Application Potential of Coir Geotextiles

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ABSTRACT: The paper presents the tensile and interface friction behaviour of woven and non-woven coir geotextiles in pull-out test. It also presents the biodegradation of coir geotextiles embedded in different soil environment. The possible improvement in granular soil behaviour with coir fibre is demonstrated through triaxial test results.

1 INTRODUCTION

Despite the extensive use of geosynthetics the world over they are expensive in developing countries like India, and are also beginning to be the targets of environmentalists. Coir fibres have found wide spread applications in surface erosion control. With the changing attitude of construction and landscaping, mainly to save the environment, natural fibres offer a convenient alternative in non-critical areas of separation and reinforcement such as in temporary foundations or highway constructions as well as for filtration and drainage.

Coir fibre is an organic fibre consisting of 46% lignin and 54% cellulose. Due to its high content of lignin as against 11.5% that of jute, coir fibre is more resistant to rotting. Erosion control field trials conducted in India and elsewhere in the world have proved coir geotextiles as excellent for river bank protection and embankment stabilization (Venkatappa Rao and Balan 1994).

In this paper results of preliminary tests conducted on characterization of woven and non-woven coir geotextiles are presented. Also included are the results of triaxial tests conducted on the coir fibre reinforced sand.

2 EXPERIMENTAL WORK

2.1 Coir geotextiles

Commercially available woven coir geotextile made out of 2-ply hard spun yarn (quill type). Non-woven needle punched coir geotextiles of low density with HDPE slit film tape woven scrim are supplied by the Central Coir Research Laboratory, Bangalore. Their physical properties are given in Table 1.

2.2 Soil

For pull-out tests and triaxial testing, fine sand was used. Its properties are given in Table 2. Degradation tests were conducted using fine sand, kaolinitic clay (LL = 62%, PI = 41% and % finer than 2 micron = 85) and fine sand/clay mixed with biogas manure.

2.3 Testing

Woven coir geotextiles have been evaluated in pull-out tests in large size pull-out test apparatus. Coir fibres of different length were used to study the reinforcing effect in sand, when it is randomly distributed using triaxial testing.

Table 1 Typical properties of woven and non-woven coir geotextiles

Property	Woven	Non-woven
Thickness, mm	9.5	11.8
Mass per unit area, g/m2	1860	1500
Tensile strength, kN/m	58	6.2
Percent elongation at failure	42	10

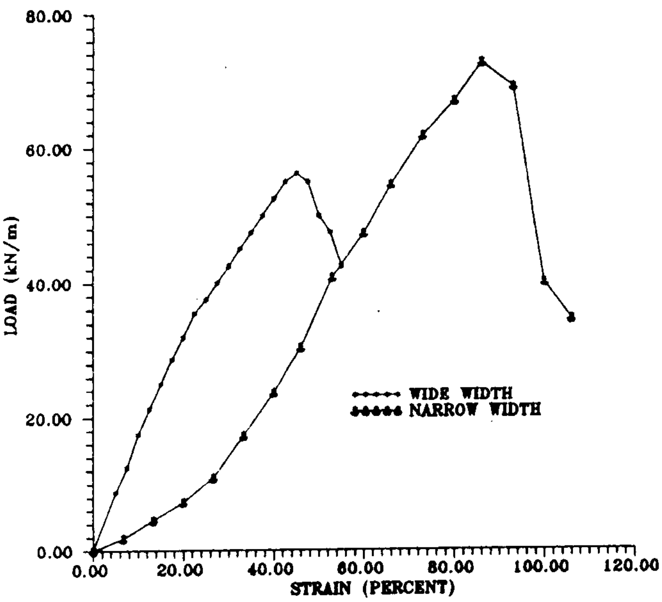

Fig.1 Typical stress-strain curves for tensile strength of woven geotextile

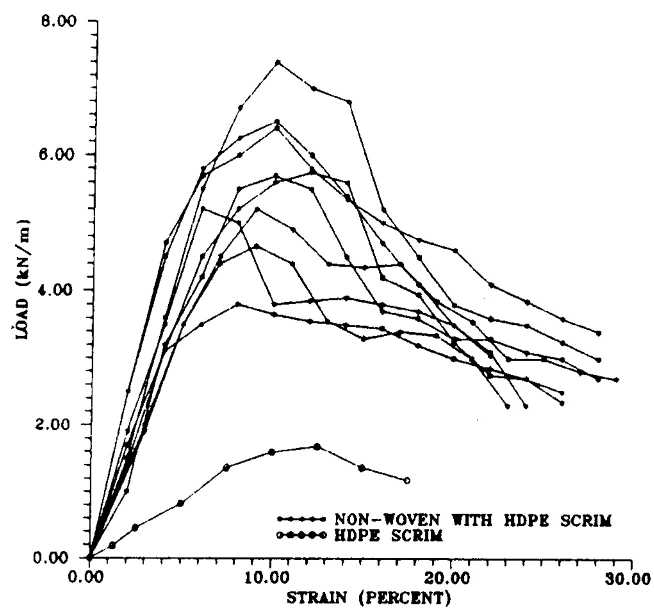

Fig.2 Stress-strain curves for tensile strength of non-woven coir geotextile with HDPE Scrim

3 TENSILE STRENGTH

Both wide width and strip tensile strength of woven coir geotextile were conducted as per ASTM D-1632 and ASTM D-4596 respectively. Typical test results are given in Fig.1.

Though the woven coir geotextiles are much heavier than their synthetic counterparts, the strength and percent elongation are at best comparable with that of low to medium range of synthetic geotextiles.

Wide width tensile test results of non-woven coir are presented in Fig.2. It is evident that though the initial load-deformation behaviour is nearly the same the load at failure shows considerable variation amongst the various specimens. They are weak in strength but surprisingly exhibit much lower strains at peak load than their woven counterpart. This is perhaps due to the slippage among the coir fibre.

4 BIODEGRADATION

Woven coir is embedded in four different soil conditions viz. sand with biogas manure, clay with manure, sand and clay without manure. The soil system was kept in humidity chamber, which was kept at a temperature of 25 to 30^{o} C and at a relative humidity of 90%. Curing was carried out upto 5 months, some specimens were taken out for narrow strip tensile testing at different intervals. The percent loss of strength versus time is shown in Fig.3.

It can be seen that even after five months in the most severe conditions coir has retained about 55% of its original strength in highly vegetative sandy soil, whereas in highly organic clayey soil it retained about 70% strength. Degradation in pure sand/clay was relatively marginal even after 5 months.

5 PULL-OUT

Pull-out tests were conducted in a large size pull-out apparatus of 600 mm x 600 mm x 400 mm. Embedment lengths of 100 mm, 200 mm and 300 mm were used. Typical variation of shear load(kN/m) with horizontal displacement (mm) for the front and rear portion of the fabric for different embedment

Table 2 Properties of sand

Property	
D_{50}, mm	0.24
D_{max}, mm	0.52
D_{min}, mm	0.04
C_u	1.76
C_c	1.09
Bulk Density, kN/m^3	15.00
Relative Density %	60.00

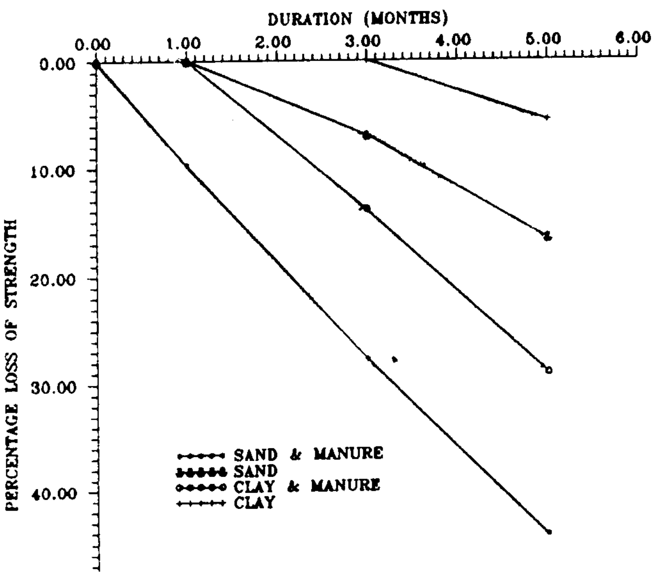

Fig.3 Percentage loss in strength of coir geotextile in different soil environment

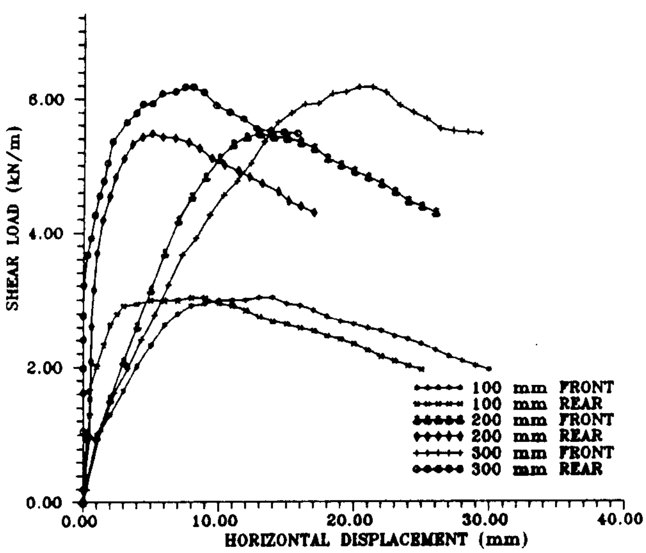

Fig.4 Typical shear load vs horizontal displacement in pullout under a normal load of 6.86 kN/m^2

length under a normal load of 6.86 kN/m^2 is presented in Fig 4.

The coefficient of friction against normal stresses for various displacements of 2 mm, 5 mm, 10 mm and 15 mm for different embedment lengths are depicted in Figs 5,6 and 7.

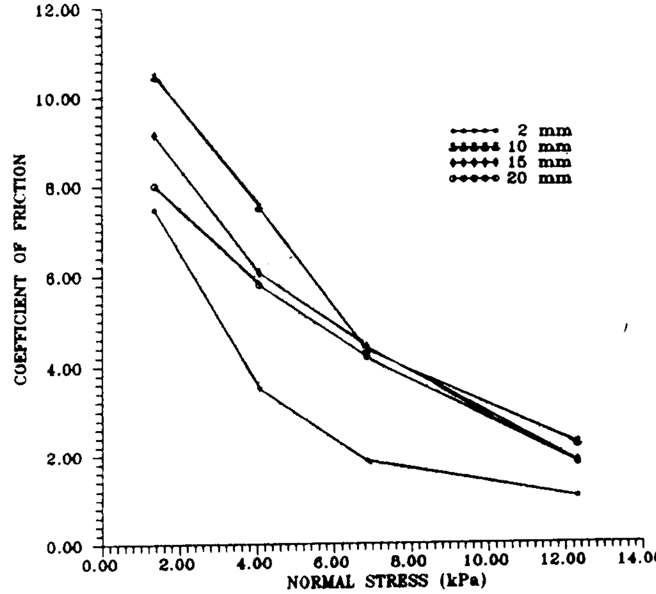

Fig.5 Variation of Coefficient of friction with normal stress for an embedment length of 100 mm

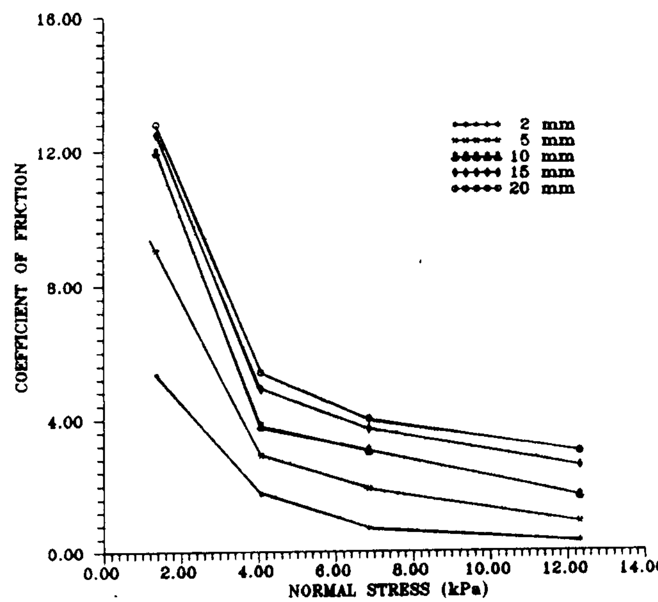

Fig.6 Variation of Coefficient of friction with normal stress for an embedment length of 200mm

The results of the pull-out tests show an increase in pull-out load with increase in embedment length. On the other hand there is an increase in pull-out load with normal stress in all the cases. It is also observed that the difference between the displacement at the front and rear end of geotextile increases as the length of embedment increases. The coefficient of friction is also found to decrease with increase in length.

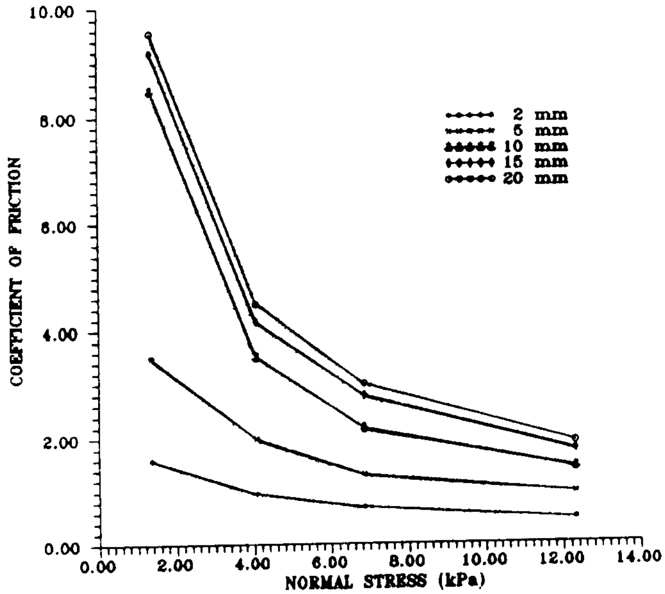

Fig.7 Variation of Coefficient of friction with normal stress for an embedment length of 300mm

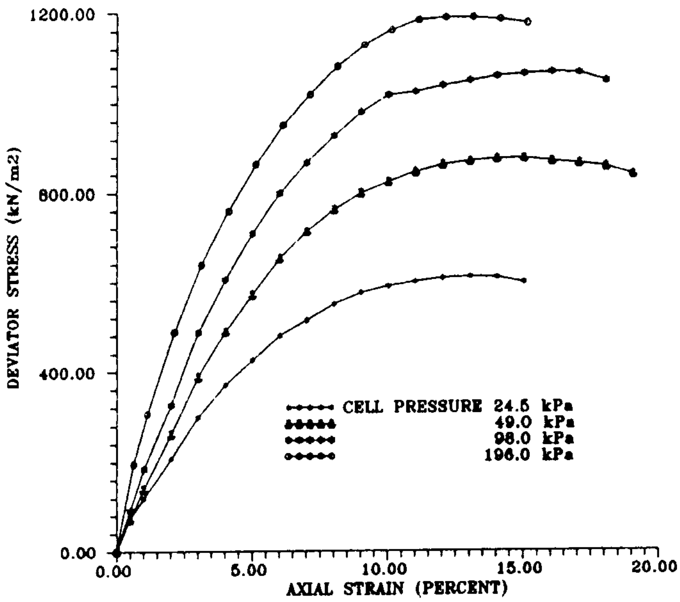

Fig.8 Stress-strain curves for randomly distributed coir fibre of 25 mm length

6 RANDOMLY DISTRIBUTED COIR FIBRE REINFORCEMENT IN SAND

Conventional drained triaxial tests with randomly distributed coir fibres of 25 mm and 50 mm length consisting of 1% by weight, on 100 mm x 200 mm samples were conducted. The stress-strain curves for 25 mm long fibres is shown in Fig 8 and the 'p-q' plot for both 25 mm and 50 mm fibres is given in Fig 9.

It is seen that the cohesion intercept increases from zero to 50 kPa to 150 kPa for fibre lengths 25 mm and 50 mm respectively, whereas the angle of internal friction remains nearly the same.

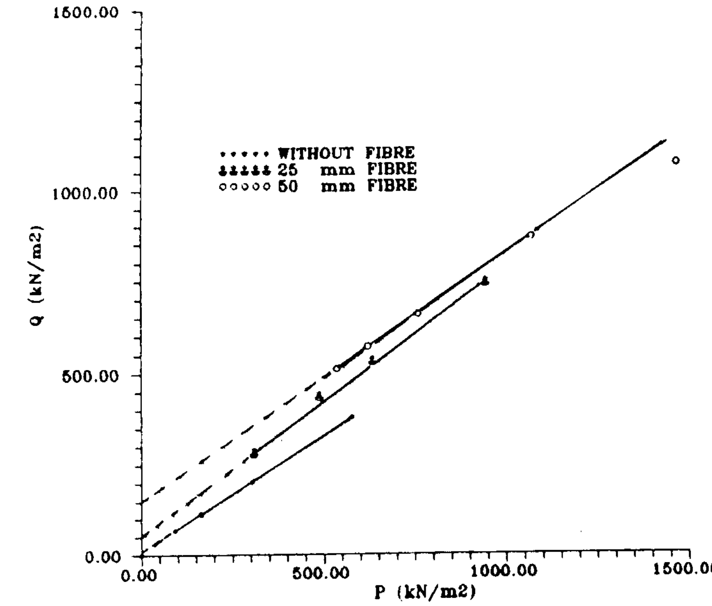

Fig.9 'p-q' plot of randomly distributed coir fibre of 25 mm and 50 mm length

7 CONCLUSIONS

1. With the range in strength and percent elongation and their excellent behaviour in pull-out tests, the woven coir geotextiles can be used in reinforcement applications such as in unpaved roads, temporary retaining walls and steep sided slopes of low height and also possibly embankments on soft ground.

2. Coir fibre can be successfully used to improve behaviour of granular soil and thereby further increase the bearing capacity of the soil. This may also be used to advantage in construction of pavements over soft soils.

3. Coir fabric has much longer life than jute as is evident from the biodegradation tests. Since its life is more when permanently kept in water, it can be used in underwater construction in soft soil.

REFERENCES

Venkatappa Rao, G.and Balan,K., "Coir Geotextiles-A Perspective", Proc. Second Int. Workshop on Geotextiles, New Delhi, India, 1994, pp.119-126.