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M.T. SULTAN

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CENTRIFUGE MODEL STUDIES ON THE PERFORMANCE OF GEOGRID REINFORCED SOIL BARRIERS OF LANDFILL COVERS BY JUTE AS GEOTEXTILE

M.T. SULTAN

Lecturer, Department of Textile Engineering, Southeast University, Banani, Dhaka-1213, Bangladesh.

Corresponding author & address: Md. Tipu Sultan, E-mail: tipu2603@gmail.com
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ABSTRACT

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While the employ of jute in packaging, home décor etc. is well known, the application of jute in geotextiles is a chiefly unexplored vicinity although it can propose enormous payback to the indigenous industry and agri-economy overall. Erosion control blankets are typically woven from jute & are meant to slow down the pace at which water moves across the surface. This experimental result show that satisfactory erosion control can achieved especially when jute fabric coated with bitumen. A jute woven fabric employing leno based structure was planned for mounting an asphalt superimpose fabric, accurate for low traffic roads. To evaluate the fitness of this fabric, were subjected to accelerated repeated mechanical loading and also to extensive hygral loading. For assessment, comparable tests were also conducted on concrete models without any implanted fabric and in addition on those implanted with commercial fabrics. The experiments disclose that the leno based product execute far better than the others. As a consequence of additional study it was establish that the grid-like manufacture of the new construction as also openings of appropriate extent were chiefly liable for the experimental superior performance.

Keywords: *asphalt overlay fabric, reflection cracking, jute, asphalt concrete beam, leno weave, grid-like structure*

INTRODUCTION

Man-made geo textiles based on petrochemical derivatives have uncertain eco-compatibility. There are certain allied problems as well. There is slow but definite exhaustion of the precious source warranting its controlled utilize. There is thus unabated increase in prices of the raw objects as a consequence which in turn makes geo textiles expensive (Barazone 1990). There is therefore a require for seek for ecological, renewable, abundantly accessible and economically possible alternatives. Rising inclination to utilize natural geo textiles stems from this necessity (Barry 1985).

A fibre would be suitable for developed geo textiles when

(a) It possesses appropriate mechanical properties and in several cases along with excellent hydraulic properties
(b) It is logically resistant to bio-degradation

Natural fibers can be of vegetable, animal or mineral origin. Vegetable fibers have best prospective for use in geo textiles because of their greater mechanical properties. The significant vegetable fibers which are either in exercise or have potential to be used as raw matter for geo textiles are jute, coir, sisal, flax, kenaf, abaca, pineapple etc.

Table 1. Some related properties & characteristics of different fibers for geo textile application

Type of Fibre	Tenacity N/tex	Extension at Break (%)	Initial Modulus N/tex	Work of rupture N/tex	Volume swelling %	Moisture regain% at 65% RH, 20^0c	Lignin content %
Jute	0.3-0.9	1-1.8	17-19	0.005	44.3	12-14	12-14
Coir	0.18	41-45	4.22	0.016	-	10	30
Sisal	0.37-4.7	1.9-4.5	25-26	0.0043	39.5	11-14	9.9
Polyester	0.3-0.8	15-55	6-12	0.020-0.092	-	0.4-0.6	Nil
Poly propylene	0.3-0.8	15-35	2-9	0.082	-	<0.1	Nil

Jute, a bast fibre (imminent from the stalk of the plant, by retting procedure), has a tenacity of about 30 cN/tex with a low extension at break of roughly 1.6 to 3.8% (Batra 1998). The tenacity of coir fibres (imminent from the husk of the coconut, retted or unretted – white coir or brown coir respectively) is much lesser 15 cN/tex, but elongation at break is much higher, around 40%. The development of microorganism on vegetable fibres depends on their chemical composition, mainly the lignin content. Coir has about 35% lignin content, building it enormously resisting against biodegradation, while for jute it is just approximately 12%. The other bast fibres like flax, hemp and ramie contain much little extent of lignin (0.6 to 3.3%).

Furthermore, jute is ecological, abundantly available in India and Bangladesh, reasonably priced and famous to have excellent adhesion with asphalt as apparent from the extensive application of bituminized jute fabric. Hence, it

appears sensible to recommend that asphalt overlay fabrics can as well be manufactured from jute & can be used for erosion control (Marienfield and Smiley, 1994).

THE FOREMOST R & D PROJECTS ON JUTE GEOTEXTILE

a) Development of water-repellent and robust Jute Geo textiles with natural eco-friendly additive for erosion control applications.
b) Development of a suitable overlay fabric to serve as a cheaper substitute of bitumen mastic.

For erosion control application

Geo textiles are employed on inclines where there is a high threat of soil erosion- i.e. the loss of soil, nutrients & seeds by the means of erosion- stream (rainwater and runoff), storm and reported that woven jute fabrics performed the most excellent among other natural and synthetic erosion control products under abundant experimental status, through different rainfall intensities and soil types. In the practice of investigating jute's dominance over others, she identified several enormously vital geo textile properties having fine relationship with erosion control performance. These are region of the geo textile (% cover), water holding capacity of geo textile, geo textile induced unevenness to the flow, mass of geo textile when wet and depth of flow improved by the geo textile (Stout 1988).

Soil Saver' is a trade name name of open weave Jute Geo textile (JGT) which has been in utilize in Europe and America since early 1950s control for of surficial soil erosion caused by precipitation, predominantly in slopes through vegetation (Bernard and Dobrosielskli, 1996) Every grid (opening) in open mesh woven JGT, like 'soil-saver', helps confine detached soil particles surrounded by and thus prevent their migration. At the same time, the weft yarns of soil-saver perform as successive mini-barriers to decrease the rapidity of surface run-off.

For application in asphalt overlay fabric

Asphalt is a black material used to construct the surfaces of things such as roads & playgrounds. Asphalt Concrete is a mixture of stone aggregates & Asphalt. Asphalt superimpose fabric is utilize among new Asphalt concrete through road rehabilitation & to avoid reflection cracking. A coarse, woven organic fabric soaked with an oxidized asphalt binder normally known as asphalt treated burlap well-matched with both hot and cold (liquid) applied bitumen covering systems. Holds more bituminous materials per sheet than, glass or cotton reinforcements. Uses comprise erosion control on embankments, as a defending barrier for recently seeded areas, as a ditch liner to hold planted materials in position until growth starts (Mather 2005).

At 1st age group of Asphalt overlay fabrics (A/O) were Spun-bonded or needle-punched slim non-woven structures prepared of polypropylene or polyester. These can provide as dampness proof & thereby prevent weakening but delay mirror image cracking to several slight levels. No standard A/O material made up of natural fibres has been produced although some of the natural fibres like jute, sisal, hemp, flax, ramie, etc. have mechanical properties better in many respects than PP or polyester. A jute based manufactured goods might not last long adequate while subjected to elements of nature owing to biodegradability. Jute in asphaltic medium upon hygral action and enzyme action simulating microbial attack reveal, asphalt acts as defender for jute against microbial hit (Maurer and Malasheskie, 1989).

METHODOLOGY

Preparation of fibers & yarn

- Fibers: Thick fibers 1.5 – 2.2 tex
- Yarns: Two types –

a) Coarser & Stronger:
   Count or Finness: 740 tex or 1.3 mm thick
   Breaking strength: 93 N (CV=13.5%)
   Breaking extension: 3.2%
b) Thinner & Weaker:
   Count or Finness: 310 tex or 0.70 mm thick
   Breaking strength 32.5 N (CV=19%)
   Breaking extension 2.2%
   Used as doup & ground threads

Preparation of fabric for erosion control

The widespread practice in river-related applications for JGT is to care for the fabric with manufacturing bitumen generally of Viscosity rank 30.Bitumen-smeared JGT is supposed to defend the fabric from direct water-contact. As

a result, however, entirely bitumen-coated JGT does not agree to characteristics of jute to patent. The recently developed water-repellent and durable JGT should therefore concomitantly address eco-compatibility requirements. This might be made if a benign natural stabilizer can be established to treat JGT for the purpose (Roy and Sur, 2003).

Table 2. Specification of Soil Saver's

Properties	Bitumen-Coated JGT	Coir Geotextile Mattings	Sisal Geotextile
Areal density (g/m2) at 20% moisture regain	292	500	730
Threads / dm (MDxCD)	12x12	6.5x4.5	7x7
Thickness (mm)	2	4	6
Fabric width (m)	1.22	1.22	1.22
Open area (%)	60	50	40
Strength (KN/m) (MDxCD)	10x10	10x7.5	12x12
Water holding capacity(%) on dry weight	400	500	500
Maximum durability	2	2	2

Table 3. Life time of treated & untreated JGT

Treatment	Half service life (in months)			
	UV	Soil	Saline water	Normal water
Treatment of JGT at Fabric level	37	44	51	54
Untreated JGT	12	14	18	20

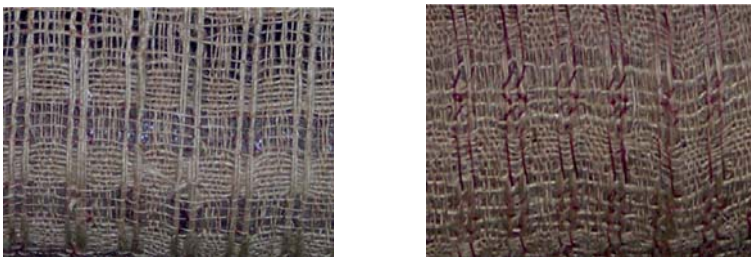
Description: It has been reported that half-life (in months) i.e. estimated service life expectancy of the JGT treated at the fabric stage compared to JGT prepared of untreated fibre stand as under. Half life is the time taken by JGT to achieve half of the primary strength. The speed of loss in strength gets slower once the half life is reached.

Jute having high water holding facility can soak up water to about 500% of its dry mass. No other solid textile fibre can state to possess this stage of capacity as reported. Hence, JGT, when wet, would generate more close contact with the soil surface underneath due to increased drape capability. Furthermore, it has the exclusive property of forming mulch on biodegradation, keeping a friendly humidity point and shortening extremes of temperature which fosters rapid vegetative growth. At this time, three types of soil-saver are in common use.

Preparation of fabric for asphalt overlay fabric

In sight of the increasing cost of bitumen, the charge of bitumen mastic used as overlay/wearing way on roads is mounting. Considering the reality that jute and bitumen have outstanding thermal compatibility, jute-based superimpose could be a feasible and cheaper replacement of the conventional bitumen mastic. The core of the overlay will be prepared up of a mixture of woven and non-woven fabric. The non-woven jute fabric is a fine receptor of bitumen and will thus assist integrate the jute-bitumen mixture. The development needs to decide on the proper jute fabric core (combination of woven and non-woven fabric) and the correct category of bitumen for the jute combination.

- A leno supported woven into a Plain or Twill through high crimp & extensibility.
- Two beams, one each for standard and ground threads while the criss-crossing doup threads can be drawn from a separate creel.
- In the case of non-availability of such a loom, one can create the grid and the absorbent fabric separately and afterward sandwich the latter between two layers of the grid.



Front Side *Back Side*

Fig. 1. Actual photograph of jute Asphalt overlay (JAO) fabric

Specification of jute asphalt overlay (JAO) fabric

1. Breaking load: 32 kN/m in both length and width directions.
2. Breaking elongation: lower than 6% in both length and width directions.
3. Grids on fabric surface: display a allocation of grid openings among little ones measuring 5 mm × 5 mm to bulky ones of 25 mm × 17 mm.
4. Having capability of absorbing asphalt and forming a constant watertight layer.
5. Fabric weight: 886.2 GSM

Tensile properties evaluation of JAO fabric

In figure 1 repeated mechanical loading tests for evaluating the 'rupture properties' of the asphalt concrete beams (ACBs) is done as following samples :

a) ACBs reinforced with Jute asphalt overlay (JAO) two fold layer.

b) ACBs reinforced with jute geo-textile (JGT). This fabric has a fairly high modulus but does not reveal any prominent grid-like construction.

c) ACBs surrounded with a viable synthetic Asphalt overlay fabric (PP non-woven paving fabric, code named SGT).

Table 4. Tensile properties of Asphalt overlay fabrics

	Breaking load (KN)		Breaking Elongation (%)		Young's modulus (MPa)	
Type of Sample	Warp way	Weft way	Warp way	Weft way	Warp way	Weft way
JAO (double layer)	0.99	0.86	9.5	9.5	105	96.5
JGT	1.2	1.16	6.5	8.75	184.5	32.5
SGT	0.58	0.55	88.3	71.85	28.8	37.5

Performance of mechanical loading

Regression equations were resultant from the experimental records obtained by testing the JGT-reinforced ACBs at 10 different factor-level combinations of load and rate, relating the amount of cycles necessary for the fracture.

Table 5. Exhumed sample history of different A/O fabrics at Mechanical loading

Test Condition		Type of Fabric	Observations		
Max peak load(KN)	Frequency (Hz)		Number of installation damages	Length of crack (mm)	Number of cycles
0.44	14	JGT	10	31	1579
0.80	18	JGT	13	30	3188
0.79	17	SGT	Innumerable	32	6299
0.79	16	JAO	Not distinguishable	0	1987

Performance of hygral loading

1. ACBs without reinforced: A pointed go down in resistance to fracture propagation after a 15 or 30 days immersion.
2. ACBs reinforced with JGT: Constant development in resistance to crack propagation with rising period of hygral loading.
3. ACBs reinforced with JAO: Finest results representing no growth of crack whatsoever, both after 15 and 30 days immersion.

RESULTS AND DISCUSSION

After summarize the collected data from table 1 to 5 and the analysis performed on those data relevant below is the result appear.

Result of water erosion control

To attain improved durability of JGT in some definite application of erosion control, like in manage of river bank erosion where the manufactured goods would be constantly exposed to water, bitumen-coated JGT are employed.

Result of tensile properties

While comparing the breaking strength, elongation and modulus values of JGT and JAO, it is experiential that JGT is as strong as JAO while its stiffness is higher and elongation is lower.

The fairly lower breaking elongation and significantly higher stiffness of JGT is also caused by the binding effect of asphalt.

Result of mechanical loading

The Asphalt concrete beam surrounded with JGT and SGT exhibited development of fracture well beyond the Jute Asphalt overlay (JAO) fabric.

Thus JAO have more resistance to fracture propagation than JGT & JAO fabric.
The JGT appears to delay this development better than the SGT.

Result of hygral loading

Finest results representing no growth of crack whatsoever, both after 15 and 30 days immersion on concrete beam of jute asphalt overlay fabric.

CONCLUSION

JGT can check the migration of soil from the bank and it has enough permeability to defuse differential more pressures & to control erosion satisfactorily especially when bitumen-coated. The opening dimension of the grids of an A/O fabric should be compatible with the Asphalt Concrete combine used in roadway and plays a crucial role in creating proper interlocking with least fabric damage. Appropriate structure of the A/O fabric plays major task in creating suitable anchorage between superimpose and old street surface and thereby prevents fracture propagation into the overlay. A grid-like construction of Jute Asphalt overlay (JAO) fabric is consequently more appropriate for accurate interlocking than sheet-like fabric structures.

REFERENCES

Barazone M (1990) Paving fabric interlayer membranes andinstallation procedures over the past 20 years. *GeotechnicalFabrics Report*, 10(4), 16–21.

Barry GF (1985) Pavement fabrics: Do they really work? *Geotechnical Fabrics Report*, 3(4), 21–25.

Batra SK (1998) Other long vegetable fibers. In M. Lewin &E.M. Pearce (Eds.), *Handbook of fiber chemistry* (Vol. 4, 2nd ed.). New York: Marcel Dekker.

Bernard F, Dobrosielskli JH (1996) Canadian climate tests paving fabric's performance. *Geotechnical Fabrics Report*, 14(3), 30–33.

Marienfeld ML, Smiley D (1994) Paving fabrics: the why and how-to. *Geotechnical Fabrics Report*, 12(4), 24–29.

Mather RR (2005) Polyolefin fibres. In J.E. Mclntyre (Ed.), *Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin*.Cambridge: The Textile Institute, Woodhead Publishing.

Maurer DA, Malasheskie GJ (1989) Field performance of fabrics and fibers to retard reflective cracking. *Geotextiles and Geomembranes*, 8(3), 239–267.

Roy T, Sur D (2003) *Handbook on jute* (pp. 14, 19). Kolkata: Indian Jute Industries' Research Association.

Stout HP (1988) *Fibre and Yarn Quality in Jute Spinning* 2, 28.