Effect of Water Submergence on the Serviceability of Jute Geotextile

M. A. HOSSAIN[1], T. TABASSUM[2]

[1]Department of Civil Engineering, RUET, Bangladesh (akhtar412002@yahoo.com)
[2]Department of Civil Engineering, RUET, Bangladesh (taniatabassum130016@gmail.com)

Abstract

In current world, connecting the every possible rural area by constructing roads is a matter of concern. At present in Bangladesh about 94% of total road length consists of low traffic volume rural roads. The structure of these rural roads is mainly consisted of the subgrade and pavement. This subgrade should possess sufficient strength as it is the only support of pavement. But, very often this subgrade is constructed with poor local soil, which may cause excessive deformation of subgrade due to some days submergence ultimately resulting the damage of the roads. The stability of subgrade of these rural roads can be enriched by using jute geotextile (JGT). However, before using the JGT in road subgrade it is very essential to determine the strength variation of JGT under different durations of water submergence. For this reason, an unpaved road (900 mm x 400 mm) was modeled, reinforced with JGT, kept under submerged condition for 15, 30 and 45 days, and tensile and puncher strengths of JGT were tested. The test results show that strip and grab tensile strength decreases with the increase of submergence duration. The puncture strength also follows the same trend with a lower decrement rate than tensile strengths.

Keywords: *Jute geotextile, Unpaved roads, Serviceability, Submergence, Usage time.*

1 Introduction

Unpaved roads are generally consisting of base aggregate placed over the subgrade without any bituminous coating. These roads are constructed in rural sites mainly due to their low cost. Also the traffic flow is low in these sites. Now a days jute is used in geotechnical applications as it is a low cost, biodegradable and ecofriendly natural fiber. Jute geotextiles (JGT) are now used in many Civil Engineering applications. This jute geotextile used as an effective reinforcing material for unpaved roads. It is used for stability, reduction of periodic repairs, and to increase the functional life of unpaved roads. But faster microbial degradation decreases the serviceability of these biodegradable jute geotextiles. About 60-80% jute fibers are degraded in 6-18 months under damp conditions depending upon the soil type, moisture content and oxygen availability.

Khan et al. (2014) conducted field trials by constructing a total of 5.0 km rural roads using jute geotextiles (JGT) in different geophysical locations of Bangladesh and finally they suggested considering JGT as a candidate material for road construction. Sridhar (2015) used ANSYS software which showed that there was regular uniform distribution of base pressure due to the rigidity between layers, maintained by various jute layers in-between, thereby preventing intermixing of various layers. Midha et al. (2015) studied the influence of chemical treatment (trans-esterification and bitumen coating), road design and rainfall intensity on the time dependent serviceability of jute geotextiles. It was observed among chemical treatment, road design (influence of sand layer) and rainfall intensity, chemical treatment was have greatest influence on strength retention and puncture resistance.

However studies related to road designs reported that subgrade reinforcing with jute geotextile improve the CBR value of unpaved roads. But time dependent serviceability of jute geotextile in such road design under submerged condition is not studied yet. This paper focuses on the evaluation of serviceability of jute geotextile in unpaved road design under submerged condition. To fulfill the goal tensile strength and puncture resistance of jute geotextile were evaluated before and after usage in unpaved road designs for different durations of 15, 30 and 45 days.

2 Materials and Methods

2.1 Materials

In Bangladesh, the construction work of roads linking the rural parts is governed by Local Government and Engineering Department (LGED). They suggested that JGT mass per unit area of 627 gsm is suitable for light vehicle driven roads (rural roads) JGT mass per unit area of 627 gsm was used in the present study. The basic properties of that JGT are shown in Table 1. Locally available soil sample was used for this research, whose basic properties are shown in Table 2.

Table 1. Basic properties of the studied JGT.

Parameter	Test Standard	Unit	Test Result
Mass per Unit Area	ASTM D3776	gm/m^2	610
Thickness	ASTM D1777	mm	1.79
Apparent/Effective Opening size	ASTM D4751	µm	#30-#50
Vertical Permeability	DIN 5396	m/sec	4.14 x 10-4
Grab Tensile Strength	ASTM D4632	N	1570/1208
Grab Tensile Elongation	ASTM D4632	%	22.6/19.4
Wide Width Tensile Strength	ASTM D4595	KN/m	36.4/34.5
Wide Width Elongation	ASTM D4595	%	21.7/12
CBR Puncture Resistance	ASTM D6241	N	2305

Table 2. Basic properties of the studied soil.

Properties	Results
Optimum moisture content	15.46
Finness modulus	1.29
Dry density	1.59 (g/cm^3)

2.2 Methods

To design an unpaved road a sheet metal box of dimensions 905 mm length, 475 mm width and 400 mm height was constructed. In the road design jute geotextile sample was provided above 60 mm soil and covered by 30 mm of stone aggregates, and the road was submerged in water. These were followed to check serviceability of jute geotextile in terms of tensile strength, puncture resistance and the CBR value.

Figure 1. Laboratory model road design.

3 Results and Discussion

3.1 Tensile Strength

ASTM Designation: D 4595 – Standard Breaking Force (Strip Method) and ASTM Designation: D 4632-08 – Standard Test Method for Grab Breaking Load was used. Tensile strength of jute geotextiles at different time of

Table 3. Strip and Grab tensile strengths of JGT under different durations of submergence.

Duration (Days)	Strip tensile strength (KN/m)		Grab tensile strength (N)	
	Warp	Weft	Warp	Weft
0	36.4	34.5	1568.74	1207.65
15	28	23.8	1050.66	831.5
30	2469	23.53	925.97	689.59
45	214	19	776.5	676.4

usage under submerged condition is shown in Table 3. The variations of strip tensile strength and grab tensile strength with the duration of submergence are depicted in Figure 2 and Figure 3 respectively. From the Figures 2 and 3, it is obvious that with the increase in duration of submergence from 0 to 45 days the both tensile strengths of jute geotextile continues to decrease. This is because of the time dependent microbial degradation and hydrophobic nature of jute fibers in geotextiles.

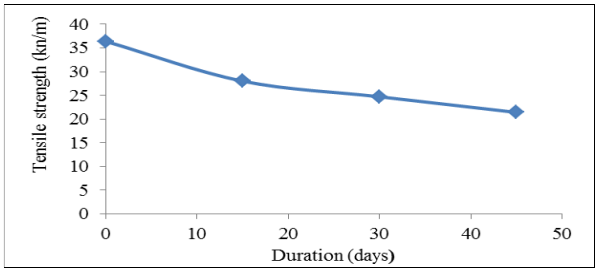

Figure 2. Effect of submergence on strip tensile strength of JGT.

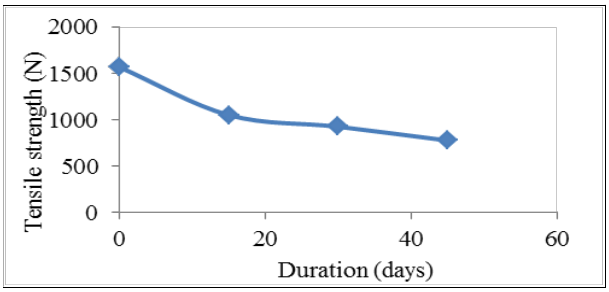

Figure 3. Effect of submergence on grab tensile strength of JGT.

Figure 2 and 3 show an approximate linear fall in tensile strength of JGT in submerged condition along the machine direction, and reduction in tensile strength may pose any threat to the road design system.

3.2 Puncture Resistance

ASTM Designation: D6241 – 14 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe was used for determining puncture resistance of jute geotextiles. The puncture resistance of jute geotextiles at different time of usage under submergence is shown in Table 4.

Table 4. Puncture resistance of JGT under different durations of submergence.

Duration (Days)	Puncture resistance (N)
0	2305
15	1819.5
30	1637.55
45	778

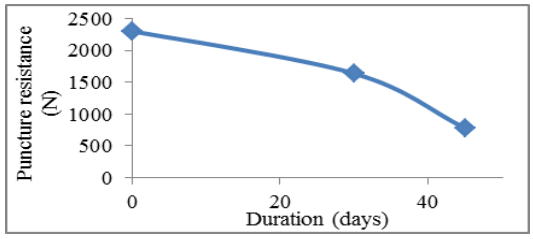

Figure 4. Effect of submergence on puncture resistance of JGT.

The relationship of puncture resistance with duration of submergence is presented in Figure 4. It is obvious that like the tensile strengths the puncture resistance of JGT also dcreases with the increase of submergence duration. But, the decrement of puncture resistance is lower than the strip and grab tensile strengths. This indicates that the sample will have greater resistance against the puncture by sharp materials and penetration of aggregates.

Conclusions

A series of tensile strengths and puncture resistance tests of JGT samples were conducted after 0, 15, 30 and 45 days submergence to evaluate the serviceability of jute geotextile under submerged condition. From the discussion presented above the following conclusions can be drawn:

- The strip tensile strength of treated JGT decreases with durations of submergence, and the decrement is approximately linear.
- The grab tensile strength follows the same pattern of strip tensile strength. However, in case of grab tensile strength the decrement is not linear.
- The JGT sample showed higher puncture resistance intially. After 45 days submergence 66.24% strength are decreased.
- This large reduction puncture resistance will reduce the reinforcement properties of jute geotextile which will eventually pose an instability to the system. But, it is expected that, small reduction in tensile strength will not pose any threat to the system.

References

ASTM (1996), Standard Test Method for Particle-Size Analysis of Soils, D 422-63, 100 Bar Harbour Drive, PO Box C 700, West Conshohocken, PA 19428-2959, United States.

ASTM. (2003). Standard Test Methods for Measuring Mass Per Unit Area of Geotextiles, D5261-03, West Conshohocken, PA

ASTM. (2004). Standard Test Methods for Water Permeability of Geotextiles by Permittivity, D4491-04, West Conshohocken, PA.

ASTM. (2006). Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method), D5035-06, West Conshohocken, PA.

ASTM. (2008). Standard Test Method for Grab Breaking Load and Elongation of Geotextile, D4632-08, West Conshohocken, PA.

ASTM (2009), Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort, D698, 100 Bar Harbour Drive, PO Box C 700, West Conshohocken, PA 19428-2959, United States.

ASTM. (2014). Standard test Methods for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe, D6241-14, West Conshohocken, PA.

Khan, A.J., Huq, F., Hossain, S.Z. (2014). Application of JGT for rural Road Pavement Construction. Ground Improvement and Geosynthetics, pp. 370-379.

Midha, V.K., Joshi, S., and Kumar, S.S. (2017). Performance of chemically treated JGT in unpaved roads at different in situ conditions, Journal of The Institution of Engineers (India), vol. 98, no.1, pp. 47-54.

Nithin, S., Rajagopal, K., and Veeraragavan, A. (2015). The Use of Natural Geotextile in Reinforcing The Unpaved Roads. The 6th International Geotechnical Symposium on Disaster Mitigation in Special Geoenvironmental Conditions, September, India.

Sridhar, S. (2015). Optimization of Jute Geotextiles in Pavement Design State of the Art. InternationalJournal of Research in Engineering & Technology, vol. 3, no. 8, 2015, pp. 2321–8843.