Durability of Jute Geotextiles

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ABSTRACT: Four types of woven jute fabrics embedded in soil for periods upto 2.5 months and submerged in water upto 4 months were examined for changes in stress-strain behaviour through narrow strip tensile strength tests. The durability of jute yarns was also assessed by conducting tests with solutions at values of pH ranging from 4.5 to 9.0 at room temperature. The studies reveal that the tensile strength of the different fabrics falls to zero with in 2.5 months in the biotic environment prevalent in Delhi. However when jute was fully submerged in water for 4 months, the loss was only 35%. On the other hand, a strength loss upto 50% was observed under conditions of different pH, the maximum loss being at pH : 5.2.

1 INTRODUCTION

In all the previous studies, functions of jute geotextiles such as reinforcement, filtration, drainage and erosion control were effectively brought forth but the aspect of durability to generalise their use for other soil/ environments is not attended to. For instance, jute should have a minimum life of one season when it is addressed for a soil erosion problem where as the same for the purpose of drainage should be not less than the time required for the consolidation of the highly compressible soil. Though the life of the jute geotextiles has been variably stated as 3 months to 3 years, it has not been the subject of detailed examination from geotechnical view point. It is therefore imperative to study the biodegradation of jute, in terms of reduction in strength, in different environments which simulate the conditions which they might be subjected in their specific applications in civil engineering.

2 MATERIALS

2.1 The jute geotextiles

Four jute geotextiles made available by Indian Jute Industries Research Association (IJIRA),Calcutta designated as Types A,B,C & D are studied in detail. Their physical properties are presented in Table 1.

2.2 The jute yarns

Three varieties of yarns - Type 1,2 and 3 are studied. Their physical properties are presented in Table 2. The tensile strength test was conducted with a gauge length of 75 mm and a deformation rate of 300 mm/min.

3 TESTING METHODOLOGY

In order to assess the durability of jute geotextiles, three types of environments were chosen simulating the biotic environment which they might be subjected to in their specific applications in civil engineering. They are detailed in the following.

Table 1 Properties of jute fabrics

Property		Type A	Type B	Type C	Type D
Construction		B-Twill	A-Twill	Hycee cement	D.W. plain
Thickness (mm)		2	2	2	2
Mass/unit area (g/m^2)		644	756	682	538
Linear density	M/C	0.3721	0.4656	0.3355	0.3416
of yarns (g/m^2)	X-M/C	1.0431	1.2745	0.8633	1.1736
No. of yarns	M/C	13	10	10	10
per inch	X-M/C	9	8	11	8
Narrow strip tensile	M/C	21.78	27.50	24.26	20.00
strength (kN/m)	X-M/C	22.50	27.50	25.00	24.50

3.1 Embedment in soil

The jute samples were buried in a 3 m x 3 m x 0.3 m deep pit in the I.I.T. Delhi Campus. Attempts were also made to protect the samples from rhodents and termites. The specimens were exhumed from time to time upto 2.5 months and tested for narrow strip tensile strength.

3.2 Submergence in water

Jute geotextile samples A,B,C & D were kept submerged in water. The samples were taken out after 4 months and after air/ovendrying tested for narrow strip tensile strength.

3.3 Submergence in solutions of different pH

All the three types of yarns were placed in aqueous solutions of pH ranging from 4.5 to 9.0. The yarns were periodically tested for tensile strength upto 14 days.

Table 2 Properties of yarns

Property	Type-1	Type-2	Type-3
Linear density (g/m)	0.3388	0.6400	4.2115
Tensile strength (N)	37	59	175

In all 308 specimens of jute fabric and 262 specimens of jute yarn have been tested.

4 RESULTS AND DISCUSSION

The stress-strain curves obtained from the narrow strip tensile tests on the jute geotextile samples types A,B,C & D are shown in Fig.1. The plots are generally similar in nature. The

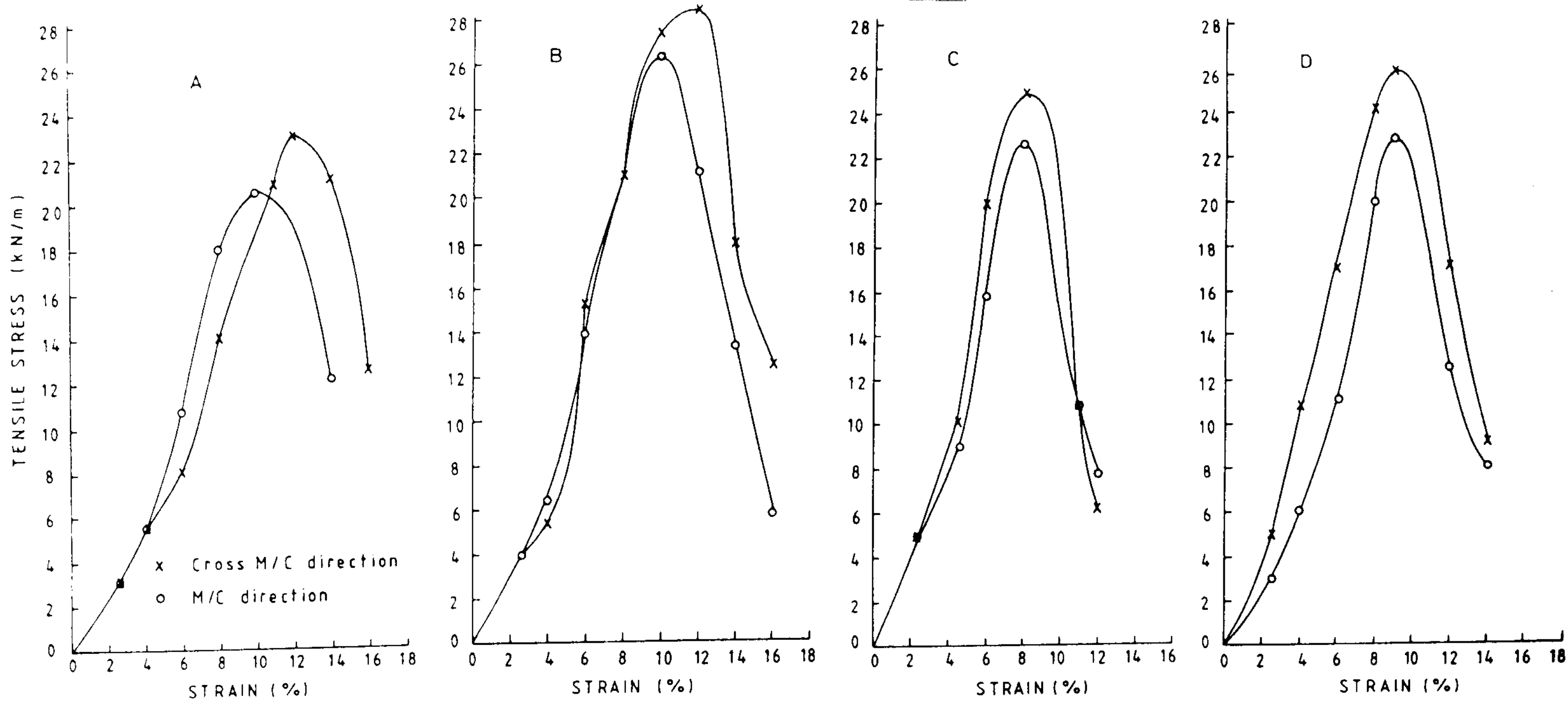

Fig.1 Typical stress-strain curves for samples A,B,C & D jute geotextiles

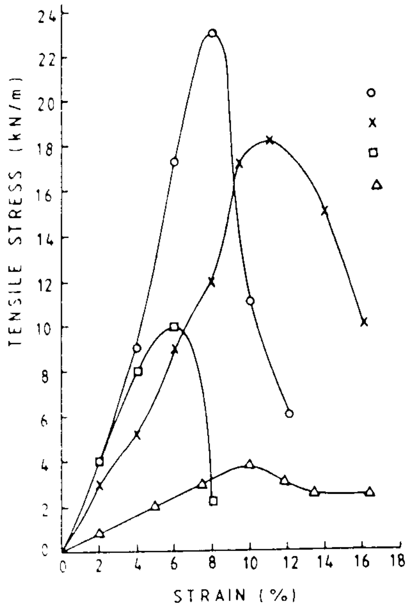

Fig.2 Stress-strain curves for jute geotextile 'A' embedded in soil for different periods

strength in the cross-machine direction is comparatively more which can be ascribed to the yarns of relatively higher linear density as presented in Table 1.

4.1 Embedment in soil

The stress-strain behaviour of jute geotextiles type A embedded in soil is depicted in Fig.2. It is seen that both the strength of the fabric as well as the initial tangent modulus reduced with time, as expected. The behaviour was similar for the other three geotextiles.

Figure 3 shows the percentage reduction in strengths, (as medians), when embedded in soil. The strength reduction is different in the two directions. With the exception of type 'C' geotextile all the other fabrics in general showed less degradation in the cross-machine direction. This difference may again be viewed in terms of 'linear density of yarns'. In all the fabric varieties used, the cross-machine direction had fewer number of denser yarns per inch while the machine direction had larger number of yarns of smaller linear density. The strength deterioration appears to be inversely proportional to the linear density of yarns.

Jute geotextiles when exhumed from the pit 2.5 months after burial are found to have strengths so small that they could not even withstand the handling. A number of black spots were observed and fungus growth visible. This fast decay in the biotic environment prevalent in Delhi has serious implications particularly in areas where reinforcement functions of jute fabrics is relied upon.

4.2 Submergence in water

The results of narrow strip tensile strength tests on jute geotextiles submerged in water for 4 months are presented in Table 3. It can be seen that the reduction in the strength is of the order of only 35%. This slower reduction strength in water than in soil indicates that the growth of the particular micro-organisms that acted on jute in water are either different or less intense than those that acted on jute when it was in soil. This agrees with the studies of Ghose and Basu (1962) who observed reduced

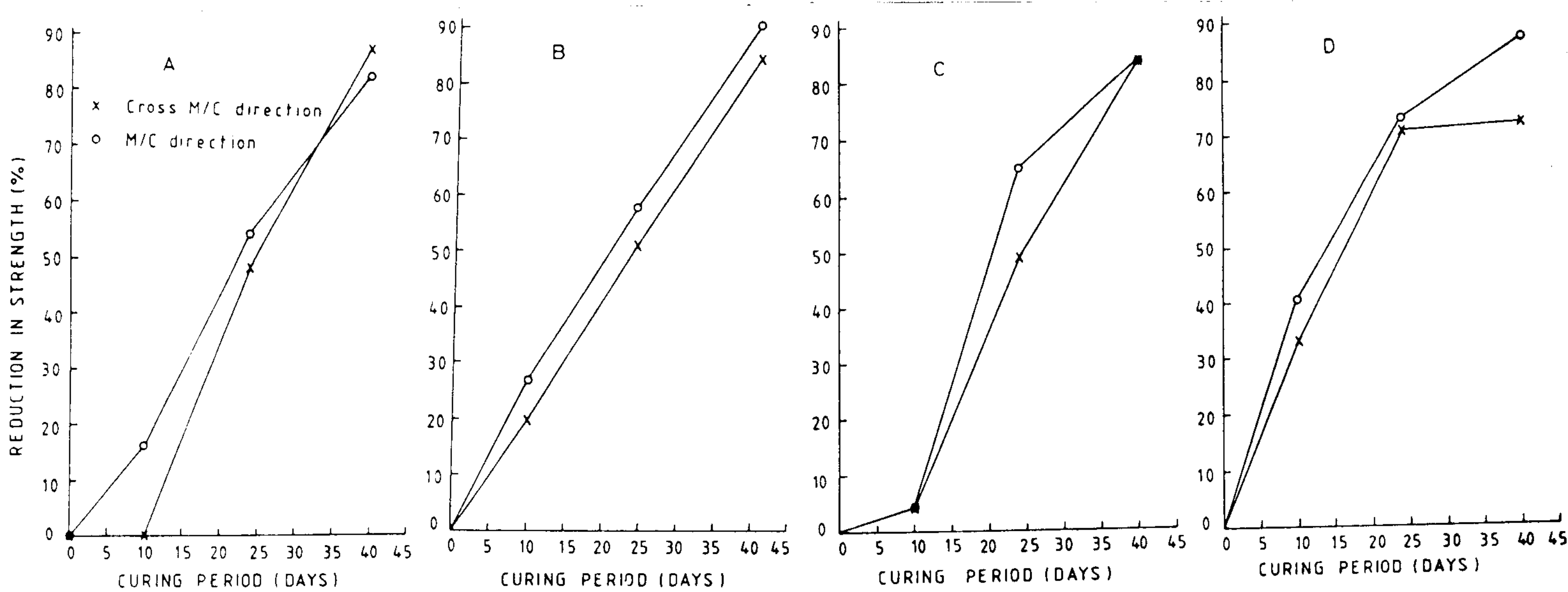

Fig.3 Variation of strength with time for jute geotextiles A,B,C & D embedded in soil

biological activity on jute under full submergence. The jute geotextiles can be used to advantage for surface protection works in canals and river banks where jute comes in contact with a 100% humid environment.

Table 3 Reduction in strength after 4 months submergence in water.

Type	Direction	% reduction in strength
A	M/C	35
A	X-M/C	25
B	M/C	22
B	X-M/C	43
C	M/C	36
C	X-M/C	40
D	M/C	45
D	X-M/C	38

4.3 Submergence in solutions of different pH

The results presented in Figure 4, indicate that the maximum strength reductions for all the three varieties of yarns was at pH = 5.2. This supports the observations made earlier by Ghose and Basu (1962) that fungus attack on jute is most severe when pH is less than 5.8. For all types of yarns the rate of degradation is high in initial curing period upto 7 days afterwards the rate decreases for lower pH ranges whereas the same is lower in the beginning and later it is higher in higher pH range. Thus the lower pH ranges of acidic environment is most detrimental to the jute fabric.

From Fig.4 the strength reduction in type 1 yarn is 36% at pH 5.2, and is 32% for type 2 yarn. On the other hand the strength reduction in type 3 yarn is 58%. It may be recalled that the linear density of type 2 yarn is relatively higher than that of the type 1 (both being drawn from DW plain), and that of type 3 is the maximum (Table 2). It appears that the yarn with maximum linear density is depicting maximum degradation. Type 3 yarn is derived from 'soil saver' whose material quality is considered to be poor. It is thus apparent linear density of yarns does play a role but a more extensive study is needed to thoroughly understand its influence.

5 CONCLUSIONS

The biodegradation of jute varies distinctly with the environmental factors. It is a complex mechanism involving different parameters and a more fundamental approach is suggested for assessing the durability of jute geotextiles.

REFERENCES

Ghose R. and Basu S.N. (1962), "A Microscopical Study on Degradation of Jute Fibre by Micro-organisms", Textile Research Jl., pp.677-694.