Jute Based Geotextiles & Their Evaluation for Civil Engineering Applications

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ABSTRACT: Six nonwoven jute based geotextiles consisting of varying proportions of jute and polypropylene fibres were evaluated for their engineering properties by ASTM/BIS standards for geotextiles and related products. The test results, their evaluation and categorisation of jute based geotextile fabrics are reported. The test results show that jute based geotextiles are capable of adequately performing different engineering functions such as, separation, filtration, drainage and reinforcement. The degree to which the fabrics tested fulfill the requirements for the above functions is also brought out.

INTRODUCTION

Geotextiles, geomembranes and related products(Geosynthetics) are being increasingly employed in various civil engineering applications. In wider terms these include natural, synthetic and composite materials which are being used extensively in India. Different type of natural fibre products available are jute, coir, bamboo etc., The abundant availability of jute in India renders Jute fabrics cost-effective for various applications such as temporary roads and yards , repair of permanent roads, drainage applications, reclamation works, stabilisation of temporary bunds and erosion control. Ramaswamy and Aziz(1989), Lee et al(1987), Siew Ann Tan et al(1993), Lee et al(1989), Rao et al(1994) and Sanyal (1993) have respectively reported on the utilization of Jute fabrics in the construction of haul roads on poor subgrades, land reclamation works, drains for preconsolidating soft clays and for control of erosion.As of now, there are no specific standards for evaluating the physical, mechanical and hydraulic properties of natural geotextiles. In this direction, a few investigators have attempted (Ramaswamy and Aziz, 1989, Mandal and Murti, 1990 and Karunaratne et al, 1992) to evaluate physical, mechanical and hydraulic properties of natural geotextiles. Also attention is being concentrated on retarding the degradation of natural fibers from micro biological attack. Following sections of this paper deal with testing of jute based geotextile fabrics, categorisation through analysis of test data.

EXPERIMENTAL INVESTIGATIONS

Six varieties of Jute based geotextile fabrics were made available to the Central Road Research Institute, New Delhi by the Bombay Textile Research Association, Bombay. To characterize the fabric types under simulated conditions three types of soils viz., i)soft clay ii)fine sand iii)coarse sand (properties as given in Table-I) were used in the investigation. The six fabric types are designated as JGT1, JGT2, JGT3, JGT4, JGT5 & JGT6. These non woven fabrics consist of a blend of varying proportions of Jute(J) and PolyPropylene(PP). Summary of tests carriedout on each fabric and the standard adopted is given in Table-II

DISCUSSION OF TEST RESULTS

Detailed tests were carriedout on each fabric type to evaluate the engineering properties of Jute based geotextiles. Fabric character istics are evaluated through tests for physical, mechanical, survivability and hydraulic properties.

Thickness

Except for JGT6, the compressibility behaviour was found to follow a similar pattern. All the fabric types exhibited on an average 80% compressibility within the normal stress range of 0 to 100kPa (Fig.1).

TABLE-I SOIL PROPERTIES

PROPERTIES	SOIL TYPE SC	FS	CS
Grain Size Distribution			
Gravel %	---	---	17.5
Sand %	14.74	97.2	79.7
Silt %	40.0	---	2.8
Clay %	45.26	2.8	---
Placement density(kN/m)	15.2	17.2	17.5
Cu(kPa)	16.0	---	---
Ou( )	0	39	45

SC = Soft Clay; FS = Fine Sand; and CS = Coarse Sand

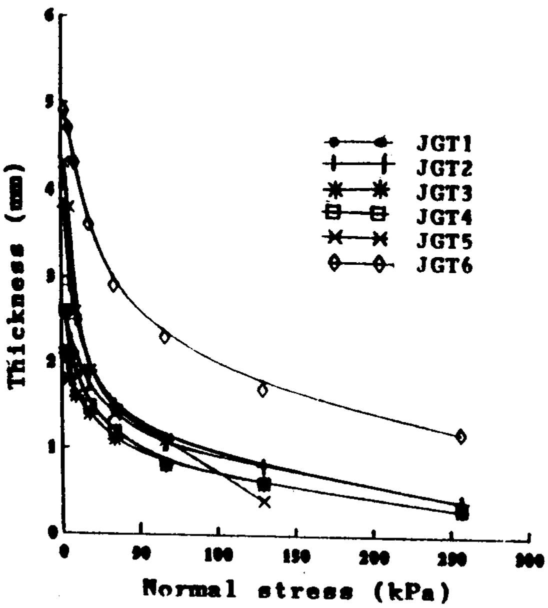

Fig.1 Thickness vs Normal stress

Tensile strength

Tensile strength tests on JGT1 and JGT3 were carried out both in the cross machine and machine directions. In all the tests a low strain rate of 1.25mm/min. was maintained. Fig.2 shows that fabrics having 75% J and 25% PP can stretch up to 90% elongation at failure. On the otherhand, fabric type JGT1 having 25% J and 75% PP reaches failure at about 25% elongation. In the case of fabric type JGT3, which has PP backing, it was observed that at failure the PolyPropylene strands have broken, whereas in JGT6, even after 95% elongation, no breaking of fabrics was observed to occur. The failure patterns, elongations and deformed grids for two fabric types JGT3 & JGT6 can be seen in Photos(i.e,Fig.3(a) & (b). The ultimate tensile strength of JGT4 which has mass per unit area of 220gsm was found to be about 0.25kN/m. In the case of JGT6 which has mass per unit area of 500gsm, but with identical material composition as in JGT4, the ultimate tensile strength is much higher at about 4.2kN/m. The influence of mass per unit area and hence indirectly of the thickness of the fabric on the tensile strength can be observed from JGT4, JGT5 & JGT6.

TABLE -II SUMMARY OF TEST RESULTS

PROPERTIES/ DETAILS	JUTE BASED GEOTEXTILE TYPES JGT1	JGT2	JGT3	JGT4	JGT5	JGT6
Physical properties Material composition	25% J+ 75% PP	50% J+ 50% PP	75% J+ 25% PP (backing)	75% J+ 25% PP	75% J+ 25% PP	75% J+ 25% PP
Weight (gsm)	282	270	272	220	353	500
Roll Width, length (m)	0.5,10	0.5,10	0.5,10	0.5,10	0.5,10	0.5,10
Thickness (mm) (IS: 13162(Part3)-1992)	2.6	3.8	2.1	2.6	4.3	4.9
Mechanical properties						
Tensile strength (kN/M) (ultimate) (IS: 13162(part5)-1992)	6.7	2.65	8.43	0.25	2.65	4.2
Percentage elongation at maximum load (%)	21.6	98.7	29	83	89	95.8
Interface friction (IS: 13326(part1)-1992)						
soft clay (Cu kPa, ø°)	14,11	8,12	6,14	8,12	10,12	10,14
Fine sand (ø°)	38	32	34	32	31	32
Coarse sand (ø°)	41	38	40	37	38	39
Survivability properties						
Puncture resistance Falling cone method (IS: 13162(part4)-1992) (Dia.of hole, mm)	9.5	2.0	9.5	1.0	0.5	0.5
Elongation(mm)	--	70	--	100	60	60
CBR push through test						
Push through load (kN)	1.54	0.42	1.92	0.07	0.24	1.49
Elongation (mm)	48	92	42	68	80	60
Index puncture resistance test (ASTM D-4833 1988)						
Puncture resistance(kN)	0.34	0.18	0.45	0.036	0.13	0.50
Elongation (mm)	14	28	14	29	31	22
Hydraulic properties						
Permitivity Coeff. of normal permeability mm/sec.						
Case(i)	0.1	2.59	0.03	1.8	3.9	2.0
Case(ii)	Refer	Fig.4				
Case(iii)(mm/secX10^{-1})	1.04	3.64	0.55	3.59	3.62	3.60
Transmissivity Coeff. of in-plane permeability Case(iv)	Refer Fig.5					

Casei = Unstressed condition-fabric in isolation;
Caseii = Stressed condition-fabric in isolation
Caseiii= Unstressed condition-Coarse sand layer above and below the fabric
Caseiv = Unstressed condition-Clay layer above and below the fabric

Interface friction

In the presence of the fabric, the shear strength parameters of the soft clay(Cu = 16kPa, ø = o°) have shown an improvement in the internal friction component by an average 10° . In the case of fine sand and coarse sand the soil-fabric friction angle for all the fabrics tested was of the order of 85-90% of internal friction angle of the sand (Table-I and II).

Penetration Tests

Penetration tests have clearly brought out significant differences between the behaviour of synthetic fabrics and jute based geotextiles (strain rate:25mm/min.). Jute based geotextiles have shown permanent deformation in the direction of the load(refer

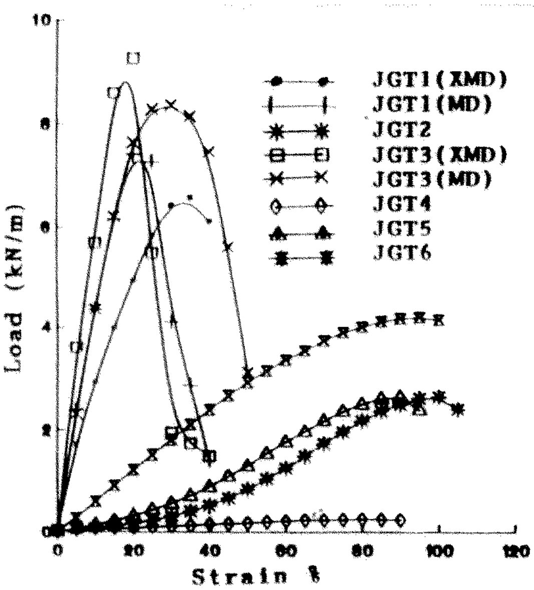

Fig.2 Tensile strength - Load vs Strain

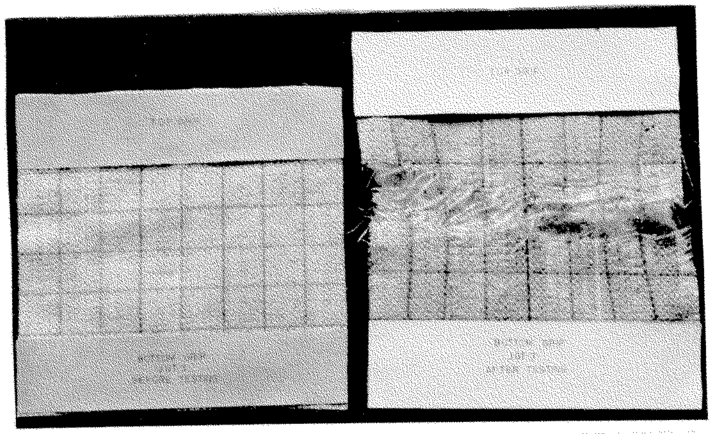

Fig.3(a) JGT3 before and after tensile strength test (photo)

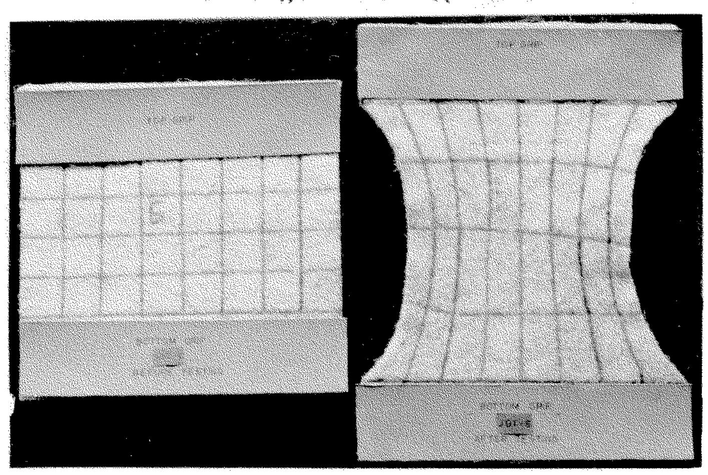

Fig.3(b) JGT6 before and after tensile strength test (photo)

Table-II). Even after the removal of the load a significant amount of residual plastic deformation remained. Synthetic fibres not usually show any residual plastic deformation in penetration tests. As the percentage of PolyPropylene in the fabric increases(as in JGT1), the behaviour of the fabric was found to be close to that of synthetic fabric. Through this study it can be inferred that to arrive at a comparison between natural and synthetic fibres, penetration tests and tensile tests at low strain rate can be used. Similar pattern of behaviour of fabric was observed in the CBR push through tests and the Index puncture resistance tests.

Hydraulic Properties

Both normal and in-plane permeabilities were determined for all the fabric types. As can be seen from Fig.4 & 5, both the coeff. of normal

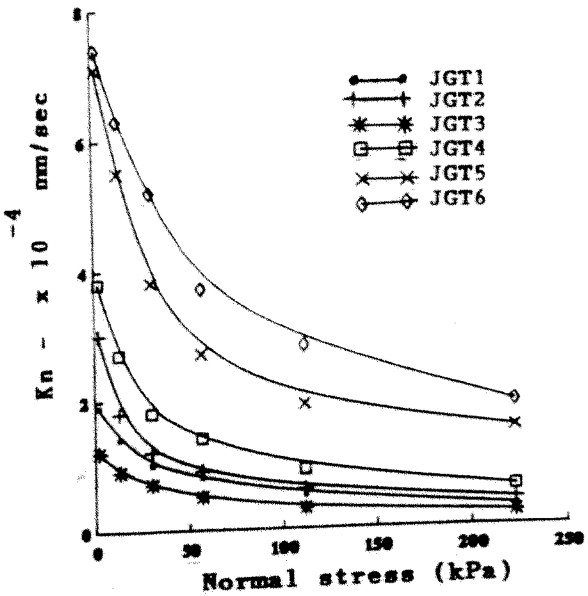

Fig.4 Coeff.of Normal Permeability, Kn Vs Normal stress

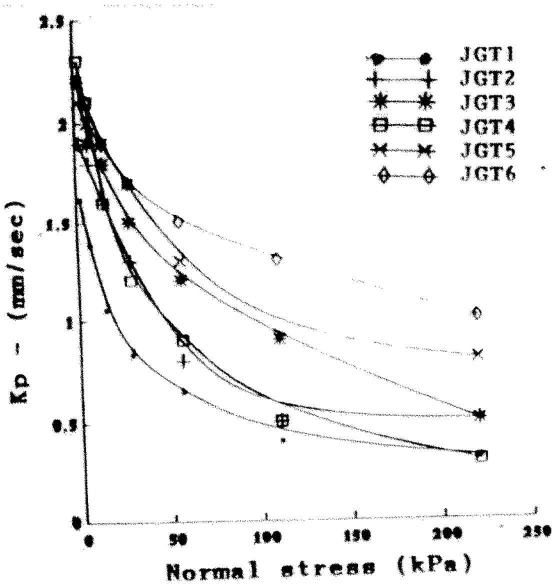

Fig.5 Coeff.of In-plane permeability, Kp Vs Normal stress

permeability and coeff. of in-plane permeability follow a decreasing trend with increase in normal stress. Except JGT1 & JGT3, the coeff. of permeability for sand fabric system is found to be more than that for sand alone(Table-I). The noraml and in-plane permeabilities of the fabrics were increasing with thickness of the fabric. Thus, the thicker fabrics have excellent filtration and drainage characteristics.

Categorisation

Based on the results presented above summarised in Table-II, an attempt is made to categorise the Jute based geotextile fabrics as to their suitability for various geotechnical functions such as separation, filtration, drainage and reinforcement(Refer Table-III). Cost effectiveness of Jute based geotextile fabrics as compared to synthetic fabrics opens up new avenues for various applications such as temporary roads and yards, repairs of permanent roads, drainage applications, land reclamation works and stabilisation of temporary bunds and erosion control etc., The authors wish to state here that results presented above are based on short duration tests and for further studies emphasis would be given to long term tests such as strength degradation with time, clogging tests etc.

TABLE-III. CATEGORISATION OF JUTE BASED GEOTEXTILES

Fabric Type	Typical Functions			
	S	F	D	R
JGT1	Y	Y	Y	Y
JGT2	Y	Y	Y	N
JGT3	Y	Y	N	Y
JGT4	N	Y	Y	N
JGT5	Y	Y	Y	N
JGT6	Y	Y	Y	Y

S = Separation; F = Filtration;
D = Drainage; R = Reinforcement
Y = can be used; N = can not be used

CONCLUSIONS

Based on the test results, the following observations were made:

-All the fabric types exhibited 80% compressibility within the stress range of 0 to 100kPa.

-Tensile tests on Jute based geotextiles at low strain rate help to study closely the tensile behaviour of the fabrics. In the case of fabrics with the same material composition, with increase in mass per unit area, there is a increase in the tensile strength of the fabric.

-All the fabrics tested have exhibited excellent interface friction characteristics.

-Results of the penetration tests, showed a significant difference in the behaviour of synthetic fabrics and jute based geotextiles.

-All the fabrics samples tested exhibit good in-plane as well as cross-plane permeability characteristics.

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