Effect Of Nylon Knitted Coir Geotextile On Shear Strength And Load Bearing Capacity Of Sand

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Abstract - *Coir geotextiles are widely used in geotechnical engineering fields, as a reinforcing material for soils of poor geotechnical properties. Sand is an abundantly available material in the coastal regions. But it has low shear strength and bearing capacity. The effect of knitted geotextile on the shear strength and bearing capacity is studied. The material used for knitting is nylon.*

Key Words*: *Sand, coir geotextiles, nylon, shear strength, bearing capacity

1.INTRODUCTION

Sand is a material that is abundantly available in the coastal regions. Thus the use of sand for construction purposes proves to be economic. But the poor geotechnical properties of sand such as low shear strength and inadequate load bearing capacity makes it impossible to use sand safely as a foundation material. Thus sand should be stabilized by chemical, physical or mechanical methods. The sand used for this study falls under the classification of poorly graded soils. It easily fails by sliding or bearing capacity failure. Liquefaction may also occur in sand due to sudden loading in the case of earthquake or pile driving. For the sustainable use of geotechnical resources, the use of sand is suggested. Stabilization of these materials will improve their properties and can be used effectively in construction areas.

In this study, coir geotextiles are provided as reinforcement in between sand layers to improve the shear strength and load carrying capacity of sand. The use of coir geotextiles as reinforcement to soil is widely gaining popularity. The thickest and most resistant of all commercial natural fibers, coir is a coarse, short fiber extracted from the outer shell of coconuts. Its low decomposition rate is a key advantage for making durable geo-textiles. Coir is extracted from the tissues surrounding the seed of the coconut palm (Cocos nucifera), which is grown on 10 million ha of land throughout the tropics. There are two types of coir: the more commonly used brown fiber, which is obtained from mature coconuts, and finer white fiber, which is extracted from immature green coconuts after soaking for up to 10 months. Brown fiber is used in this study. Mature coir fibers contain more lignin, a complex chemical and less cellulose than fibers such as flax or cotton. Geotextiles made from coir are durable, absorb water, resist sunlight, facilitate seed germination and are 100% biodegradable. These blankets have high strength retention and a slow rate of degradation; meaning they last for several years in field applications. Coir geotextiles are easily available when compared to other natural geotextiles. Coir geotextiles are comparatively cheap and thus the use of these geotextiles can be economical. It is naturally resistant to rot, moulds and moisture. Since coir geotextile is strong in nature, it can be easily spun or woven into desirable forms such as strips, mats, nets etc. Coir geotextiles can be effectively used for the purposes of reinforcement, separation, filtration and drainage. The coir fibers will degrade after a certain period but the organic skeleton is found to remain in place in compressed form. This will act as a filter and keep the moisture content of the soil constant.

The effect of knitting coir geotextiles with nylon is studied. Nylon is a thermoplastic silky material which can be melt processed into fibers, films or shapes. It can also be mixed with a wide variety of additives to achieve property variation. Nylon is less absorbent than wool and cotton. This makes it an adequate material for knitting coir geotextiles. Because for natural geotextiles; the rate of degradation is accelerated in the presence of water.

2. MATERIALS

A. Sand:

Sand used for this study is poorly graded. The grain size distribution of sand is given in figure 1 and the properties of sand are shown in table 1.

B. Coir Geotextiles

In this study, sand is reinforced with coir geotextile for improving the strength characteristics of sand. The properties of coir geotextile used are given in table 2.

Table 1- Properties of Sand

PROPERTY	VALUE
D_{10} (mm)	0.26
D_{30}(mm)	0.34
D_{60}(mm)	0.41
C_u	1.58
C_c	1.04

Relative Density, D_r (%)	70.7
Soil Classification	Poorly graded
Specific Gravity	2.67
Angle of internal friction, φ	28^0
Cohesion (kg/cm²)	0.14
Bulk density (g/cc)	1.47

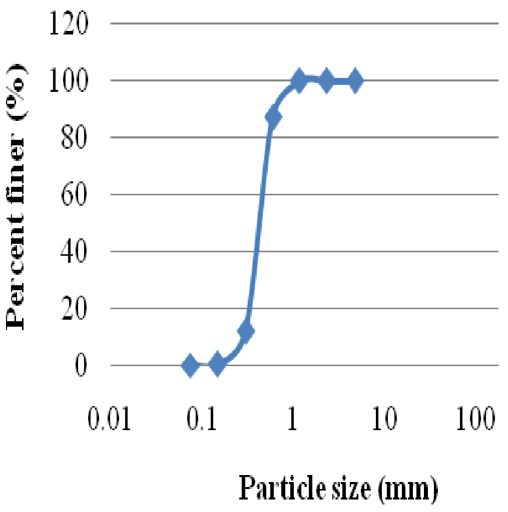

Fig -1: Grain Size Distribution curve of sand

A. Nylon

Nylon is a generic designation for a family of synthetic polymers, based on aliphatic or semi-aromatic polyamides. Nylon was the first commercially successful synthetic thermoplastic polymer. The increase in strength of geotextile when knitted with nylon thread is studied.

Table 2- Properties of coir geotextile (Source: Coir Board)

PROPERTY	VALUE
Mass	900 g/m²
Thickness at 20 KPa	6.5 mm
Percentage elongation at break	30%
Ends (warp)	210
Picks (weft)	250
Trapezoidal tear strength (cross machine direction)	0.15 N
Trapezoidal tear strength (machine direction)	0.5 N
Break load for dry coir (min) (machine direction)	15 kN/m
Break load for dry coir (min) (cross machine direction)	8 kN/m
Break load for wet coir (min) (machine direction)	12.5 kN/m
Break load for wet coir (min) (cross machine direction)	5kN/m
Aperture size	4.2 X 5.2 (mm)
Initial tangent modulus at 5 mm deformation	65 – 75 kN/m

3. METHODOLOGY

A. Direct shear tests (IS 2720-13)

Direct shear tests were conducted at a density of 1.7g/cm³. The test apparatus was of size 6cm X 6cm X 6cm. Coir geotextile of 6cm X 6cm size was sandwiched in between sand layers and kept at a depth of 3cm from top of direct shear apparatus.

B. Load tests (IS 1888 : 1982)

A series of model load tests on an embedded square footing resting on a reinforced sand bed were carried out. A test tank of internal dimensions 100cm X 100cm X 50cm and a footing plate of size 20cm X 20cm are used. The load-reaction frame was attached to the tank. The tests were conducted on a dense sand bed with a relative density (Dr) of 70%. A single layer of geotextile was provided at a depth of 0.3B from top of the test tank. The embedment depth of footing was varied as Df/B = 0, 0.5 and 1. B is the width of footing and Df is the depth of footing from ground surface. The bearing capacity of plate (q_{up}), used in the model test is obtained from the load – settlement graph. The bearing capacity of foundation (q_{uf}), can be obtained as-

$$quf = qup\frac{Bf}{Bp}$$

Where, B_p is the width of plate and B_f is the width of foundation.

4. RESULTS

Direct shear tests were done on sand reinforced with coir geotextile and nylon knitted coir geotextile. The variation in angle of internal friction and cohesion when coir is knitted with nylon is studied. This variation is shown in table 3. Figure 2 shows the comparison of shear stress vs. normal stress plot of sand reinforced with coir geotextile and that with nylon knitted coir geotextile.

A percentage increase of 25% and 67.57% was observed in angle of internal friction and cohesion respectively, when coir geotextile was knitted with nylon threads.

Table 3- Comparison of angle of internal friction and cohesion values of coir geotextile and nylon knitted coir geotextile

Material	Property	
	Angle of internal friction (φ)	Cohesion (c)
Nylon knitted coir geotextile	45º	0.62 kg/cm²
Coir geotextile	36º	0.37 kg/cm²

Load tests were conducted on sand reinforced with coir geotextile and nylon knitted coir geotextile. The load settlement variations are shown in figures 3 and 4. Table 4 shows the variation in bearing capacity while using nylon knitted coir geotextile.

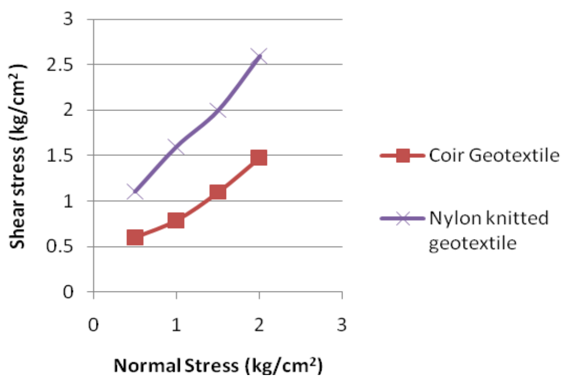

Fig-2: Variation in shear strength of yarn knitted and nylon knitted coir geotextile

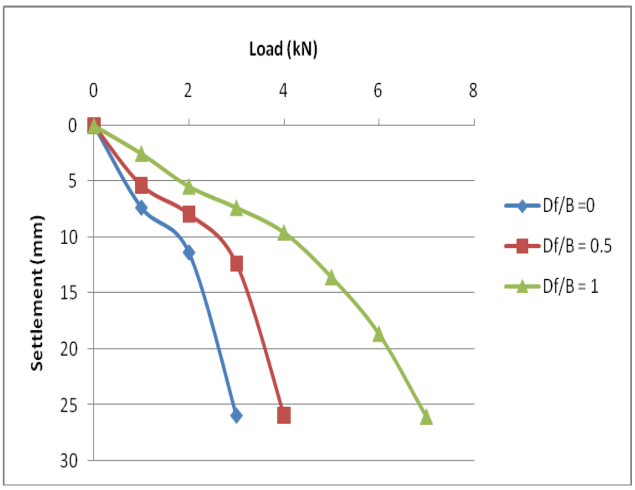

Fig- 3: Load settlement curves of coir geotextile reinforced sand

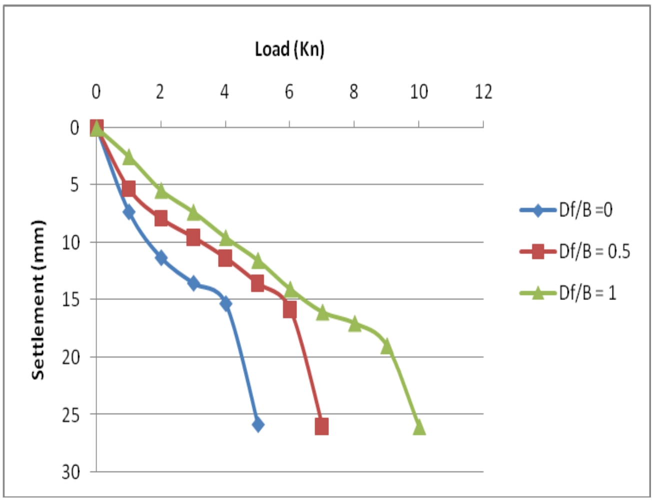

Fig- 4: Load settlement curves of sand reinforced with nylon knitted coir geotextile

Table 4- Variation of ultimate bearing capacity for nylon knitted coir geotextile

Depth to width ratio	Ultimate bearing capacity, q_{uf} (kN/m²)	
	Coir reinforcement	Nylon knitted coir reinforcement
Df/B = 0	60	120
Df/B = 0.5	90	180
Df/B = 1	180	270

At Df/ B = 0 and 0.5, nylon knitted coir geotextile showed twice better bearing capacity when compared to unknitted coir geotextile. Similarly, at Df/B = 1, nylon knitted coir geotextile showed 1.5 times better load carrying capacity than unknitted coir geotextile.

5. CONCLUSION

- A percentage increase of 25% was observed in angle of internal friction when coir geotextile was knitted with nylon threads.
- The value of cohesion of nylon knitted coir geotextile showed a percentage increase of 67.57% when compared with unknitted coir geotextile.
- At Df/B = 0 and 0.5, the bearing capacity of nylon knitted coir geotextile was twice better than unknitted coir geotextile.
- At Df/B = 1, nylon knitted coir geotextile showed 1.5 times better bearing capacity when compared to unknitted coir geotextile.

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