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ENGINEERING OF GEOTEXTILES — THE EXPERIENCES OF A MANUFACTURER

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1. INTRODUCTION

The Geotextile has become as synonym with many civil engineering structures as is cement and sand. This is true for developed countries but the days for adoption of the same in India may not be too far. Extensive research in this field and large scale application has provided the guidelines, today, in testing of soil, designing of structures and in specifying fabrics. India also has its goods share in research and in many small scale experimentations. This paper is an attempt to open the dialogue for inter disciplinary discussion on problems involved in manufacturing of the geotextile fabrics to the specifications and supply to the user with reasonable cost. A mutual understanding help in future applications.

2. ENGINEERING OF GEOTEXTILES

Engineering of any fabric has to be followed in a scientific manner. Once the end use requirements are known then all possible options in designing of fabric to match the end use demand are to be tried. They may be raw material selection, web preparation, machine parameters, process parameters and finishings. Let us discuss the role of such parameters in engineering of geotextiles.

2.1 Raw Material Selection: The criterias involved in raw material selection are type of fibre, cross sectional shape, fibre length, crimp, fiber denier, fibre finish, strength and elongation and cost. The literature search shows that at many applications in civil engineering blends of fibres or use of special fibres are rarely adopted. Where as no single fibre meets all end use requirements. The acrylic fibre can be selected when low strength and high water transportation is required. Polypropylene is ideal for Geotextile but it lacks in resistance to sunlight, etc. While polyester is stronger, resilient but lacks in resistance to certain chemicals. It is cheaper than PP in India. The nylon is again stronger but smoother and difficult to prepare web.

Finer fibres produce stronger, compact and less permeable fabric [11, 2]. Similarly the longer fibres [3] increase the fabric strength due to higher fibre interlocking. The fibre strength and elongation have influence on fibre carrying, fibre rupture, interlocking and in turn on fabric strength, elongation and compactness. Similarly high crimp fibres, non circular cross-sectional fibres [4, 7] increase bulkiness of fabric and permeability. The fibre finish applied helps in pushing of fibres by needles and locking-in. However, when selection of fabric is influenced by price then many of above options are compromised.

2.2 Web Preparation: The various factors involved in web preparation are, GSM of web, number of layers in final web [11], thickness of web, fibre orientation, opening of fibres, laying of web, etc. When initial card web is thin then fibre opening, orientation and fibre locking is better. The thicker webs get drafted more leading to higher unevenness in fabric. By changing the fibre orientation the strength and elongation of fabric in any specific direction (MD & XMD or any other) can be changed. Fibres can be randomly oriented to produce fabric with equal strength in all directions and also of high puncture resistance. But cross lapping and longitudinal laying are largely practiced. The simple laying by above methods have wide disparity in strength to their directions. The strength ratio from 10:1 can be brought down to 1:1.

2.3 Machine Parameters: The needling machine (as the paper discusses only needle punched non-wovens for Geotextiles) can be adjusted by many of its parameters listed below:

Needle Shape : The two important contradictory properties of geotextile strength and permeability can be balanced by using star needles which increases strength by retaining permeability [3].

Barb Shape : Rounded barb shape with no-kick-up and 20° barb angle [3] reduces fibre damage and increases strength due to higher fibre inter locking. This also reduces size of holes and permeability. While lower barb angle produces lofty and thick fabric as it carries less fibre with it.

Barb Spacing : When needling is from top and bottom of web then close barb [3] spacing and more number of barbs reduce fibre damage and better entanglement and permeability increases. The orientation of barb in weaker direction of web (MD or XMD) helps in improving fibre reorientation and increase of strength in that direction.

2.4 Process Parameters : A number of options available in selection of process parameters are - Needle punch depth, Distance between hole plates, Pre-needling density, Number of runs, Final needling density, Punching speed, Number of barbs punching the web, Diameter of holes, Rate of web movement, Calendering or any other, 'Drafting of web, Finishing to fabric.

The fibres carried by needles, its depth of movement in web, help by the plates and their hole diameter, etc. [2, 5] decide the fibre entanglement and pore size in fabric. The strength puncture resistance, compactness and permeability, clogging of holes are affected by them. The drafting of web leads to unevenness in it. The increase of needle density in single run or reducing the number of runs [2] increases unevenness and reduces strength. The higher number of layers in web also reduces their splitting tendency. The calendering of fabric [9] at certain heat reduces thickness, permeability and increases strength. Relaxing of fibres by passing through ovens or stenter improves the stability of fabric by retaining their original properties for longer duration when laid under soil.

3. CASE STUDIES IN ENGINEERING OF GEOTEXTILES

The difficulties encountered in engineering of geotextiles can be pointed out with some specific examples.

3.1 Erosion Control: The 'Geotextile A' supplied for sea erosion control against tidal waves at sea port had the specifications as listed in Table 1. The fabric was used for wave protection at the sides of structures projecting to sea. The geotextile was expected to permit reversing flow conditions without allowing soil particles to follow them. Then permeability, pore size and its distribution, range of pore sizes alongwith strength and elongation is important. But the manufacturer was compelled to compromise in permeability and pore size both for obtaining specified strength. The GSM and thickness are increased by 10% and above. In fact the strength value could have been met by specified GSM if good quality fibre was used. This increases cost of fabric. By changing the needle, or cross lapping or fibre denier or their blend, etc. the specifications could have been met. Such modifications in process again add to the cost. The order was for a small quantity of 6300 sq.m. The fabric was, therefore, manufactured by using substandard raw material and without modifying the process. Probably the customer not being serious in application of geotextile counts cost in deciding the purchase of fabric.

Table 1: Specifications of Geotexiles

Sr. No.	Properties	Geotextile A		Geotextile B		Geotextile C	
		As per order	Actual supplied	As per order	Actual supplied	As per order	Actual supplied
1.	Material	PP	PP	PP	PP	PP	PP.
2.	GSM	300	350	100	180	400	430
3.	Thickness in mm	3	3.3	0.9	1.73	3.5	4.3
4.	Tensile strength - MD in kgs. - XMD	72 72	80 110	36 36	28.7 46	100+5% 90+5%	98 186
5.	Breaking elongation-MD in % - XMD	60 60	90% 75%	NS NS	NS NS	NS NS	86 57
6.	Water permeability in lit/m^2/sec.	72	66	110	100	NS	45
7.	Pore size in microns	NA	78	150	NA	150-200	65
8.	Bursting strength in kg/cm^2	NS	NS	16	17	NS	NA
9.	Resistance to chemicals & bio-degradation	Good	Ex.	Good	Ex.	Good	Ex.

NS - Not specified, NA - Not available, Ex - Excellent

3.2 Drainage in Agriculture: Though the end use has been named as drainage the function of geotextile was to release and distribute water in controlled rate so that soil around it in agriculture field remains damp. The fabric was covered on perforated pipes connected to water tanks. The 'Geotextile B' was supplied for this application. The 0_{95} value of fabric was to be between 100 and 150 microns, the thickness and GSM were the minimum values acceptable. The water permeability, quite naturally, should be as per specifications.

In the designing of this fabric the polyester fibre could have easily met the end use requirements. This fibre being cheaper in India could be cost effective. At the same time the water transportation across and along the fabric by capillary action could be appropriately achieved by utilising fibre of hollow or trilobal cross section. But by use of polypropylene with available length and denier of the fibre we could do our best to the specification supplied. If cost factor is not again the constraint, we could have improved water permeability by changing depth of penetration of needle, or by using coarser needle, or by using less GSM and better quality fibre or by changing cross lapping angle to secure minimum strength required. Use of polyester would have been the best option. Even use of better quality polypropylene was not practically possible because of only 1300 sq.m. of fabric requirement. One more lot of fabric for the same end use is supplied recently.

3.3 Road: The 'Geotextile C' was supplied for construction of approach road to creek. The use of scrim cloth was permitted. When the fabric was taken up for designing it was not possible to achieve such fine opening by coarse fibres and for given GSM. Finer fibres had to be blended. The strength value in MD specified was very difficult to achieve. The scrim cloth of required construction in small quality was not available. Manufacturing the same against order consumes time and money. The GSM of the fabric was increased to 430 which increased the thickness to 4.3 mm. While maximum thickness allowable, as per specifications was 3.8 mm. This increased thickness reduced the opening size (dry sieve method) to 65 microns though minimum specified was 150 microns.

As discussed in previous examples the machine or process parameters could have been modified to achieve given specifications. But they need special inventory and time consuming operations. Use of good quality fibre would have helped again. All such possibilities are restricted by price factor. Unfortunately price of fabric is given much importance and it is really amazing that the most critical functional properties in road application like opening size, water permeability and thickness are compromised for cost. These properties were especially of high importance when the fabric was used in high water bed soil receiving more rain.

Another lot of fabric of 525 GSM has been supplied for unpaved approach road to jetti where unloading of huge machines takes place. Surprisingly, in this case, only tensile strength was strictly demanded not other properties.

We have supplied geotextiles to chemical waste disposal control site, pier construction under creek water, stabilisation of soil for construction, and many more.

4. EXPECTATIONS OF GEOTEXTILE MANUFACTURER

We being the largest needle punched nonwoven fabric manufacturer in India are capable of supplying fabrics of varied specifications. Provided the cost is not imposing severe restriction. If the demand for geotextile increases then we will have more freedom in raw material selection. The order for small quantities do not permit us neither to purchase new lot of fibre for this purpose nor to maintain inventory of wide range of fibres.

The fibre other than PP may be more suitable in few cases. Especially, as on date, polyester costs 60% less than PP in India. The civil engineers are requested, hereby, to consider the option of using polyester wherever possible.

The criteria of selecting the fabric based on specifications achieved should have higher weightage than that of price. We are clearly aware of that use of substandard fibres do not perform satisfactorily at the laying site. We are sorry to say that our organisation (or any other manufacturer for that matter) is not meant for charity. We, therefore, request the geotextile users to give more importance to quality of fabric than price.

One of the problems we are frequently encountered with is testing of geotextiles. For tensile strength testing of wider strip width the standard clamps are not available. This introduces variation in results. At many end uses strain rate should be different [10]. That is not specified to us. The testing of permeability or opening size is generally performed by locally fabricated instruments. The instrumental error factor is involved. Similarly the availability of standard size sand particles. So is the case with puncture resistance. The heavy GSM fabrics can not be tested for bursting strength. We require such testing facility on instruments of international standard to avoid errors.

One of the most common problems in manufacturing is supply of fabric through traders. The user is not directly contacting us. We are not told the end use. We do not get chance to visit the site. We are not receiving feed back. These aspects severely restrict enrichment of our knowledge, scope for judicious designing of fabric and utilisation of our know-how in further designings.

CONCLUSION

The engineering of geotextile is a bit difficult task but we are capable to perform it. The users of geotextiles shall give higher weightage to quality aspects than cost factor in selection of fabric, so that we can engineer it better utilising all possible combinations listed above. As far as possible the fabric shall be purchased directly from the manufacturer by supplying sufficient specifications or by a dialogue with them. The availability of performance report helps in improving designs. Let the geotechnical engineering forum develop standard instruments (though many testing procedures are standardised) for testing geotextiles. The manufacturers of geotextiles are well equipped and capable in meeting the demands of geotechnical engineers. A large scale application of it will benefit both and also the society.

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