

# Standards For Application Of Jute Geotextile In Strengthening Of Sub-Grade In Roads

## **FOREWORD**

### **(applicable for both the guidelines)**

Jute Geotextile (JGT), a natural geotextile made of bast fibres of the plant bearing the same name, is being increasingly favoured by civil & geotechnical Engineers for its eco-concordance and competitive price. The species of jute in common use are– *Corchorus Capsularis* (white jute) and *Corchorus Olitorius* (Tossa Jute). Fibres are separated from the plant by tying the plants in bundles and immersing them into slow moving water. The process is called “retting”. The major components of jute fibres are natural cellulose (85% – 87%) & Lignin (12% - 14%) with wax, ash & nitrogen as its other insignificant ingredients.

Jute possesses high tenacity and remains stable over a range of 30%-80% of RH. It has also high initial torsional rigidity. Jute has low extensibility and, hence, low toughness. Jute is highly hygroscopic and can absorb water up to about 5 times its dry weight.

Jute Geotextile (JGT) made out of the jute fibres/yarns functions in much the same way as its man-made counter part. All geotextiles –whether man-made or natural, basically acts as change agents to the soil on or in which it is laid.

Biodegradability is therefore not a technical constraint as may seem. Effectively life of JGT can be enhanced by two to five years with special chemical treatment, depending on the conditions of the soil on or in which it is laid.

Soil behaviour improves due to natural consolidation effected as a result of concurrent functioning of separation, filtration and drainage on application of JGT.

BIS has already published **IS-14986:2001** entitled “**Guidelines for Application of Jute Geotextile for Rain water Erosion Control in Road and Railway Embankments and Hill Slopes**”. Guidelines for application of JGT for

i) **Strengthening of sub-grades in roads &**

ii) **Control of bank erosion in rivers & waterways**

are now published for the benefit and guidance of the end-users.

## 1. SCOPE

- 1.1 This standards provides guidelines for application of Jute Geotextile (JGT) in strengthening of sub-grades of including specifications and installation methods.

## 2. REFERENCES

- 2.1 The guidelines have been prepared on the basis of performance of JGT in strengthening road-sub-grades in several field applications mentioned in the anthology of case studies entitled “**Performance Evaluation of Jute Geotextile**” published by Jute Manufacturers Development Council (JMDC), Ministry of Textiles, Govt. of India (2003).

## 3. TERMINOLOGY

- 3.1 For the purpose of these guidelines, the following definitions shall apply.

- 3.1.1 Woven Geotextile -

Interlacement of warp and weft yarns to form a fabric , conforming to the specified weight, tensile strength, porometry, transmittivity and permittivity.

- 3.1.2 Non-woven Geotextile –

Mechanically bonded fabric formed by entangling fibres to ensure comparatively loose bonds where fibres cross over.

- 3.1.3 Open Weave Jute Geotextile –

Open structured Jute Geotextile in which yarns of a specified diameter are laid in specified numbers /length in both warp and weft directions.

- 3.1.4 Ends

The number of warp threads of a JGT.

- 3.1.5 Picks

The number of weft threads of a JGT.

- 3.1.6 Moisture Regain

Weight of moisture regain in a JGT (or any jute product) expressed as percentage of its oven dry weight (105°C + 3°C mixed with air under standard atmospheric conditions).

### 3.1.7 Permittivity of JGT ( $\psi$ )

Flow capacity across a JGT under a given hydraulic gradient and flow area.

$\Psi = K_g/t_g$ ; where  $K_g$  is the coefficient of permeability of JGT (m/s.) and  $t_g$  is the thickness of the same JGT (m)

$\Psi$  is expressed in reciprocal of time ( $\text{sec}^{-1}$ )

### 3.1.8 Transmittivity of JGT

and Flow or draining capacity of a JGT along its plane under a given hydraulic gradient flow area.

### 3.1.9 Porometry of JGT

Pore size of a woven JGT. A finer pore size reduces OAR (Open Area Ratio), thus reducing its permittivity. Also called A.O.S. (Apparent Opening Size).

Symbol –  $O_n$

### 3.1.10 Open Area Ratio (OAR)

Ratio between total area of openings in a JGT and total area covered by the JGT expressed as percentage.

### 3.1.11 CBR (California Bearing Ratio)

Measure of the bearing capacity of a road sub-grade. Ratio of the resistance of a sub-grade /soil to a standard plunger up to a pre-stated thickness (2.5 cm or 5 cm) to the corresponding resistance through a crushed rock. Expressed as percentage (%)

### 3.1.12 Consolidation of Soil

Process of gradual expulsion of water from voids of a soil due to imposition of loads.

### 3.1.13 Drapability of JGT

on Measure of a JGT to shape itself to the contours of any surface. It is a measure of JGT's "flex-stiffness" i.e., bending of JGT under its own weight between two points a surface.

### 3.1.14 Puncture Strength of JGT

Measure of resistance of a JGT against puncturing under imposed loads.

### 3.1.15 Tensile Strength of JGT

The stretching load at which a JGT sample breaks. The JGT is stretched by gripping it at two ends till its failure or break. Expressed in kN/metre.

### 3.1.16 Elongation-at- break of JGT

Measure of extension of a JGT- specimen at failure (break) over its initial length. Expressed in percentage (%).

### 3.1.17 Grain Size Distribution of soil

Represented by a semi-logarithmic curve that plots logarithm of the grain size in the abscissa against percentage of grains by weight smaller than the size denoted in the abscissa, in the ordinate. The more uniform is the grain size, the steeper is the curve.

## 4. SPECIFIC REQUIREMENTS

### 4.1 Mechanism of Strengthening of a Road Sub-grade

Poor sub-grade often causes pavement-failure as strains accumulate under repeated dynamic loads of traffic. It often happens that the materials in the base course of the pavement get intermixed with the sub-grade reducing the required depth of the pavement decided on the basis of class of loading vis-à-vis CBR (California Bearing Ratio). A poor sub-grade may also cause lateral displacement of the sub-grade and the base materials under loads. Insufficient drainage of the surface water and also the entrapped moisture/water within the sub-surface layers along with the seepage of water from the sides often lead to road failure.

JGT can tackle all these problems effectively by segregating different layers of a road pavement, preventing movement of the sub-grade soil (soil-tightness) and facilitating filtration through it, leading to enhancement of CBR percentage of the sub-grade.

Concurrent functioning of separation, filtration and drainage causes the sub-grade soil to consolidate. Separation by a suitable woven JGT prevents interpenetration of the soil particles from the underlying layer (sub-grade) into the base course and aggregates from the overlying layer (base course) into the sub-grade. A properly designed woven JGT with the right porometric features and tensile strength ensures “sand tightness” on the one hand and release of the entrained water from the sub-grade through the pores of the fabric (permeability) and along the plane of the fabric (transmissivity). High hygroscopicity of jute facilitates transmissivity by acting as a drain within its own thickness.

Comparatively low elongation at break of jute also helps in enhancing the membrane effect and causes an upward reaction to develop to counteract the downward moving load of the road.

Case studies so far conducted have shown augmentation of CBR of the sub-grade to the extent of 1.5 to 3.0 times the control CBR value. For the purpose of design it is advisable to consider the enhancement of CBR in the sub-grade by 1.5 times the control figure. The design guidelines standardized by the

Indian Roads Congress with the enhanced CBR value should be followed. It is recommended that appropriately designed woven JGT should be used in sub-grades with CBR equal to or greater than 3% (shear strength greater than 90 kN/sqm).

Treatment of JGT with an additive (a branded chemical marketed as COMPSOL- a blend of cupro-ammonium carbonate and ammonium hydroxide) will ensure longer durability of JGT till such time the consolidation of the sub-grade soil maximizes (filter cake formation).

Non-woven JGT can be used to advantage as concealed drains encapsulating ballasts for facilitating road side drainage. Such drains are especially suitable for hill roads.

#### 4.2 Selection of JGT

Selection of JGT (Woven) shall be decided principally on grain size distribution of soil, soil permeability (i.e., soil flow capacity under a given hydraulic gradient and flow area), class of volume of traffic (as per Indian Roads Congress classification) and the allowable rut-depth.

Usually a woven JGT having tensile strength of 25 to 30 kN/m, puncture strength in the range of 375-400 N and AOS (porometry) in the range of 150 microns to 300 microns should serve the purpose. Permittivity of JGT should be more than the soil permeability.

The highway engineer concerned should clearly specify its requirements in respect of tensile strength, soil permeability and grain size distribution. It should be the task of the Jute Technologist in the Mill to conform to them. For facilitating drainage, non-woven JGT may be used in combination with woven JGT. Incidentally, non-woven JGT is much weaker than the woven type in so far as tensile strength is concerned.

### 5. INSTALLATION METHOD

#### 5.1 The following sequence in laying of JGT should be followed

- the subgrade is to be excavated to the required level, cleared of all foreign materials and compacted to the OMC (Optimum Moisture Content). The subgrade should be done up with the specified profile. Vegetation, if any, should be uprooted and the area leveled with earth and rolled.
- JGT as selected should be laid by unrolling, ensuring proper drapability (i.e., JGT should touch the sub-grade surface at all points) and stapled at an interval of 300 mm with overlaps of 150 mm. Staples should be preferably U-shaped nails (11 gauge). It is preferable to avoid overlaps to the extent possible.
- thin cushion of local sand (maximum 12 mm thick ) may be spread over the JGT to prevent puncture/damage due to rolling of the upper sub-base/base-layer.
- the first layer of aggregates in the base-layer should then be spread with grading as recommended in the relevant IRC guidelines. No traffic should be allowed on an

uncompacted base with less than 200 mm (150 mm for  $CBR \geq 3$ ) thickness laid over JGT.

- any rut that may develop during construction should be filled in
- parallel rolls of JGT should be overlapped and stapled
- for application in curves, JGT should be folded or cut and overlapped in the direction of the turn. Folds in JGT should be stapled at an interval of 300 mm.
- before covering up the JGT, its condition should be assessed for any construction /installation damage. Torn/damaged portions may be covered by pieces of JGT and duly stapled on all sides preferably at an interval of 75 mm. The extent of overlap will be such as to fully cover the damaged/torn portion fully plus at least 75 mm beyond, on all sides.
- Installation guidelines for open JGT–encapsulated sub-surface or shoulder drains shall ensure that JGT touches the three arms of the trench excavated for the drain excepting the top. Loose aggregates are to be filled in with JGT adequately stapled and wrapped over with the already placed JGT. The top of the drain should be wrapped with a minimum overlap of 300 mm.

## 6.0 SHOULDER DRAINS

Often the sub-surface water is drained through the JGT-medium to the shoulders of a carriage way. In such cases, shoulder drains are required to be constructed either beneath the edge of the shoulder or immediately adjacent to its edge (In USA, such drains are called “under drains”). In the event of existence of black cotton soil or expansive clay, porous drain pipes are also inserted within the shoulder drain to augment drainage-efficiency.

## 7.0 TRANSPORTATION, STORAGE AND HANDLING

7.1 JGT can easily be handled and transported. Jute yarns are basically robust. But care is to be taken to keep a free from moisture (being hygroscopic) and fire. JGT can be transported in rolls or bales. A bale weighs around 340 kg. (680m<sup>2</sup>) and may consist of a number of lengths (8 to 10) depending on the required individual roll length.

### 7.2 Storage

Prolonged storage of JGT in warehouse is discouraged as JGT is susceptible to microbial action and loss of strength. JGT should be provided with a water-proof cover for protection against rains and moisture. Its direct contact with soil during storage should also be avoided.

7.2.1 Humidity, temperature variation, lack of air-circulation and abnormal moisture absorption affect the quality of JGT and therefore calls for attention. The main thrust should be on safe transportation and storage of JGT at site without damaging and unduly exposing the material to adverse climatic conditions.

### 7.2.2 Site unloading

A fork lift or front-end loader fitted with a long tapered pole (carpet pole/stinger) is recommended for unloading JGT rolls. The carpet pole is inserted into the core of the JGT roll which is then unloaded from the truck. Nylon straps/ropes/roll pullers may also be used. Not more than three JGT rolls should be lifted / unloaded at a time. Use of chains & cables for unloading purposes is discouraged. A tarpaulin, a sheet of plastic or the like should be placed on ground for initial storage of JGT.

### 7.2.3 Site Handling

As already stated, JGT rolls should be provided with a protective wrapping. It should be kept above the ground and should be covered with a tarpaulin or a thick plastic sheet.

7.2.4 Exposure of JGT to moisture/water may pose handling problems. As JGT can absorb water up to 5 times of its own dry weight, handling wet JGT becomes more difficult than handling a moisture-free JGT. The cores of JGT-rolls usually made of laminated paper are susceptible to damages on being exposed to moisture / water and should be kept dry.

7.2.4 JGT should not normally be stored for a long period. Protracted storage of JGT may impair its strength to some extent.

## 8.0 DESIGNING ROAD PAVEMENT WITH JGT

8.1 All the laboratory trials and field applications conducted so far substantiate that CBR of a road sub-grade of any type enhances by at least 150% on application of the right type of JGT.

It is advisable to follow the design procedure recommended by the Indian Road Congress with CBR augmented to 1.5 times to control value under the appropriate class of loading for deciding on the thickness of a pavement.

## 9.0 MONITORING

9.1 The performance of the pavement with JGT should be monitored closely, especially in regard to development of pot holes, subsidence, road side drainage, dispersion of sub-grade and the like. Frequency and extent of surface treatment and also re-sectioning needed are also to be noted. Special attention is also necessary during and after the rains. Pot holes should be immediately restored. Surface drainage over the pavement should not be allowed to hinder due to malfunctioning of road side and shoulder drains.

## 10.0 PACKING

10.1 The roll shall satisfy the requirements specified in 10.1.1 to 10.1.5.

10.1.1 The roll shall be completely covered on all sides excepting the core protrusions which may also be covered if required by the buyer.

10.1.2 A roll may be covered with a polyethylene sheet inside the roll covering if agreed to between the buyer and the seller.

- 10.1.3 The loose ends of the roll covering shall be sewn with jute twine about 8 cm between stitches on all sides.
- 10.1.4 At either end, the core shall protrude but not more than 7.7 cm or as agreed to between the buyer and the seller.
- 10.1.5 The loose end of roll shall be closed with gum tape and also compressed suitably so as to avoid excessive pressure, which may cause damage to the content.

## 11.0 MARKING

11.1 Unless otherwise agreed to between the buyer and the seller, the roll shall be stenciled with an indelible ink of any suitable colour with the following :

- a) Roll Number
- b) Specification including quality and construction
- c) Length of cloth rolled in metres or yards or both as specified by the buyer.
- d) The legend "MADE IN INDIA" with the name of the manufacturing jute mill.
- e) Port of entry, and
- f) Other declarations required as per law in force.

## 12.0 TESTING OF JUTE GEOTEXTILE

12.1 Table IV hereinbelow states the Standards that shall be adhered to for ensuring quality of the JGT. The American standards are recommended as BIS Standards for testing all the required properties are not available.

**Table - I : Specifications of Woven Jute Geotextiles**

<b>Nomenclature</b>	<b>Woven JGT 20 kN/m</b>	<b>Woven JGT 30 kN/m</b>
Construction	2/1Twill Weave	2/1 Twill Weave
Corrected mass (gsm)	760 (+7%)	810 (+7%)
Width (cm) min	200	200
Ends x Picks /dm	102 x 39(+4,-2x+2,-1)	102 x 41(+4,-2x+2.-1)
Thickness, (mm at 200 kPa)	1.85 ± 10%	2.0 ± 10%
Tensile Strength (kN/m) MD CD	20+10% 20+10%	30+10% 30+10%
Elongation at break (%) MD CD	8 8	9 9
Puncture Resistance(kN)	0.500	0.600
Burst Strength (KPa)	3500	4500
Permittivity at 50mm constant head ( per second)	350 x 10 <sup>-5</sup>	350 x 10 <sup>-5</sup>
A O S ( micron ) O <sub>95</sub>	180	150

**Table - II : Specifications of bitumen treated woven JGT**

<b>Nomenclature</b>	<b>Woven 20 KN/ m bitumenised</b>
Construction	Twill Weave (2/1)
Corrected mass ( gsm)	1200 (+7%) (-5%)
Width (cm) min	200 +5%
Ends x Picks/dm	102 +4, - 2 x 39+2, -1
Thickness, (mm) at 2 kPa	2.0 +10%
Tensile Strength(kN/m) MD x CD	21 X 21
Elongation at break (%) MDxCD	8 x
Puncture Resistance (kN) min	0.500
Burst Strength (kPa) min	3500
Permittivity at 50mm constant head ( per sec )	$350 \times 10^{-5}$
A O S ( micron ) O <sub>95</sub>	180

**Table - III : Specifications of Non- woven JGT**

<b>Nomenclature</b>	<b>500 gsm</b>
Construction	Non-woven
Corrected mass ( gsm)	500 ( $\pm 10\%$ )
Length min (m)	50 or as required
Width min (cm)	150
Thickness, (mm at 200 kPa)	$4 \pm 10\%$
Tensile Strength (kN/m) MD x CD	4 x 5
Elongation at break(%) MD x CD	20 x 25

**Table-IV Test Methods of Jute Geotextile**

Sl. No.	JGT - Properties	ASTM Test Method
1	Weight/Unit area	D-5261-92 (1966)
2	Thickness	D-5199-01
3	Tensile Strength and Elongation test- Strip tensile test method	D-4595-86 & D 4885
4	Tensile strength and Elongation test- Grab tensile test method	D-4632
5	Impact Tear strength Test etc.	D-5884
6	Cone plunger test / cone drop test	D-5617-99
7	Trapezoidal Tear test	D-4533
8	Pore size determination - dry	D-4751—99a
9	Water flow test – Normal	D-5493-93 (1998)
10	Water permeability test	D-4491
11	Planar Water flow test	D-4716-01
12	Abrasion resistance test and Fatigue resistance test	D-4886 & 6243
13	Bursting Strength test	IS : 1966 -1975

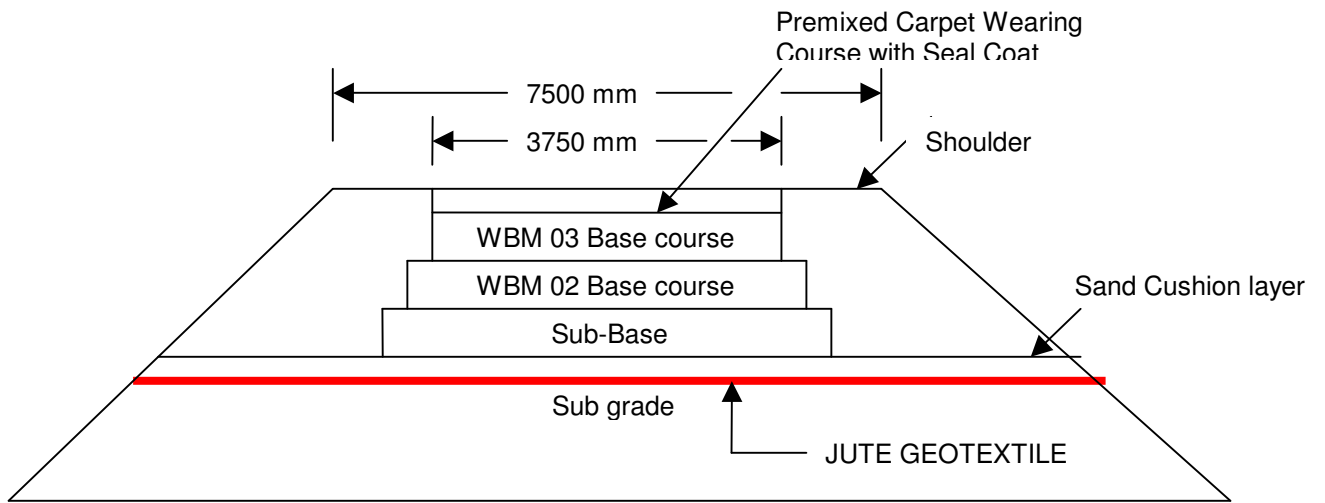


Fig. Typical Cross Section of a road with Jute Geotextile laid on the Sub-grade