PROSPECTIVE APPLICATIONS OF JUTE GEOTEXTILES

by

TAPOBRATA SANYAL
Geotechnical Advisor, Jute Manufactures Development Council
3A Park Plaza, 71 Park Street, Kolkata-700016, India
e-mail-jmdcindia@vsnl.com

1. Introduction

Versatility and distinctive physical characteristics of jute fibres coupled with its high spinnability, make it an ideal material for new technical applications beyond the existing conventional end-uses. Tailor-made technical textiles can be made out of its fibres/yarns--a feature that can hardly be matched by any other natural fibre. Principal application of Jute Geotextiles (JGT) is in the sector of erosion control where its efficacy stands established. Bio-degradability of jute and, for that matter, of other natural fibres such as coir is a distinct advantage from environmental considerations. But coir is deficient to jute in so far as spinnability is concerned. In view of the renewed global emphasis on adoption of bio-engineering measures especially to address geotechnical problems, jute-made technical textiles have seemingly bright prospects. At the same time there is need to explore avenues for their use in geo-environmental sector. These are areas where man-made geotextiles have inherent limitations.

In this paper, an attempt has been made to present before the readers the prospective applications of JGT other than its conventional uses.

2. Distinctive Characteristics of Jute

Jute fibres possess the following distinctive characteristics that add to their versatility leading to diverse end-uses.

- High initial strength & secant modulus
- Low extension at break
- High roughness co-efficient
- Good dimensional stability

- High moisture absorbing capacity
- Superior drapabilitty
- Excellent spinnability--can be tailor-made
- Easy availability
- Soil-nourisher—acts as mulch
- Eco-concordant
- Competitively priced

3. Existing Applications of JGT

So long JGT has been used in the following areas with success.

--slope stabilization
--surficial soil erosion control
--strengthening of road sub-grades and drainage
--protection of river & canal banks

Slope stabilization envisages strengthening a soil body threatened with distress. JGT, when inserted within an embankment in appropriate layers, can prevent rotational slides. As a basal reinforcement, JGT curbs the settlement of an embankment or any fill. The principal cause of lateral dispersion of any fill, besides its low shear strength, is intrusion of water into the fill-body. Drainage of water can be facilitated by insertion of the right type of JGT at appropriate levels within the fill.

Erosion of top soil either on a flat ground or on a slope can be effectively prevented by open weave JGT. Three-dimensional construction of open weave JGT helps reduce the velocity of surface run-off by interposing successive micro-barriers to the direction of flow and entrap the soil particles dissociated by the kinetic energy of rain drops. Bio-degradability of JGT facilitates growth of vegetation because of conditioning of the ambient temperature and regulation of humidity to a congenial level effected by it. It has also been reported that JGT may add micronutrients to the soil on which it is laid and do not draw upon nitrogenous reserves on bio-degradation. Moreover JGT-residue is beneficial as it helps enhance the hydraulic conductivity of soil. The efficacy of JGT in control of surficial soil erosion for all these reasons is now well established.

Appropriately designed woven JGT when placed on a *road sub-grade* enhances its bearing capacity (expressed as CBR %). The phenomenon is the result of the functions of separation and filtration performed by an appropriately designed woven JGT laid on the sub-grade. Consolidation of

soil is a protracted process. It is for this reason CBR of a sub-grade keeps on increasing over a period even after degradation of the jute fabric. This is a pointer to the fact that JGT and, for that matter, all geotextiles act as a change agent to the soil helping it to consolidate to its maximum. Normally the range of enhancement of CBR of a sub-grade treated with JGT is 150% to 300% of the control value.

Bitumen-treated woven JGT has performed satisfactorily in *controlling erosion of river and canal banks*. Woven JGT can serve as a better and cost-effective substitute of the conventional granular filter. Availability of granular aggregates often poses difficulty, apart from the difficulties encountered in exercising quality control. A layer of woven JGT treated with a suitable water-repellant additive may replace the layers of granular aggregates. An armour layer over the fabric is however necessary to prevent the fabric displacement and its exposure to weather.

Bitumen however is not the ideal material for coating JGT as bitumen makes the fabric rigid and less drapable. Search is on for a better additive that can retard degradation of JGT even after its continuous exposure to water; but we may have to rely on bitumen as a water-repellant additive till such time a more suitable alternative is found and successfully tried. Incidentally bitumen and jute have excellent thermal compatibility. IIT Kharagpur has been entrusted with this project by JMDC under Jute Technology Mission, India. We may have to wait for a period of three years for the result.

4. Prospective Applications of JGT

Considering the physical attributes of jute, it is worth trying JGT in some form or the other in areas other than what was indicated above. Geo-environmental applications of JGT should demand priority considering its eco-concordance. In developing countries the progress so far in this area has been sluggish. Developed countries are likely to encourage use of natural bio-degradable products that decompose within its short ecological cycle. Man-made geotextiles have obvious limitations in this respect.

a) prospective geo-environmental applications

Prospective application of JGT may be categorized into two groups—*geo-environmental and geo-technical*. JGT holds commercial promise under the *first group* in the following areas that come under Environmental Geotechnology.

--stabilization of mine-spoils and over-burden dumps (OB dumps)

--management of fly ash (PFA) heaps

--management of solid municipal waste (MSW)

--water-shed management.

Open cast mines are saddled with the problem of *over-burden stability*. Mine safety is jeopardized as a result of unplanned heaping of O B dumps that may rise up to a height of 50 meters and above with apprehension of sliding/slipping. Mine Safety Regulations are often not followed in private open cast mines. Besides, such unplanned heaping contravenes the national mineral policy of the government that emphasizes adherence to mine safety rules and stabilization of vulnerable bare dumps.

Mine spoils usually consist of coarse aggregates varying in size from 0.2 mm to 50 mm. Hydraulic conductivity being very high, water retention on surface can be ensured by use of thick open weave JGT. Entrapment of particles detached as a result of precipitation can also be effectively achieved due to 3-D structure of thick open weave JGT. Conjunctive use of open weave JGT and vegetation is recommended in stabilizing such dumps. The method was successfully tried in O B dumps under Northern Coalfields at Singrauli and Western Coalfields at Nagpur in India with the advice of the World Bank consultants, IIT Kanpur..

Thermal power plants face persistent problems with *PFA heaps*. Only about 15% of PFA out of 100 million tonnes generated in thermal power plants in India are used for diverse applications such as land filling, brick manufacture. Accumulation of PFA in the precincts of thermal power plants not only poses environmental threats (air and sub-surface pollution), but also intrudes upon the essential free space within the plant along with uncertainties on their stability. A few years back a fly ash bund failed at Kolaghat thermal power plant in West Bengal.

PFA is usually alkaline and therefore should not stand in the way of land-filling and brick-making. It has a lower specific gravity than soil (between 2.15 and 2.18). If no other avenues are found, there remains hardly any option but to use the heaps for landscaping at least to prevent pollution. What is needed is proper planning considering the normal life of a thermal power plant to be 30 years. The quantity of PFA likely to be generated during the period is to be estimated vis-à-vis the extent of its utilization and open area availability for disposal.

Any way, PFA heaps can be similarly treated with open weave JGT and vegetation as in the case of O B dumps. Additionally a cover of non-woven JGT will prevent air pollution. Both O B dumps and PFA heaps can be developed into pleasing greeneries with the support of JGT. It is however needed to be selective about the species of vegetation. Expert advice in the matter should be sought.

Management of solid municipal waste (MSW) is a neglected sector in developing countries. MSW is a veritable source of pollution. It may contaminate ground water, pollute air and spread diseases. In developed countries daily covers are used over MSW. Non-woven JGT can be conveniently used as daily covers to help dissipation of foul gases and entrapped polluted liquids and to keep air pollution on check. Unfortunately the concept of providing daily cover over MSW heaps has not gained ground in developing countries.

Watershed management has not received the importance it deserves in developing countries. Denudation of ground makes it vulnerable to erosive forces of precipitation and overland flow. Detached soil particles are carried away to the nearest waterway with the run-off and either deposited over the bed of the waterway or transported further to a distance by the flowing stream depending on velocity of flow, weight and plasticity of particles. Any way deposition of sediment is instrumental in reduction of cubature of waterways and consequently their capacity to hold. This is the main reason of occurrence of floods in this part of the globe. If vegetation can be grown on bare ground, the probability of soil erosion will get substantially reduced. Open weave JGT may be especially effective for growth of vegetation in arid and semi-arid regions because of high water absorbing capacity of jute and its mulching properties.

b) prospective geotechnical applications

Under the *geotechnical category*, the following prospective applications are worth trying.

--turf-reinforced mat (TRM) with JGT- backing
--jute-reinforced asphaltic overlays
--jute-reinforced temporary haul roads
--fabriforms
--jute fibre-reinforced concrete

Ready-to-use *turf mat* with JGT backing can be conveniently used on vulnerable slopes and denuded ground. TRMs are in good demand in the overseas. Cost aspects however deserve consideration.

Bitumen-soaked jute-overlays may be used as riding surface of roads. Presently in India mastic asphalt is being extensively used. Jute-based asphaltic overlays will be cheaper though less durable. Jute and hot bitumen have excellent thermal compatibility. Moreover non-woven JGT is a very good receptor of bitumen. A combination of woven and non-woven JGT smeared with bitumen is expected to work as a resilient, water-proof and abrasion-resistant paving sheet on roads. Such sheets will have wide application especially for resurfacing the distressed riding surfaces of flexible pavements. A project to design and develop jute-based asphaltic overlay is included in the on-going Jute Technology Mission in India.

Jute possesses a higher modulus than its competitive man-made counterpart, has lower elongation at break and is proportionately stiffer. For *temporary haul roads* as in the case of approaches to construction sites, internal roads in mines, woven JGT hold both a technical and commercial advantage over its man-made counterpart. New roads can be built over such temporary roads without the hazard of lifting the used JGT. This is an unexplored area in developing countries though JGT should have a good market in developed countries for such use.

Fabriform is a kind of fabric that can hold wet concrete in a desired shape. Once the concrete hardens, the utility of the fabric ceases. It can be used as revetment mattresses, for restoration of concrete and as lining and armour. The advantage is its cost and degradability. JGT fabriforms may replace the costly boulders—granite, laterite etc—used conventionally as armour or ballast.

Concrete reinforced with jute fibres should be stronger and is expected to be resistant against minor distresses in concrete. Recently man-made fibres have been tried to reinforce concrete with reported success. Jute fibres should add to the both tensile and compressive strength of concrete. A project for this purpose has been included in the ongoing Jute Technology Mission under “Design & Development of JDPs”. Jute fibre-reinforced concrete may also reduce the extent of steel reinforcement in RCC.

Jute geogrids may serve as a substitute of man-made geogrids if proved cost-effective. Geogrids can be used for control of slips and slides in hilly slopes and to check the sustained migration of debris along the slopes. Such geogrids may be used with advantage in shallow surficial slides in areas with

temperate rainfall and moderately cohesive soil cover. Central Road Research Institute (CRRI) used such geogrids in Himachal Pradesh, India. Till date, jute geogrids have been used sparingly.

Prefabricated Vertical Jute Drains (PVJD) should have a good market for ground improvement. A wide range of such drains with man-made yarns are being marketed commercially. PVJD are equally effective as substantiated by studies and trials. PVJD has been patented in the U K and Singapore and has also been registered as a utility model in Japan (Ramaswamy 1997). PVJD, according to reports, are being used in south-east Asian countries, especially in Indonesia for hastening consolidation of soft deep-seated clay. IIT, Delhi has devised a similar drain with a braided sheath. In India use of PVJD has been insignificant so far. PVJD needs special rigs for insertion into the ground. This could be a reason why the product has not found encouragement from the consultants.

Woven JGT has been experimented successfully as separator and filter *in reclamation of land from the sea* (Tan et al 1994). But for some reasons use of woven JGT in land reclamation has not gained ground. It is felt that problems of reclamation of water-logged areas can be effectively obviated by use of JGT as separator and filter.

In hill slopes fall of fine debris, especially during the monsoon, is common. This is precursor to heavier slips and slides. Arresting the detached aggregates within the slope itself is a way that can reduce or delay the chances of heavier damages as a result. Ranklor (1994) suggested erection of *silt fences* for this purpose. Silt fences can be constructed by erecting locally available timber/ bamboo/ tree branches down the slope at suitable intervals and filling the interspaces between the posts with woven JGT. Understandably woven JGT screens will need replacement when it loses strength or worn out.

Prof Ramaswamy indicated in a paper (1990) that he had developed *jute geomembranes* while working in a UNDP project at Indian Jute Industries' Research Association, Kolkata. This was a blend of two layers of woven JGT impregnated with bitumen emulsion and a high density HDPE sheet sandwiched in between. It is however felt this exercise will not provide any commercial advantage. Moreover use of HDPE sheet sandwiched between JGT layers is apt to raise questions on the suitability of bitumen-smeared woven JGT as a water-proof barrier.

4. Conclusion

In order that prospective applications of JGT may find larger acceptability, it is imperative that technical requirements of the end-users should be precisely ascertained and appropriate JGT developed with an eye to the comparative commercial advantage over its man-made counterpart. It is to be accepted that JGT cannot match man-made GT in terms of durability. However in the majority of geotechnical applications geotextile acts as a change agent to the soil on and in which it is laid. Durability therefore is a matter of secondary concern in such cases. JGT scores over its man-made counterpart if environmental aspects are considered. Measures to protect environment with eco-friendly materials should fetch a special discount.

Harding (1994) suggested an Erosion Control Benefit Matrix (ECBM) for comparative assessment of environmental management practices. The matrix takes into account six salient characteristics viz acceptance, cost, effectiveness, installation, vegetation establishment and maintenance with several sub-variables under each. JGT has distinct advantages in respect of each variable determinant. What is perhaps needed is to standardize each existing and prospective application of JGT, to exercise quality control over the product to meet the desired specification and to adopt a pro-active marketing strategy by the manufacturers. At the same time there should no relenting of efforts to improve the products on the basis of scientific studies and research in the field. The deficiencies need be continually addressed through relentless research.

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ABSTRACT

Versatility and distinctive physical characteristics of jute fibres coupled with its high spinnability, make it an ideal material for new technical applications beyond the existing conventional end-uses. The conventional end-uses of Jute Geotextiles (JGT) in the areas of slope stabilization, surficial soil erosion control, strengthening of road sub-grades and protection of river and canal banks have yielded satisfactory results in the quite a few field trials carried out in India. Standardization in use of different varieties of JGT in the aforesaid end-uses is under way.

Application of the appropriate JGT in *other* geo-environmental and geotechnical end-uses should be concurrently thought of considering the distinctive features of jute fibres to widen its market base. The prospective applications should be considered in the following sectors.

Prospective geo-environmental end-uses—
--stabilization of mine-spoils and over-burden dumps (OB dumps)

--management of fly ash (PFA) heaps

--management of solid municipal waste (MSW)

--water-shed management.

Prospective geotechnical end-uses--
--turf-reinforced mat (TRM) with JGT- backing

--jute-reinforced asphaltic overlays

--jute-reinforced temporary haul roads

--fabriforms

--jute fibre-reinforced concrete.

Of the aforesaid prospective applications, the following hold an edge over the others.

--stabilization of mine-spoils and over-burden dumps (OB dumps)

--management of fly ash (PFA) heaps

--management of solid municipal waste (MSW)

-- jute-reinforced asphaltic overlays in roads

-- strengthening of temporary haul roads

--jute fibre-reinforced concrete.

While the first application has been tried in the Northern & Western Coalfields in India, the other applications await field applications. We are confident about success of JGT in respect management of solid waste and strengthening of haul roads. Studies on the remaining two applications viz. jute-reinforced asphaltic overlays in roads and jute-reinforced cement concrete have been entrusted to Institute of Jute Technology, Kolkata & Central Road Research Institute (CRRI), Delhi jointly and to Indian Institute of Technology, Kharagpur respectively by JMDC under Jute Technology Mission.

The author feels that standardization of the prospective applications of JGT will pave the way for larger acceptability of JGT. At the same time there should be no relenting in efforts to continue study and research in the field for improvement of production and quality of products to ensure greater customer satisfaction.