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Specially treated woven jute geotextiles for river bank protection

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In this paper, studies on treatment of jute geotextile with isothiazolinone and fluorocarbon derivatives to impart antimicrobial and water repellent property have been reported for its improved end use specific performance. It is observed that the treated jute geotextile possesses higher durability in water as well as soil-water ambience.

Keywords: Antimicrobial property, Fluorocarbon derivatives, Geotextile, Isothiazolinone, Jute, Water repellent property

1 Introduction

With the growing environmental awareness about the use of ecofriendly materials as an alternative of synthetic products, natural products like jute based textile materials are slowly but steadily regaining its lost regime. Jute geotextile (JGT) has emerged out as a potential natural alternative to synthetic geotextile for many civil engineering applications because of its typical functional characteristics and eco-concordance[1-4]. JGT, being biodegradable, is having short life span under soil and water ambience[5-6]. For commercial exploitation of JGT in addressing various geotechnical issues there is a need to improve its end use specific functional properties[7]. River bank erosion is a general phenomenon in our country and for its prevention JGT can be applied with minimum adverse impact on the ecosystem.

For the wider acceptance of JGT in river bank protection, comprehensive durability of JGT under combined soil and water ambience has to be ensured[8]. The current practice for enhancing life of JGT is by using copper based compounds and bitumen. However, it is felt that both the methods seem to be inadequate technically as well as environmentally[9].

As the demand for JGT with improved functional properties is increasing, in this study efforts have been made to develop and optimize durable JGT by using ecofriendly chemicals in an alternate route for their commercial exploitation in river bank protection. The study also deals with undertaking experimental field trial of treated woven JGT for river bank protection to assess its efficacy under actual usage condition.

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2 Materials and Methods

2.1 Materials

Standard double warp plain woven JGT of 85 ends/dm × 32 picks/dm, 627 g/m^2 and 1.5 m width has been used as the basic reference fabric as well as fabric for treatment with suitable finishes. Isothiazolinone derivative, considered to have antimicrobial property against broad spectrum of microorganisms, least environmental toxicity and cost, has been used as non-metallic organic biocides. To minimize wetting of JGT by water, a water repellent compound based on fluorocarbon derivatives has been selected and subsequently used along with selected antimicrobial agent after checking the compatibility between these two chemicals.

2.2 Chemical Treatment

Woven jute geotextile fabric samples have been padded at 90-100% wet pick-up, in aqueous solution containing mixture of isothiazolinone and fluorocarbon derivatives at different concentrations. Treated woven JGT is dried at 100ºC and finally cured at different temperatures.

2.3 Simulated Experiments

A study was earlier carried out to examine the biodegradability of untreated jute fabric by composting using ASTM D 6400. The study indicated that jute fabric (580 gsm) is degraded by 98% within 5 months by composting.

Accordingly, durability of both untreated and treated JGTs in soil ambience has been examined in the laboratory by putting the JGT fabrics on static water for a period of up to 150 days. Periodical measurement of loss in tensile strength has been evaluated for both the treated as well as untreated air dried JGT samples.

Similarly for studying durability of treated woven JGT in combined soil-water ambience, as observed in usual river bank, an artificial river bank condition has been created. Durability of both untreated and treated JGTs in soil-water ambience has been examined in simulated river bank conditions for 150 days.

2.4 Test Methods

The treated and untreated JGT samples have been tested for durability under soil (soil burial test as per IS: 1623,1992), water repellency (spray test rating as per IS 390-1975, water permeability (ASTM D 4491-99a), porometry (AOS, ASTM D 4751-99a), flexibility (Drape, %, IS: 8357-1977), microbial analysis (agar plate technique; AATCC100 and AATCC30), biological oxygen demand (IS 3025, Part 44: 1993) and chemical oxygen demand (IS 3025, Part 58: 2006). Periodic evaluation of tensile strength of treated and untreated JGT in warp and weft directions has been done following ASTM D 4595 – 94 standard.

3 Results and Discussion

3.1 Microbial Profile of Soil and Water

Type of soil used and the microbial profile of soil and water used during durability study have been analyzed. The results suggest that textural class of the soil used during experimentation is silty loam which is reported to be mild alkaline and enriched with reasonably good number of bacteria (2.0×10^7 CFU/g) and fungus (3.2×10^4 CFU/g). Microbial profile of water used is, however, on the lower side and has reported only 2.7×10^2 CFU/g of bacteria and negligible amount of fungus.

3.2 Optimization of Chemical Treatment

Table 1 shows the effectiveness of different combinations of chemicals, curing temperature and its duration on the durability of treated JGT under water and soil ambience. Effectiveness of chemical formulation and durability of JGT have been studied by monitoring its strength loss at different time intervals and different experimental ambiences. Results indicate that treatment of woven JGT fabric with 0.5% iso-thiazolinone derivative (owf) and 1.0% fluorocarbon derivative (owf) is found effective to impart durability under combined soil and water ambience. Considering cost competitiveness of treated JGT, application of identified chemical additives beyond said doses has been restricted. It has also been observed that a curing temperature of 125-130ºC for 2 min is required to impart durable finishes.

Table 2 depicts the comparative statement on the physical parameters and mechanical properties of the treated and untreated JGT samples. It can be observed from the table that the optimized chemical treatment does not adversely affect the major physical properties like tensile strength, apparent opening size (AOS), water permittivity and rod puncture resistance of woven JGT. In addition, it has also been observed that the treated JGT acquires good water repellency and remains flexible after treatment.

3.3 Effect of Chemical Treatment on Strength Retention and Water Repellency of JGT

Performance of treated woven JGT under soil has been observed by conducting soil burial test and the observation made on microbial resistant property

Table 1—Special treatment of woven jute geotextile

Treatment No.	Composition of formulation (on wt. of JGT)	Amount, %	Wet pick up, % (w/w)	Curing temperature, ºC	Curing time, min	Durability against water & soil
1	Water repellent compound	2.0	90-100	100	-	Not effective
	Organic biocide	1.0				
2	Water repellent compound	2.0	90-100	110-115	2	Not Effective
	Organic biocide	1.0				
3	Water repellent compound	2.0	90-100	125-130	2	Effective
	Organic biocide	1.0				
4	Water repellent compound	1.0	90-100	125-130	2	Effective
	Organic biocide	1.0				
5	Water repellent compound	1.0	90-100	125-130	2	Effective
	Organic biocide	0.5				
6	Water repellent compound	1.0	90-100	125-130	2	Not Effective
	Organic biocide	0.25				
7	Water repellent compound	0.5	90-100	125-130	2	Not Effective
	Organic biocide	0.5				
8	Water repellent compound	2.0	90-100	125-130	2	Not Effective
9	Organic biocide	1.0	90-100	100	-	Not Effective

Table 2—Characterization of untreated and treated woven jute geotextile

Test parameter	Untreated JGT fabric	Treated JGT fabric	Test method
Weight at 20% MR, g/m^2	631.7	638.4	ASTM D 5261 – 1996
Thickness at 2 kPa pressure, mm	1.24	1.32	ASTM D 5199 – 01
Tensile strength, kN/m			
Warp-way	24.39	22.25	ASTM D 4595 – 94
Weft-way	20.59	19.74	
Elongation at break, %			
Warp-way	7.08	7.14	ASTM D 4595 – 94
Weft-way	8.04	8.16	
Water flow rate at 50 mm water head, L/m^2/s	21.60	20.12	ASTM D 4491 – 99a
Permittivity at 50 mm constant water head per second	0.50	0.43	ASTM D 4491 – 99a
Apparent opening size (O_{95}), µm	251	220	ASTM D 4751 – 99a
Rod puncture resistance, N	386.3	373.8	ASTM D 4833 – 2000
Drape, %	90.8	62.5	IS: 8357 – 1977
Water repellency, %	0.0	90.0	IS: 390-1975

acquired by treated vis-à-vis untreated JGT justifies that treated JGT is rot resistant as it retains 88% of fabric strength even after incubation under enriched soil for 21 days, whereas untreated JGT retains only 17% strength in the same condition for the same period. Treated JGT is therefore expected to have better durability in association with soil during river bank protection. On the other hand the spray test carried out as per IS: 390-1975 indicates that chemically treated JGT has an extent of 90% water repellency as compared to negligible water repellency of untreated sample.

3.4 Durability of Treated JGT in Water Ambience

Figure 1(a) shows the loss of tensile strength of treated and untreated JGT samples taken out from the static water ambience after periodical intervals. It can be observed from the plot that strength retention in both the directions of treated JGT is always higher than that of untreated JGT sample at any span of exposure in water ambience. The significance test between the results also shows significant difference between the losses in fabric strength. After 150 days of exposure of the samples in static water, both in warp and weft direction tensile strength loss of treated woven JGT is only 12.4% and 17.8 % respectively which is well below to that observed in untreated counterpart (59.6 % and 57.2 % respectively), indicating its better durability in water ambience.

3.5 Durability of Treated JGT in Soil-Water Ambience

A plot on exposure day *vs*. % loss in fabric strength in both warp and weft directions under exposure to combined soil-water ambience is shown in Fig. 1(b). It can be observed from the graph that a significant

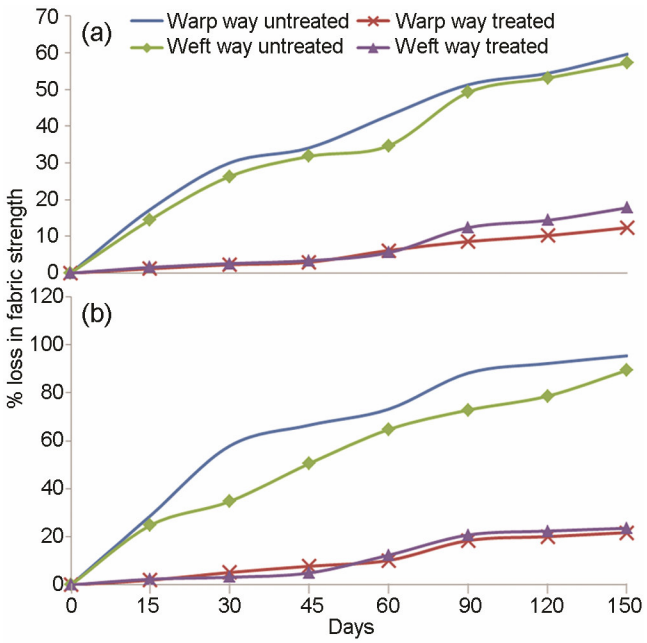

Fig. 1—Loss in strength of woven JGT under (a) water ambience (b) soil-water ambience

loss in fabric strength at any exposure duration is far less for treated woven JGT as compared to that for untreated JGT. It is also observed that % loss in strength of treated woven JGT at 150 days are 21.8% and 23.6% in warp and weft directions respectively and the values are found much below to that for untreated JGT samples (95.4 % in warp direction and 89.4% in weft direction). Such loss in strength of untreated JGT makes it unusable for longer duration in combined soil-water ambience. These observations made on treated JGT suggest its effectiveness in combined soil and water ambience.

3.6 Environment Compatibility of Treated Woven JGT

Impact of treated woven JGT on defined environmental parameters, such as COD and BOD of water, has been studied and corresponding values of the samples drawn from the experimental tanks after 3 months are given in Table 3. It has been observed that special chemical treatment on woven JGT has no negative environmental impact.

3.7 Life Prediction of Treated Woven JGT

In a river, the water level goes high in the rainy season and major surface runoff i.e. soil erosion in the bank mostly occurs due to rainfall. In general, rivers become filled for a maximum period of 3 months due to the persistence of rainy season. Considering this fact, the life prediction of treated woven JGT has been carried out under water ambience by monitoring loss in tensile strength at different intervals for 90 days and compared with untreated JGT fabric. Finally a statistical life prediction model (Fig. 2), has been suggested. Life prediction of JGT in water ambience suggests that in treated JGT 100% loss in strength is observed in more than 1200 days unlike untreated JGT wherein total loss of JGT strength is observed in around 200 days only. In case of soil-water combined ambience, the predicted life of treated JGT is about 600-700 days. In both cases, life of treated woven JGT is substantially higher than the untreated counterpart.

3.8 Field Trial on Treated Woven JGT

Irrigation and Waterways Directorate, Govt. of West Bengal has been encountering severe problem of erosion of left bank of river Bhagirathi at Santipur, Dist-Nadia, West Bengal, India since a long time. Conventional bank protective measures like using inverted filter armoured with stone boulders has not worked well.

To mitigate the said problem newly developed durable 627 gsm woven jute geotextile was used as filter fabric for a stretch of 2200 m from Barobazar Burning Ghat to Steamer Ghat under Santipur Municipality before monsoon, which is reported to be an example of first river bank protection work in India with non bituminous and light weight jute geotextile fabric. The approximate cost of the treated JGT fabric is around Rs. 57-58 /- per square metre against Rs. 42-43/- per square metre for untreated fabric.

After preparing the bank slope at a gradient of about 30 degree, the durable woven 627 gsm JGT fabrics have been laid down across the slope and the individual pieces of JGT fabrics have been joined by seaming at site with the help of portable sewing machine. 2-rows of 101 type stitches (single thread chain stitches) with about 12 cm seam allowance have been used for seaming. The top and bottom ends of the fabric have been anchored on to the ground and suitable pegging has been carried out to fix the fabric on to the surface of the slope. After laying the JGT fabric, stone boulders of standard weight have been placed over the fabric for armouring. Unlike bitumen treated JGT which generally causes problem due to stiffness and imperfect porometry this light weight non-bituminous woven JGT fabric draped easily on the surface of the bank slope and porometry has been observed not to be impaired which necessitate for filtration function.

The performance of non-bituminous, lightweight woven JGT product under actual field condition has been evaluated by the experts of the appropriate agencies engaged for the purpose. Experimental site has been inspected for three times over a period of about eight months and it has been observed that the treated 627gsm woven JGT fabric is in intact condition and the treated slope of the river bank has been found stable after elapse of one season cycle. Field level performance evaluation is still being monitoring for one more season cycle. However, the initial study indicates that the treated woven JGT fabric is effective in river bank erosion control work.

Table 3—Environmental impact of woven jute geotextile

Sample	BOD_5, mg/L	COD, mg/L
Water	12	20
Water + untreated woven JGT	18	30
Water + treated woven JGT	16	26

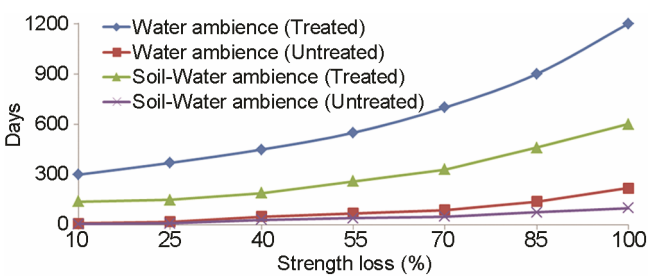

Fig. 2—Statistical life prediction of treated woven jute geotextile

4 Conclusion

JGT fabrics treated with 0.5% isothiazolinone and 1.0% fluorocarbon derivatives show higher water repellency as well as rot resistant characteristics. These improved functional properties of treated JGT are

advantageous in terms of its end use in river bank protection. It is observed in river bank simulation test that the life of treated JGT under combined soil-water ambience is 600-700 days. Major functional properties desired for JGT such as strength, elongation, porometry (AOS), water permittivity and rod puncture resistance etc. do not alter much due to such chemical treatment. All these positive attributes of specially treated JGT suggest its effective application in river bank protection.

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References

1 Gon Debi Prasad & Paul Palash, *Indian Tex J*, 122 (6) (2012) 73.
2 Datta Utpalendu, *J Natural Fibers*, 4 (3) (2007) 67.
3 Chattopadhyay B C & Chakravarty S, *Geotext Geomembr*, 27 (2) (2009) 156.
4 Sanyal T & Choudhury P K, *J Indian Highways*, 34 (12) (2006) 31
5 Choudhury P K, Das A & Sanyal T, *New Horizon in Earth Reinforcement* (Taylor & Francis Group, London) 2000.
6 Datta U, Chatterjee P K & Mukherjee B, *19th IJIRA Tech Conf* (IJIRA, Kolkata) 1996.
7 Chattopadhyay B C & Chakravarty S, *Geotext Geomembr*, 27 (2009) 156.
8 Sanyal Tapobrata, *Jute Geotextile* (National Jute Board) 2011.
9 Saha P, Roy D, Manna S, Adhikari B, Sen R & Roy S, *Geotext Geomembr*, 35 (2012) 69.