# Natural Geosynthetics and its Appropriateness for use in Geotechnical Application

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**Abstract** : Sustained measures for alleviating soil related problems with the use of natural eco-friendly materials are now a days being preferred by the geotechnical professionals all over. Depleting petroleum reserves and deteriorating environment have prompted the engineers, consultants and end-users to look for environment-friendly alternatives for use in civil engineering constructions in general wherever feasible. Soil related problems so long tackled by structural interventions, are now increasingly addressed by bio-engineering measures and by using ingredients that would help in carbon foot-print reduction. It is for these reasons Jute Geotextiles (JGT), a natural variant of geosynthetics, are finding greater acceptability. Its price-competitiveness as well as conformity to precise technical requirements is also a deciding factor.

In India JGT has been used to address a number of soil related problems in civil engineering. Years of R & D work conducted by Indian Jute Industries' Research Association (IJIRA) in collaboration with National Jute Board have led to develop different varieties of JGT. Backed by the support and initiative of National Jute Board, a national body under the Ministry of Textiles, JGT has been used for strengthening roads, controlling erosion of river banks and stabilizing slopes of embankments and in hills. In fact open weave JGT, popularly known as 'soil saver', is the most sought-after fabric for surficial soil erosion control in the developed countries.

The paper highlights the special features of jute that make it distinctive in soil-related applicability with special reference to India. Comparison of properties and performance evaluation of JGT with reference to few case studies have also been highlighted in the paper.

## 1. Introduction :

Present day's man made geotextiles owe their origin to natural components like tree-shreds, reeds that were used to combat soil erosion in earlier days. The Netherlands pioneered use of polymers in making of man-made geotextiles way back in 1953. Research, studies and field application of man-made geotextiles developed for a variety of geotechnical applications have paved the way for standardization of the products and their ultimate acceptability to the engineers using them. However, long life of man-made geotextiles and their probable immiscibility with soil on which they are laid leaves room for doubt about their eco-compatibility. It is this aspect that bestows preponderance on Jute Geotextile over its artificial counterpart. Flexibility, drapability, high initial strength and low extensibility of Jute fibre make Jute Geotextile an ideal alternative to man-made geotextiles in addressing majority of geotechnical applications. In fact, concerted studies and application on Jute Geotextile were taken up in mid-1980s. Two UNDP-sponsored projects on Jute Geotextile were taken in hand in India when elaborate laboratory studies and field application were initiated where the results were highly encouraging. Again in 2005 a Pilot Project was undertaken

to observe the performance of JGT in construction of rural road. Performance evaluated by CRRI was found very satisfactory. Further, an International Project was undertaken in 2010 both in India and Bangladesh for road construction, river bank protection and slope protection. Performance of JGT here also was observed to be extremely satisfactory. Understandably, results of field application are more convincing to engineers in the sense that simulation of soil constituents and time-dependent extraneous loading parameters in laboratory may leave room for exactness, creating space in proper understanding of performance of both the geotextile and the structure treated with it. However, on the basis of its performance, JGT are now being used commercially in a large scale all over. Standard specifications of the products have been made by BIS and most of the which are already included in the Schedule of Rates ( SoR) as an item of work by the respective departments of state and central gov.in India

In this paper attempt has been made to present basic properties of jute, specifications of different types of JGT developed, its role in geotechnical engineering and functional mechanism along with scope of applications.

## 2. Properties of Jute Fibre :

Jute is a natural ligno-cellulosic bast fibre. Its chemical constituents are given in table I and a comparative study on physical properties of jute and other fibres are shown in table II.

**Table I - Chemical constituents of jute fibre :**

| Constituents | % |
|---|---|
| Cellulose | 60 – 62 |
| Hemi Cellulose | 22 - 24 |
| Lignin | 12 – 14 |
| Others | 1 – 2 |

**Table II – Comparative physical properties of jute and other fibres :**

| FIBRE | DENCITY (G/CC) | FINENESS (DENIER) | TENACITY (G/DENIER) | ELONGATION AT BREAK (%) | INITIAL MODULUS (G/DENIER) | MOISTURE REGAIN % AT 65 % RH |
|---|---|---|---|---|---|---|
| JUTE | 1.47 | 20 | 4.2 | 1.2 | 380 | 13 |
| COTTON | 1.55 | 2 | 3.5 | 8.0 | 50 | 8.5 |
| FLAX | 1.50 | 12 | 5.0 | 2.2 | 250 | 10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| KENAF | 1.46 | 27 | 3.7 | 1.1 | 330 | 12.5 |
| COIR | 1.40 | 162 - 450 | 1.25 – 1.6 | 41 – 45 | 45 | 10 .5 |
| RAMIE | 1.56 | 3.6 – 7.2 | 4.5 – 7.2 | 3 – 4 | 160 | 6.5 |
| HEMP | 1.53 | 45 – 135 | 4 – 5 | 1.5 – 2.5 | 245 | 11 |
| NYLON | 1.14 | 1.5 – 3.0 | 5.0 | 15.0 | 40 | 4.0 |

3. **Jute geotextiles (JGT)**:

JGT is a permeable textile fabric available in woven, non-woven and open weave forms used in or on soil to improve its engineering performance. Woven JGT performs the functions of separation, filtration, initial re-enforcement and drainage when used in the interface of road sub-grade and sub-base, thereby helps soil consolidation and increases the CBR%. Woven JGT overlain with non woven JGT when applied on the surface of weak formation arrest scope of intrusion of ballasts into the soil bellow and also allow passage of precipitation along the plane of the fabric thereby keeps the soil dry and tight and ultimately check the possibility of settlement of railway tracks. Properly designed woven JGT with appropriate porometry ( $O_{95}$) treated with suitable additives is used as filter material in river bank protection. Open weave JGT when laid on vulnerable slope it reduces surface run off with check dam effect and foster vegetation, thereby control erosion..

**4. Types of JGT and specifications :**

JGT is a tailor-made product. Site- specific products can be manufactured depending upon end-use requirements. Stronger (40kN/m) and wider (up to 5 m) fabric with finer porometry (100 micron) can easily be produced utilizing the existing machinery capacity of the jute industry in the country. In the recent past two new varieties of DW Plain weave JGT like, 627gsm of 20 kN/m and 724 gsm of 25 kN/m have been developed for use in river bank protection work and road construction work respectively which are cost effective and technically suitable for their specific uses. However, specifications of few of the JGTs developed and used in the fields under the technical guidance of NJB are shown as reference in the following Tables:

**Table III – Specifications of woven jute geotextiles :**

| **Nomenclature** | **Woven JGT 20 kN/m** | **Woven JGT 25 kN/m** |
|---|---|---|
| Construction | DW Plain Weave | DW Plain Weave |
| Weight (gsm) | 627 | 724 |
| Width (cm) | 100 | 100 |

| | | |
|---|---|---|
| Ends x Picks / dm | 85 x 32 | 94 x 39 |
| Thickness, (mm at 2 kPa) | 1.7 | 1.85 |
| Tensile Strength (kN/m) MD x CD | 20 x 20 | 25 x 25 |
| Elongation at break (%) MDx CD | 8 x 8 | 10 x 10 |
| Puncture Resistance(kN) | 0.400 | 0.500 |
| Burst Strength (KPa) | 3100 | 3500 |
| Permittivity at 50mm constant head ( /second) | 350 x $10^{-3}$ | 350 x $10^{-3}$ |
| A O S ( micron ) $O_{95}$ | 150 - 400 | 150 - 400 |

**Table IV – Non woven JGT :**

| Properties | Type 1 | Type 2 |
|---|---|---|
| Weight (gm/sq.m) | 500 | 1000 |
| Thickness (mm) | 4 | 8 |
| Width (cm) | 150 | 150 |
| Strength (kN/metre) MD x CD | 4 x 5 | 6 x 7 |
| Elongation at break (%) MD x CD | 20 x 20 | 25 x 25 |
| Porometry ($O_{90}$) (micron) | 500 | 300 |
| PermittivityCo-efficient (metre/sec) | 3.4 x $10^{-3}$ | 3.4 x $10^{-4}$ |

**Table – V Open weave JGT :**

| Properties | Type 1 | Type 2 | Type 3 |
|---|---|---|---|
| Weight (gm/sq.metre) | 292 | 500 | 730 |
| Threads/dm (MD X CD) | 12 x 12 | 6.5 x 4.5 | 7 x 7 |
| Thickness (mm) | 3 | 5 | 7 |
| Width (cm) | 122 | 122 | 122 |
| Open Area (%) | 60 | 50 | 40 |
| Strength (kN/metre) (MD X CD) | 10 x 10 | 10 x 7.5 | 12 x 12 |
| Water holding capacity on dry weight (%) | 400 | 500 | 500 |

## 5. Functional mechanism of JGT :

It is well known that any geotextile performs four basic functions viz., separation, filtration, drainage and initial reinforcement. The right porometry of the fabric in commensurate with the average particle size distribution of soil and initial strength to withstand hydraulic and mechanical loads are the basic requirements of a geotextile that facilitate performance of the four functions as indicated. Jute Geotextile, like its man-made counterpart, can be tailor-made. The apprehension frequently expressed by engineers is about performance of Jute Geotextile beyond its effective life i.e. after its bio-degradation. Case studies have confirmed findings in laboratories about catalytic function of Jute Geotextile and, for that matter, any geotextile in effecting improvement of engineering properties of soil for an initial period not exceeding two season cycles according to our experience. Soil gains strength in two ways basically—through separation and retention of fines on the one hand and drainage efficiency facilitated by geotextile on the other. It is an accepted understanding that eradication of water from soil imparts strength to it. It does not take more than six to seven months to optimize moisture content in soil as has been found in laboratories. In fields the process may take a slightly longer time, but not more than two season cycles in any case. The accepted procedure in soil compaction is to ensure OMC in soil first to achieve maximum dry density in it. It is worth mentioning here that the ingredients of Jute Geotextile increase permeability of soil due to the intrinsic properties of jute fibre. This is a special feature of Jute Geotextile unmatched by other types geotextiles made of other fibres-natural and man-made. We feel prompted to make mention of the findings of Ramaswamy & Aziz (1989) in this regard. According to their findings, soil treated with Jute Geotextile becomes less and less dependent on the fabric with the passage of time. Secondly, the loss in strength of Jute Geotextile with time is compensated by corresponding gain in strength of soil under the same time frame. Recent studies in Jadavpur University, India also confirm the aforesaid findings of Ramaswamy & Aziz. Further, JGT is a highly hydrophilic and best drapable

among all other geotextile fabrics which establish its uniqueness for surficial soil erosion and establishment of vegetation on the slope of hills and earthen embankments.

## 6. Application of JGT :

Demand of above specified JGTs are increasing very fast for their various applications within the country and beyond . As of now total number of applications in different sectors as per record available is road construction : 223 + , river bank protection : 115+, slope stabilization : 107 + , railways : 53+ etc.

Among the above number of field applications carried out with JGT general findings based on some of the cases in India are discussed below -

### 6a. Road Construction

In all the field applications in roads, it has been observed that sub-grades, despite being expansive, experienced increase in CBR in the range of 1.5 to 3.0 times the control value. As soil consolidation is a time-dependant process, with the passage of time CBR shows a sustained rise even after a period of 8/9 years. For example a PMGSY road, Andulia to Bairatala at 24 Parganas ( N ) was constructed by WBSRDA with JGT in 2002 . IIEST evaluated the performance of the study. The Subgrade CBR was increased from 2.22 to 12 % within a span of 18 months. Another road in Karnataka was constructed with JGT in 2014 by KRRDA. Performance evaluated by the deptt showed that CBR value of road subgrade was increased from 3.2 to 8 % within a span of 18 months In most of the cases 25 kN /m tensile strength woven JGT was used.

### 6b. Slope Stabilization

Open weave JGT was used for stabilization of slopes in hills and embankments followed by creation of vegetative cover that protects the slopes from destabilization on bio-degradation of JGT. In almost all case studies, the yield of vegetation improved by around 5 times the usual yield (Kg per ha.) after 3 years of plantation. For example, destabilized slope of Shashradhara at Uttarakhand, Sonapur land slide at Meghalaya etc. Moisture conservation, reduction of the velocity of surface run-off and quality improvement of soil were in evidence in all the applications The extent of improvement of soil character depends on selection of the vegetation, soil type and climatic features. The choice of open weave JGT (500 gsm or above) depends on the amount and intensity of precipitation, and gradient of slope.

### 6c. River Bank Protection

Woven JGT treated with additive was used in all application related to erosion control in river and waterways. This was done with a view to protecting JGT yarns from direct exposure to water and bank soil. Moreover, time of bank soil consolidation in river depend on the nature of flow (two way or one way), existence of vortices at the toe of the bank slope and other hydraulic factors. In the tidal river (e.g., the Hugli in West Bengal, India), mangrove implant was tried to add to the strength of the bank soil through its roots. In non–tidal reaches (one way flow), usual boulder rip rap was used above JGT as armor. Some of the works worth mention are river Hugli, river Fulahar, Bramhaputra

etc. In all the cases woven JGT of 20 kN/m tensile strength treated with suitable additive was used as filter fabric in place of conventionally used inverted filter. Erosion of river bank in all the cases were checked and banks were stabilized.

**6d. Control of Railway Track Subsidence**

In order to control railway track subsidence, both vertical and lateral, 25 kN/m tensile strength woven JGT ( treated) superimposed with 1000 gsm nonwoven JGT was used by Eastern Railway in Howrah Burdwan cord section in 2001. Settlement level was observed to reduce from 70 mm to 13 mm.

## 7. Conclusion :

Jute Geotextile, a natural variant of geosynthetics has been found to be a high potential civil engineering material and very effective in road construction, river bank erosion control, slope stabilization, control of railway track subsidence etc.