hydration. The results showed very different responses of the interfaces to the shear stress, which involved three main types of sliding mechanisms, referred to as sudden, gradual and uneven sliding. Another outcome observed was that the shear strength of geosynthetic-geosynthetic interfaces cannot always be properly characterised following the procedure proposed by the European standard for soil-geosynthetic interfaces (EN ISO 12957–2), since the actual mobilised kinematic behaviour should be taken into consideration. In this regard, the paper provides some hints on the choice of the more representative parameter of friction for each type of sliding. A particular focus was given to the case of gradual sliding interfaces, for which the static friction is difficult to detect due to the very slow movements; for practical purposes, the design friction of these interfaces should be evaluated by using an adequate safety factor with respect to the friction evaluated at 1 mm of displacement.

6. Decolourization of textile effluent using native microbial consortium enriched from textile industry effluent

Saurabh Samuchiwal, Deepak Gola, Anushree Malik[a]

Journal of Hazardous Materials, Volume 402, 15 January 2021, 123835

A robust and efficient treatment process is required to address the problem of residual colour and avoid expensive post-treatment steps while dealing with textile effluents. In the present work, a novel microbial consortium enriched from textile effluent was used to optimize the process of decolourization under extreme conditions with minimum inputs. With Pre-treatment Range (PTR) effluent as a carbon source and only 0.5 g/L yeast extract as external input, the process enabled 70-73% colour reduction (from 1910-1930 to 516-555 hazen) in dyeing unit wastewater. Unhindered performance at higher temperatures (30 °C-50 °C) and wide pH range (7-12) makes this process highly suitable for the treatment of warm and extremely alkaline textile effluents. No significant difference was observed in the decolourization efficiency for effluents from different batches (Colour: 1647-4307 hazen; pH-11.5-12.0) despite wide variation in nature and concentration of dyes employed. Long term (60 days) continuous mode performance monitoring at hydraulic retention time of 48 h in lab-scale bioreactor showed consistent colour (from 1734-1980 to 545-723 hazen) and chemical oxygen demand (1720-2170 to 669-844 mg/L) removal and consistently neutral pH of the treated water. Present study thus makes a significant contribution by uncovering the ability of native microbial consortium to reliably treat dye laden textile wastewater without any dilution or pre-treatment and with minimum external inputs. The results ensure easy applicability of this indigenously developed process at the industrial scale.

7. Recycling hazardous textile effluent sludge in cement-based construction materials: Physicochemical interactions between sludge and cement

Zhan, Bao Jian, Jiang-Shan Li, Xuan, Dong Xing, Poon , Chi Sun

Journal of Hazardous Materials, Volume 381, 5 January 2020, 121034

The textile industry produces a large amount of textile effluent sludge (TES). Many studies have explored the potential use of TES in cement-based materials. However, the physicochemical interactions between the TES and ordinary Portland cement (OPC) have rarely been studied. In this study, the effects of increasing dosage (0–20% by OPC) of TES on the performance of OPC-TES blends were investigated in terms of hydration progress, mechanical strength, microstructure evolution and metal leachability. The results showed that TES markedly delayed the OPC hydration at the early age, and increasing dosages of TES decreased the portlandite content at 7 and 28 days' age. Compared to the reference, the OPC-TES mortar exhibited seriously degraded mechanical strength; when using 20% TES, the decrease in compressive and flexural strength reached up to 71% and 42% respectively at the age of 28 days. Scanning electron microcopy and mercury intrusion porosimetry found the inclusion of TES introduced more weak interfaces in the cement mortar, thus increased the total porosity especially the macropores. But leachability tests revealed all the toxic metals in the TES were stabilized after the incorporation of OPC and exhibited very low metal mobility in the OPC-TES mortar, which posed no environmental risk.

8. Separation of reactive dyes from textile effluent by hydrolyzed polyacrylonitrile hollow fiber ultrafiltration quantifying the transport of multicomponent species through charged membrane pores.

Madhurima Dutta, Saikat Bhattacharjee, Sirshendu De

Separation and Purification Technology, Volume 234, 1 March 2020, 116063

A hydrolyzed polyacrylonitrile (PAN) based ultrafiltration grade hollow fiber membrane using sodium hydroxide having high surface potential was developed in this work. Efficacy of this membrane was demonstrated in treatment of textile effluent. Scanning electron microscopy (SEM) clearly showed that hydrolysis of PAN fibers (HPAN) made them dense. Fourier transform infrared (FTIR) spectra clearly indicated the functional groups confirming the hydrolysis of PAN matrix. The molecular weight cut-off of the HPAN fibers was reduced to 5 kDa from 20 kDa of untreated PAN lowering the average pore radius from 3.6 to 1.8 nm. A decline in the water contact angle of HPAN to 54° from 78° indicated the formation of a more hydrophilic membrane. The surface zeta potential of the hollow fiber was lowered to −12 mV from −2 mV imparting the negative potential on the membrane promoting charge-charge interaction between membrane pore and charged species during filtration. The surface roughness of the membrane was reduced almost by one order of magnitude after hydrolysis indicating its antifouling characteristics. The transport of the dyes and the electrolyte through the membrane pores was analyzed using Donnan steric pore model (DSPM) for a multicomponent system applicable for low cut off ultrafiltration. Contribution of various transport mechanisms, i.e., diffusion, convection and electro-migration was quantified. Thus, the novelty of this work includes (i) development of low cut off ultrafiltration grade hollow fibers; (ii) their application in treatment of real life effluent containing four reactive dyes; (iii) development of multicomponent pore transport model using DSPM.

9) Flame-retardant cotton fabrics modified with phosphoramidate derivative via electron beam irradiation process

Y. Liu et al., J. Ind. Text., p. 152808371988181, Oct. 2019.

In this study, a novel flame-retardant diethyl methacryloylphosphoramidate containing phosphorus and nitrogen was synthesized and characterized by Fourier transform infrared and nuclear magnetic resonance. The synthesized compound was grafted onto cotton fabrics using electron beam irradiation and pad dry cure processes. Scanning electron microscope and X-ray photoelectron spectroscopy were used to characterize the surfaces of the modified cotton fabrics to confirm that diethyl methacryloylphosphoramidate was grafted on cotton fabrics successfully. Both electron beam–cotton and pad dry cure–cotton exhibited efficient flame retardancy which was proved by limiting oxygen index and vertical flammability test. Thermogravimetric analysis results showed that both electron beam-cotton and pad dry cure–cotton degraded at lower temperature and produced higher yields at 600°C. The tensile loss of electron beam–cotton was lower than that of pad dry cure–cotton, and within the acceptable range in flame retardant finishing.

10) Water repellent treatment of cotton fabrics by electron beam irradiation

Z. Jiang, Y. Wang, Y. Liu, and X. Ren, Fibers Polym., vol. 17, no. 7, pp. 1013–1017, Jul. 2016.

In this study, traditional dip-pad-cure (DPC) process and electron beam (EB) irradiation were used to graft cotton fabrics with fluorine containing chemical, 1H,1H,2H,2H-perfluorooctyl acrylate (PFA). The grafted cotton fabrics were characterized by FT-IR and SEM. The water repellent properties were measured by contact angle, hydrostatic pressure, and spry test. It was found that there was no significant difference between the grafted cotton fabrics with DPC and EB methods, and the treated fabrics showed good water-resistant properties. The grafted cotton fabrics also showed good washing stability. By measuring the bending rigidity and bending hysteresis, it was found that the cotton fabrics grafted with PFA became softer than untreated samples.

11) Antibacterial and Hydrophilic Modification of PET Fabrics by Electron Beam Irradiation Process

S. Zhang, F. Ding, Y. Wang, X. Ren, and T. S. Huang, Fibers Polym., vol. 21, no. 5, pp. 1023–1031, May 2020.

Electron beam (EB) irradiation has been utilized to modify materials for various applications due to its remarkable advantages. As an efficient and environmental-friendly way for antibacterial and hydrophilic purposes, EB irradiation was applied to modify polyethylene terephthalate (PET) fabrics by grafting with a N-halamine precursor monomer 3-allyl-5,5-dimethylhydantoin (ADMH) and acrylic acid (AA) in this study. The grafted PET fabrics were loaded with silver ions to further enhance the antimicrobial efficacy. The hydrophilicity of the modified PET fabrics was evaluated by testing the water contact angles with different contact times. The breaking strength and thermal stability of the modified swatches were studied. The UVA light stability results showed the chlorine loading of the modified PET fabrics decreased with the extension of UVA exposure time, and most chlorine loading could be recovered by re-chlorination. The antibacterial test showed that the modified PET swatches can inactivate all inoculated *S. aureus* and *E. coli* with short contact times.

12. Predicting the delamination factor in carbon fibre reinforced plastic composites during drilling through the Gaussian process regression

Yun Zhang and Xiaojie Xu

Journal of Composite Material,published on 29 Dec 2020

https://doi.org/10.1177/0021998320984245

The carbon fibre reinforced plastic (CFPR) has been widely used in aircraft structural applications due to the superior modulus, specific tensile strength, and fatigue strength. The inhomogeneous and anisotropic nature of these composites poses great challenges on the machining process. Particularly, the delamination is one of major defects associated with drilling, which has a significant impact on CFRP's structure integrity and application. Machine learning approaches can help facilitate the optimization of machining processes. In this study, we develop the Gaussian process regression (GPR) model to predict delaminations in carbon fibre reinforced plastic composites during drilling from machining parameters. The model is simple and highly accurate and stable that contributes to fast delamination estimations. By combining the optimization results from the Taguchi method and GPR approach, it is expected that more quantitative data can be extracted from fewer experimental trials at the same time.

13. The reinforcement of styrene butadiene rubber composites with simple environmentally friendly aramid fiber modification

Yongchun Ji Chunli Liu Zhu Luo Jincheng Zhong Lianpeng Yin

Polymer composites: 27 December 2020

https://doi.org/10.1002/pc.25925

The surface treatment of aramid fiber (AF) improved the properties of reinforced composites. However, many AF modification methods were difficult to apply to the mass production of reinforced composites due to drawbacks, such as processes that were complex and not environmentally friendly. This paper described three simple and environmentally friendly methods for AF surface treatment and their effects on the properties of reinforced aramid fiber/carbon black/butadiene benzene ethylene rubber (AF/CB/SBR) composites. The AF was treated by thermal oxidation and coated with butadiene-styrene-pyridine rubber latex (VPL) or maleated polybutadiene liquid rubber. Then, AF/CB/SBR composites were produced when the modified AF was introduced into the SBR matrix. The results showed that compared with that of the composite with untreated AF, the interfacial bonding between the modified AF and the rubber matrix was improved, especially for tensile modulus elongations of 100% and 300%, and the tear strength of the composites was enhanced. Compared with those for the rubber composites with the AF treated by thermal oxidation, the mechanical properties of the rubber composites with the coated AF showed a greater improvement, but the heat generation was higher. Moreover, the thermal oxidation method not only improved the constant elongation stress and tear strength but also reduced the heat generation of the materials.

14. Development and characterizations of ultra-high molecular weight EPDM/PP based TPV nanocomposites for automotive applications

Asit Baran Bhattacharya ,Aswathy T., Raju Tuhin ,Chatterjee ,Kinsuk Naskar

Polymer composites : 18 August 2020s

https://doi.org/10.1002/pc.25765

This research article reports, the preparation of thermoplastic vulcanizates (TPVs) and TPV nanocomposites (TPVNs) based on EPDM and polypropylene (PP). New generation ultra-high molecular weight EPDM (UHMW-EPDM) and PP with nano-fillers (nano-clay and nano-silica) and has been studied and characterized extensively typically for automotive applications. This special type of UHM-EPDM-based TPVs exhibit superior physico-mechanical properties over conventional EPDM-based TPVs and in the presence of nano-fillers, they show even better physical properties. The TPVNs were prepared with a fixed EPDM: PP ratio and the nano fillers were varied at different concentrations. The influence of nano-fillers, especially hectorite nano-clay and nano-silica has been first explored through physico-mechanical properties. Tensile strength, elongation at break, and modulus at various strain are improved for nano-filler filled TPVNs. We have observed that due to the incorporation of nano-fillers into the TPV matrix, swelling has been decreased. From morphology (AFM, SEM) study, it is observed that the fillers are well dispersed in the TPV matrix and nano-silica fillers are well dispersed than nano-clay (hectorite). Furthermore, small-angle X-ray scattering (SAXS) studies have also been pursued to get a better insight into the TPV system. These newly developed TPVs can be used as potential candidates for application in the automotive sector.

15. High-efficiency ammonium polyphosphate intumescent encapsulated polypropylene flame retardant

Zhe Huang , Bo Ruan , Jin Wu , Ning Ma, Tao Jiang ,Fang-Chang Tsai

Journal of Applied Polymer Science, Volume138, Issue20

May 20, 2021, 50413

Abstract: The flame retardant polypropylene containing the micro-envelope core-shell structure flame retardant, which encapsulated ammonium polyphosphate into melamine-formaldehyde resin and sodium silicate through in situ polymerization was prepared with polyamide 6, added as a carbon-forming agent. The composition of ammonium polyphosphate, encapsulated ammonium polyphosphate with melamine-formaldehyde resin and the micro-envelope core-shell structure flame retardant were characterized. The fire safety and thermal stability were investigated and showed an improvement including limiting oxygen index, thermogravimetric analysis, vertical burning tests, and microscale combustion calorimeter. The burned compounds were also studied to confirm the burning mechanism. The results showed the flame retardant performance had been greatly improved, while polyamide 6 had better char-forming effect. Besides, the water solubility of flame retardants and their influence on the mechanical properties of polypropylene were also investigated. The results on the effects of additives demonstrated a high efficiency flame retardant to polypropylene. A core-shell flame retardant that sodium silicate and melamine-formaldehyde resin-coated ammonium polyphosphate had been constructed. The effect of the built flame retardant system on the combustion performance of polypropylene was studied from the mechanism and performance. The LOI of the most flame retardant polypropylene reached 28.6%, and UL-94 reached the V-0 level.

16. Comparison of Coconut Root with Other Geotextiles for Transportation Infrastructure

July 2020, DOI: 10.1007/978-981-15-4577-1_89

Leonardo Souza, PurnanandSavoikar

To match India's rapid growth, the transportation infrastructure has to keep pace especially in the rural regions. Embankments and hill slope stabilizations comprise a major challenge in this sector. Today, the focus of development has shifted to natural products and sustainable infrastructure. In this respect, it is vital to also study a technique that has been used for centuries by the Saraswat civilization that settled in Goa and is today classified as natural geotextiles. This paper compares the Geotextiles used today with this ancient sustainable technique. The benefits of this technique are comparable to those of modern plastics while sustainability is far better.

17. Influence of single-layer geotextile reinforcement on load capacity of buried steel box structure based on laboratory full-scale tests

Adam Wysokowski

Head of Road, Bridge and Raiway Department, Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, prof. Z Szafrana St. No. 1, Building A-8, 65-417, Zielona Góra, Poland

The paper attempts to evaluate changes in the load-bearing capacity of buried flexible structures in the aspect of using geotextiles as reinforcement of backfill. The laboratory tests carried out on a natural scale of steel box buried flexible structures with the use of only one layer of geotextiles confirms that the application of such reinforcement reduces the displacements and contributes to a slight reduction in stress values in the structure under maximum static loads. The results of vertical displacements of the crown of the structure for different types of static loads are even up to 30% lower for all cases of loads when a geotextile is used. In the case of the comparison of stress values in structural steel in the crown of the structure, a slight reduction under maximum static loads occurs. The carried out analyses were aimed at determining to what extent the use of one layer of geotextiles affects the bearing capacity of a tested buried flexible structure made of corrugated steel plates.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