Performance of Certain Antimicrobial Treated Nonwoven Jute Fabrics

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ABSTRACT : In the present study, nonwoven needle punched jute fabrics weighing 350 g/m^2 with three different needle penetration depth viz. 10,12,14 mm were prepared. These fabrics were further treated with each of the following combinations of chemicals to give the jute fabrics resistance to microbial attack as well as strength : (a) Copper napthenate + Acrylic binder (b) Copper chromium arsenic (CCA) + Acrylic binder (c) Coal pitch + Anthracene oil. Accelerated soil burial test of the fabrics was carried out in a compost of fertile garden soil and cowdung manure for different time span. Geotechnical properties e.g. tensile, thickness, bursting, puncture, California Bearing Ratio (CBR), water permeability, pore size distribution were tested for treated as well as untreated fabrics. Among the combinations, coal pitch + anthracene oil treated samples gave best results under the soil burial condition.

KEYWORDS : Antimicrobial agent, Card, Cross-lapper, Needle, Nonwoven, Soil burial test.

1 INTRODUCTION

The use of geotextile in civil engineering constructions is well accepted all over the world because it facilitates simplified construction under adverse conditions, saves time, its properties are more reliable than that of soil and cost effective. Today's geotextiles are manufactured mainly form synthetic fibres like polyester, polypropylene etc. Over the past decade, fabrics made of these fibres have been specially developed to meet the functional properties required for various geotechnical applications (Giroud, 1984). Unfortunately, the cost of synthetic fibres in India and some other Asian countries is substantially high and hence they are not in a position to adopt this technological advantage to the full extent. On the other hand, jute is cheap and available in abundance here. So far many researchers acknowledged the potentiality of geotextiles made from natural fibres like jute (Thomson, 1988; Mondal, 1988). In this context, a number of laboratory studies on jute based geotextiles have shown satisfactory results (Ramaswamy et al., 1983; Lee et al., 1989; Aziz et al., 1991; Talukdar et al., 1992). However, biodegradability of jute hinders its use in major areas of geotechnical applications. Jute fabrics, therefore, have to be treated with antimicrobial agents to increase their life span in the soil.

In the present work, nonwoven needle punched jute fabrics were treated with three different antimicrobial agents and tested to envisage the possibilities of using them for geotechnical applications.

2 SAMPLE PREPARATION

Jute fibres (TD4 variety) with 0.2% oil content were opened and fed to a nonwoven needle punching machine comprising of a roller clearer card, a cross-lapper and a needle punching loom. Fabrics of 350 g/m^2 were prepared with three different needle penetration depth viz. 10, 12 and 14 mm. Since jute is a brittle fibre, it tends to produce dust due to fibre breakage during mechanical processing. To reduce this, all the samples were prepared with lower punch density (100 punches/cm^2).

In order to make jute fabric resistant to microbial attack as well as to improve its strength, samples were treated with different combination of chemicals. These combinations are given below. Thickness and linear density of the samples are shown in Table 1.

2.1 Acrylic binder + Copper napthenate

Acrylic binder (30%) and copper napthenate were mixed in the ratio of 15 :2 by vigorous stirring. Samples were passed through the mixture and squeezed in a padding mangle. Subsequently, the samples were dried and cured at 125°C for five minutes.

2.2 Acrylic binder + Copper chromium arsenic (CCA)

Acrylic binder (30%) and CCA were mixed by stirring in the ratio 10:1 and the samples were impregnated with the mixture and passed through a pair of nip rollers. The samples were dried and cured in the same manner as above.

2.3 Coal pitch + Anthracene oil

Coal pitch is a dark brown residue left after coal tar is redistilled. It is combustible in nature and softens at 65°C. The samples were treated with the mixture of coal pitch (90%) and anthracene oil in the ratio 20:1. The samples were dried at ambient temperature.

Table 1. Thickness and Linear Density

Sample	Thickness* (mm)	Linear Density* (g/m^2)
Untreated	3.05	350.93
Binder + Copper napthenate	2.85	455.50
Binder + CCA	2.90	437.25
Coal pitch + Anthracene oil	2.75	787.50

*average

3 SOIL BURIAL TEST

This method developed by American Association of Textile Chemist and Colourists (AATCC test method 30 - 1974) was followed with certain modifications. A compost was prepared by thoroughly mixing fertile garden soil, cowdung and sand in the proportion of 2:1:1. Its moisture content was adjusted to 60% of maximum holding capacity and maintained throughout the experiment. To ascertain the development of fungi culture, pieces of grey cotton fabric when buried in this compost for 10 days were found to be severely damaged which indicate development of fungi culture. Sample pieces of size 400 mm x 250 mm were buried in a pit of 1200 mm x 900 mm filled with the compost for different duration i.e. 15, 30, 45 days. Thereafter, they were washed immediately to remove the adhering soil particles and dried.

3.1 Properties of soil

Properties of the soil used in the compost are as follows :

Dry density, kN/m^3	15.55
Natural moisture content (%)	23.50
Optimum moisture content (%)	22.28
Gravel (%)	00.00
Sand(%)	21.00
Silt (%)	53.00
Clay (%)	26.00
Liquid limit (%)	52.12
Shrinkage limit (%)	26.65
Plastic limit (%)	15.85

4 RESULTS & DISCUSSION

Sample codes of the fabrics are given below.

UJ_j	Untreated jute fabric
PCN_j	Acrylic binder + Copper napthenate
$HCCA_j$	Acrylic binder + Copper chromium arsenic (CCA)
CA_j	Coal pitch + Anthracene oil (j = 1,2,3 indicate 10,12,14 mm needle penetration depth respectively)
NDP	Needle penetration depth
MD	Machine direction
CD	Cross direction

Tensile strength in cross direction is always higher than that in machine direction as shown in Table 2. This is because of orientation of fibres mostly being in cross direction owing to cross laying of card web during manufacturing of fabrics. The results indicate the tensile strength of untreated samples is slightly increased when NDP increases from 10 mm to 12 mm. Further increase in NDP results in reduction of strength. Statistically the values are significant at 5% level only in machine direction. In fact, Hearle et al. (1974) and Debnath (1978) mentioned that the effects of NDP are complicated by the interaction of number of barbs and other parameters. In general, tensile strength of the untreated jute fabrics is very low. Strength of treated fabrics is about 5 to 25 times higher than that of untreated fabrics; CA_j treated fabrics give highest tensile strength. Results clearly

Table 2. Tensile Strength in kN/m

Sample code	days							
	0		15		30		45	
	MD	CD	MD	CD	MD	CD	MD	CD
UJ_1	0.82	1.62	0.65	1.25	0.36	0.82	-	-
UJ_2	0.95	1.75	0.46	0.95	0.32	0.66	-	-
UJ_3	0.72	1.07	0.35	0.80	0.25	0.62	-	-
PCN_1	4.56	8.56	4.14	7.07	3.57	6.21	2.93	6.21
PCN_2	4.25	8.32	3.82	8.00	2.57	7.07	2.26	6.27
PNC_3	4.02	8.12	3.76	7.85	2.19	7.12	1.82	6.02
$HCCA_1$	8.65	16.24	8.13	16.07	5.62	10.27	4.85	9.92
$HCCA_2$	8.25	12.93	7.95	11.75	6.29	9.92	5.20	8.77
$HCCA_3$	8.12	13.63	7.85	11.20	6.78	10.29	5.51	8.20
CA_1	20.15	32.62	20.09	32.52	20.16	32.53	20.12	32.50
CA_2	19.27	32.12	19.18	32.08	19.07	32.05	18.27	32.07
CA_3	19.86	31.25	19..57	31.02	19.26	31.09	19.09	31.07

Table 3. Bursting Strength in kN/m^2

Sample code	days			
	0	15	30	45
UJ_1	245.0	150.0	90.1	-
UJ_2	225.4	160.7	89.2	-
UJ_3	205.8	140.6	50.7	-
PCN_1	313.6	265.6	190.2	100.1
PCN_2	303.8	260.6	185.7	101.2
PCN_3	300.0	254.5	175.6	98.3
$HCCA_1$	340.8	280.7	262.9	180.7
$HCCA_2$	340.2	275.6	261.2	120.7
$HCCA_3$	335.2	269.3	259.2	111.7
CA_1	280.8	269.8	265.7	270.9
CA_2	275.2	270.6	272.6	270.0
CA_3	260.7	255.8	250.2	260.0

show that tensile strength of untreated jute fabrics is significantly affected even during 15 days of soil burial whereas that of PCN_j and $HCCA_j$ samples are stable upto 30 days. There is no significant deterioration in tensile strength of CAj samples even after 45 days of soil burial test.

$HCCA_j$ samples have given highest bursting strength values as shown in Table 3. Nevertheless, CA_j fabrics have lowest busting strength amongst the treated samples before soil burial, there values remain the same during the accelerated soil burial period. On the other hand for all the other samples, there is a significant drop in the values during that period.

Cone drop test (Table 4) reveals that total failure occurs in case of untreated jute fabrics whereas CA_j samples have the maximum puncture resistance. Surprisingly, the puncture resistance of CA_j samples is also affected by soil burial test which cannot be explained.

It is found from Table 5 that with geotextile the ratio C_1/C_2 (CBR with geotextile/CBR without geotextile) increases except for untreated jute fabrics. The maximum values are obtained with CA_j samples. This indicates that treated fabrics increase the bearing capacity of the soil considerably. It is observed that there is no correlation between plunger penetration depth and C_1/C_2 ratio.

Results presented in Table 6 show that the water

Table 4. Puncture Test (hole diameter in mm)

Sample code	days			
	0	15	30	45
UJ_1	-	-	-	-
UJ_2	-	-	-	-
UJ_3	-	-	-	-
PCN_1	32	38	45	-
PCN_2	38	40	48	-
PCN_3	36	39	45	-
$HCCA_1$	23	29	35	42
$HCCA_2$	23	28	32	43
$HCCA_3$	23	28	36	45
CA_1	19	20	22	25
CA_2	20	21	25	28
CA_3	22	22	25	30

Table 5. CBR Test

Sample code	Plunger penetration (mm)	with GT(C_1)	without GT(C_2)	(C_1/C_2)
UJ_1	2.5	6.15	6.27	0.98
	5.0	7.24	7.99	0.90
	7.5	7.36	7.82	0.94
PCN_1	2.5	7.52	7.24	1.20
	5.0	7.76	6.79	1.14
	7.5	7.24	5.75	1.26
$HCCA_1$	2.5	6.58	6.14	1.10
	5.0	9.56	7.54	1.27
	7.5	6.62	6.28	1.37
CA_1	2.5	8.92	6.69	1.30
	5.0	11.37	7.79	1.43
	7.5	12.48	7.81	1.60

Table 6. Water Permeability in litre/m^2/sec

Sample code	days 0	15	30	45
UJ_1	94.3	100.7	120.7	-
UJ_2	90.3	124.6	130.2	-
UJ_3	92.1	120.7	130.6	-
PCN_1	47.2	52.6	52.7	60.2
PCN_2	46.2	53.7	55.6	65.6
PCN_3	48.9	54.9	57.9	65.7
$HCCA_1$	21.2	26.7	30.1	42.4
$HCCA_2$	20.2	27.8	33.9	42.4
$HCCA_3$	21.5	26.9	32.6	45.6
CA_1	4.24	4.34	4.52	3.36
CA_2	4.30	4.60	4.70	4.80
CA_3	4.30	4.52	4.56	4.67

Table 7. Pore Size (O_{95},w) in micron

Sample code	days 0	15	30	45
UJ_1	41	72	-	-
UJ_2	44	74	-	-
UJ_3	45	76	-	-
PCN_1	36	45	68	-
PCN_2	39	47	70	-
PCN_3	40	49	72	-
$HCCA_1$	33	37	61	77
$HCCA_2$	34	38	62	78
$HCCA_3$	35	39	64	80

N.B. : CA_j samples could not be possible in wet sieving method.

permeability values normal to the plane of fabrics for all samples excepting CA_j fabrics are increased at 1% level with respect to number of days. The CA_j samples show very low water permeability. Effect of NDP on the water permeability values has been found to be statistically insignificant.

Results presented in Table 7 indicate that there is a slight increasing trend of pore size with higher NDP. This may be due to the deeper and harsher penetrating action of the needles on the fabrics. Besides, the effect of soil burial test in respect of days on pore size corroborates the water flow rate as given in Table 6.

5 CONCLUSIONS

Untreated jute fabrics are susceptible to microbial attack and undergo considerable degradation in all the properties during accelarated soil burial test. The untreated jute nonwoven fabrics do not withstand puncture resistance. On the other hand, Copper napthenate + Acrylic binder and CCA + Acrylic binder treated fabrics give better performance than that of untreated fabrics for the same duration. These fabrics can be used where separation and filtration are of major criteria.

Most promising result is obtained in case of jute fabrics treated with Coal tar + Anthracene oil. Further study indicates that these fabrics can withstand microbial attack under accelerated soil burial condition even for one year. They may be used for unpaved roads for separation and reinforcement.

ACKNOWLEDGMENT

The work described in the paper is a part of the project sponsored by Department of Science & Technology, Govt. of India.

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