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Technical Note

Construction of unpaved rural road using jute–synthetic blended woven geotextile – A case study

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ABSTRACT

Jute–high density polyethylene (HDPE) blended geotextile samples produced using HDPE slit-film in the machine direction and jute yarn in the cross direction for use in the construction of unpaved rural roads. Use of HDPE slit-film resulted in high productivity of jute-based geotextiles in modern high-speed machines, while jute (≈85%) in cross direction resulted in notable increase in modulus, breaking strength, CBR puncture resistance of the blended geotextile as compared to 100% HDPE geotextile. The optimized geotextile (plain-weave fabric with 111 tex HDPE in machine direction, 2 × 360 tex jute yarn in cross direction having area density, 316 g/m^2) was used in a field trial. During road construction, the geotextile was covered with a layer of 10 cm thick laterite gravels as the sub-grade, compacted by rolling, and then finally covered with 10 cm small granular lateritic stones, and rolled again. The field trial showed that the monitored section where geotextile was used showed an even surface without any notable subsidence or rutting after 18 months. However in sections of the road constructed without the geotextile, 5–35 mm deep ruts were observed. CBR tests (carried out 11 months and 18 months after construction) showed a 67–73% improvement in the road due to the use of jute–HDPE blended geotextile than that obtained for the part of the road where geotextiles were not used.

1. Introduction

There has been considerable recent interest in the use of natural fibres for soil reinforcement (e.g., Chauhan et al., 2008; Lekha and Kavitha, 2006; Rawal and Anandjiwala, 2007; Sarsby, 2007; Subaida et al., 2008) as well as its use as a separator in the construction of paved and unpaved roads (e.g., Ahn et al., 2002; Datta, 2007; Datye and Gore, 1994; Ghosh and Bera, 2005; Mandal, 1987; Ranganathan, 1994; Sanyal and Chakraborty, 1994; Shenbaga Kaniraj and Venkatappa Rao, 1994; Venkatappa Rao et al., 2000). In the latter applications, it is intended that the geotextile will provide the separation/reinforcement function to the soil and by the time (at least two rainy season cycles) the jute is degraded and mixed with earth, the soil has been stabilized. Longevity of jute under the soil depends upon the nature, pH, moisture content throughout the year, and composition of the soil. To increase the longevity, the jute geotextiles are bituminized to impart rot resistance property. However, possibility of leaching-out of bitumen (mostly composed of polycyclic aromatic hydrocarbons) is a threat to the environment by eventual contamination of nearby agricultural fields and river/pond water in the long run. In such case, a certain quantity of synthetic material may increase the durability to a substantial extent of the jute-based geotextiles and may provide a harder layer (due to the presence of lignin) after degradation of untreated jute. Jute–polyolefin tape (slit-film) blended geotextile may be suitable for using as separator for road construction. Geotextiles of certain quality parameters, made from 100% polyolefin slit-film are presently being extensively used world-wide for solving different geotechnical problems (Phillips and Ghosh, 2003; Veldhulizen Van Zanten, 1986). Jute and other natural fibres (*viz.*, coir, abaca, etc) also have great role to play to mitigate the rapidly increasing global need of technical textiles (including geotextile). Conjunction of jute and/or other natural fibres with synthetic may resolve that problem to a notable extent without much hampering ecological balance. In addition, it is noteworthy that in most of the cases, a single fibrous element may not offer all the essential/desirable properties to a fabric for a specified use. Each fibre has its own advantageous and disadvantageous properties. The disadvantageous properties can be minimized to some extent, if not eliminated, by incorporating certain percentage of other natural or man-made fibre(s).

Some major plus points about jute are its agro-based, annually renewable nature and availability at a low cost. The fibre has high tensile strength and modulus, good dimensional stability, anti-slip

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Table 1
Structural parameters of jute–HDPE blended and 100% HDPE fabric[a] samples.

Sample no.	Fabric mesh (threads/dm)		Type of thread		Area density (g/m^2)	Jute content (%)	Thickness (mm)
	MD[b]	CD[c]	MD[b]	CD[c]	(ASTM D 5261)[e]		(ASTM D 5199)[e]
1	39	39	HDPE[d]	4 × 360 tex plied jute[e] and 1 HDPE[d] alternately	420.6	83	1.901
2	39	60	HDPE[d]	600 tex jute	277.6	83	1.01
3	39	44	HDPE[d]	415 tex jute	205.4	78	0.943
4	39	44	HDPE[d]	4 × 330 tex plied jute and 1 HDPE[d] alternately	388.2	81.5	1.884
5	39	60	HDPE[d]	2 × 360 tex jute yarn	316	86	1.396
6	39	39	HDPE[d]	4 × 220 tex plied jute and 1 HDPE[d] alternately	281.6	75	1.49
7	39	39.5	HDPE[d]	HDPE[d]	91.0	0	0.6

[a] Plain-weave fabric, MD.
[b] Machine direction, CD.
[c] Cross direction.
[d] 111 tex high density polyethylene slit-film (draw ratio 1:7) of 2.5 mm width.
[e] Twisted jute yarn of circular cross-section, tex – Weight of 1000 m long yarn in grams (linear density) (ASTM, 2003a; ASTM, 2003b).

nature, high moisture absorption, and biodegradable. However, low extensibility, stiffness, long hairs protruded from the yarn surface, and fibre shedding are major drawbacks which restrict its processibility in subsequent high-speed machines. High biodegradability of jute also sometimes poses problems in some geotechnical uses. Further, as jute is an agricultural product, its productivity mostly depends on the vagaries of climate.

Polyolefin flat-tape can be used as warp in very high-speed weaving machines including circular weaving machines in longitudinal direction with high weaving performance due to its smooth surface, much less variability and high extensibility (15–25%). Polyolefins are non-biodegradable under earthen cover. Very low tensile modulus and photo-degradation are among the major disadvantageous properties of polyolefins. Steadily depleting resources of crude along with continuous increase in its price at a high rate are among the major concerns for the use of polyolefin. To combine the advantageous properties of jute and synthetics for different applications, work on preparing of poly-jute union fabric, involving jute yarn in weft and HDPE/PP flat-tapes in warp has been initiated.

The prime objective of the present work is (i) to explore the possibility of producing standard geotextiles using jute as a major element in conjunction with synthetic materials having improved/comparable property performance suitable for construction of rural roads of Indian sub-continent, (ii) to lay down a range of specifications of jute-based geotextiles which can easily be produced in most economic way, and (iii) to evaluate the performance of the developed geotextile in practical situation. For this, six different types of jute–HDPE union fabric samples were developed in a high-speed automatic weaving machine. Some important property parameters for geotextiles were evaluated at the laboratory as per ASTM recommendation to identify the fabric specification(s) which provides the optimum property parameters. The mechanical property of developed jute–HDPE blended geotextiles was also compared with those of the conventional synthetic geotextile prepared from HDPE slit-film. Finally, a field trial was carried out using our developed geotextiles as separation – cum – reinforcing material for making unpaved rural road.

2. Materials and methods

Jute fibres (*Corchorus olitorius*) of TD 4 grade (BIS 271, 1987) (Bundle tenacity, 28–30 cN/tex) were used for preparation of jute yarns. 111 tex HDPE flat-tape (slit-film of 2.5 mm width, made from polyethylene having a density 0.94 g/cm^3 maintaining a draw ratio, 1:7) was used for the preparation of union fabric samples.

Table 2
Mechanical properties of jute–HDPE blended fabrics.

Sample No.	Trapezoidal tearing strength (kN/m) (ASTM D 4533)[d]		Perforation resistance[a] (mm) (ISO 13433)	Puncture resistance with 8 mm and 50 mm probe		Tensile properties[b] (ASTM D 4595)[d]			
				8 mm, (kN) (ASTM D 4833)[d]	50 mm, (kN) (ASTM D 6241)[d]	Breaking strength (kN/m)		Elongation at break (%)	
	MD	CD				MD	CD	MD	CD
1	3.08 (9.58)[c]	2.45 (11.07)[c]	20.8	160	0.96	10.51	12.98	23	10
2	3.28 (6.23)	3.49 (1.84)	22.8	110	1.38	10.93	15.52	24	6
3	3.68 (4.12)	2.05 (5.13)	23.4	60	0.98	9.59	13.29	21	5
4	2.89 (12.80)	2.47 (17.93)	20.4	210	1.22	10.63	17.40	23	9
5	3.68 (3.98)	2.61 (23.56)	18.8	180	1.50	10.72	18.00	23	7
6	2.76 (4.35)	1.92 (11.94)	23.6	70	0.86	10.48	13.96	22	6
7	3.25 (3.21)	3.45 (3.52)	21.62	65	0.91	10.52	10.39	17.38	18.66

[a] Cone drop test.
[b] Strip method (Gauge length and width, 200 mm and 100 mm respectively).
[c] Figure in parentheses indicates the corresponding coefficient of variation in percent.
[d] ASTM (2003b).