

# **A Study on Shear Strength for Dune Sand Reinforced With Nylon Fibres**

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**ABSTRACT:** This paper provides general study on strength characteristics of dune sand reinforced with nylon fibres. The reuse of nylon fibres may not only address growing environmental and economic concerns but also help solve geotechnical problems associated with low soil shear strength. Laboratory tests were conducted in large scale direct shear test apparatus to investigate the feasibility of using nylon fibres to reinforce dune sand. In tests were conducted on a matrix of dry dune sand mixed with nylon fibres were randomly mixed with dune sand. Nylon fibres content was varied from 0%, 0.5%, 1.0% and 1.5% mass of sand. The density of sand and nylon fibres was kept as 1.6 g/cc throughout the test programme. A number of identical samples were tested under increasing normal loads and the required maximum shear force was recorded. The results of these tests are plotted with normal stress along horizontal axis and shear stress that produced failure of the specimen along vertical axis. A straight line, called strength envelope is drawn connecting the points and is extended to intersect vertical axis.

**KEYWORDS:** Dune Sand, Nylon Fibres, Normal Stress, Shear Stress, Shear Strength.

## **I. INTRODUCTION**

The **Thar Desert** is a covered about 60% an area of Rajasthan. The wind blown sand is popularly known as dune sand. It is fine sand with no cohesion, and thus it has got very low strength property. The construction as well as protection of pavement for the purpose of approach roads, temporary roads and landing strips in the desert region has been a problem of much interest, this necessitates stabilization of dune sand with some admixture of improve its strength property and reduce settlement. The construction of any structure on dune sand is a challenging job for Geo-technical Engineers i.e. immense shifting nature, high permeability, low shear strength and poor bearing capacity. To improving the geo-technical property of dune sand there have been used many techniques i.e. mixing of Lime, Cement, Bitumen, Chemicals, Heavy tamping, Vibro-floating, Mud, Reinforcing element, Natural fibres, Geo- textiles, Geo- membrane etc. Every civil engineering structure such as a building, a tower, a bridge, an embankment, a road pavement, a tunnel, an airport etc. have to be founded on the soil so as to transmit dead and live loads to the soil stratum.. This paper is a study of dune sand reinforced by adding particles of nylon fibres and the shear strength of the dune sand is observed.



**Figure (1.1) Dune Sand in Thar Desert of Rajasthan**

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**TABLE (1.1)**  
**Properties of Dune Sand**

Effective Particle Size (D <sub>10</sub> )	Mean Particle Size (D <sub>50</sub> )	Coefficient of Uniformity (C <sub>u</sub> )	Coefficient of Curvature (C <sub>c</sub> )	Specific Gravity (G)	Maximum Dry Density (γ <sub>dmax</sub> )	Minimum dry Density (γ <sub>dmin</sub> )	Fine soil Fraction (-75 micron)
0.12 mm	0.17 mm	1.73	1.23	2.67	1.62 g/cc	1.45 g/cc	2%

## II. ANALYSIS AND DISCUSSION OF TEST RESULTS

Laboratory tests observations obtained from the direct shear-box test apparatus on un-reinforced and reinforced dune sand have been presented in the form of graphs and tables. The strength envelopes of unreinforced dune sand have been shown in Figure (2.1). It may be observed that the strength envelopes are straight lines passing through origin. The angles of internal friction ( $\phi$ ) have been observed to be 32° and 27.1° for tests conducted at densities of 1.62 gm/cm<sup>3</sup> and 1.52 gm/cm<sup>3</sup> respectively. These values of  $\phi$  are in agreement with those determined by previous investigators. Shear tests were conducted in a small scale direct shear box also. It has been found that the angle of internal friction of dune sand is not affected by the size of test apparatus.

**TABLE (2.1)**  
**Normal Stress V/S Shear Stress of Un-reinforced Dune Sand At**

Density $\gamma_m = 1.62 \text{ g/cm}^3$ (Kg/cm <sup>2</sup> )		Density $\gamma_m = 1.52 \text{ g/cm}^3$ (Kg/cm <sup>2</sup> )	
Normal Stress	Shear stress	Normal Stress	Shear stress
0.5	0.318	0.5	0.240
1.0	0.629	1.0	0.489
1.5	0.945	1.5	0.751
2.0	1.268	2.0	1.011
2.5	1.561	2.5	1.261
$\phi = 32^\circ$		$\phi = 27.1^\circ$	

Direct shear tests observation obtained from the direct shear tests apparatus on a matrix of dry dune sand mixed with nylon fibres. Nylon fibres were randomly mixed with dune sand. Nylon fibres content were varied from 0.5%, 1.0% and 1.5% mass of sand. At least two and sometimes three tests were conducted to check the reproducibility of the tests results. The strength envelopes were linear the range of normal stress applied. It may be observed in general that maximum angle of internal friction is much higher for dune sand reinforced with nylon fibres. The increase in internal friction angle, lead to an increase in the overall shear strength of reinforced dune sand. For sake of comparison the shear strength of unreinforced and reinforced dune sand has been calculated from Coulomb's relationship.

$$\tau_f = \sigma \tan \phi \dots \dots \dots (2.1)$$

- Where  $\tau_f$  = Shear strength of soil  
 $\phi$  = Internal friction angle  
 $\sigma$  = Normal stress on failure plane

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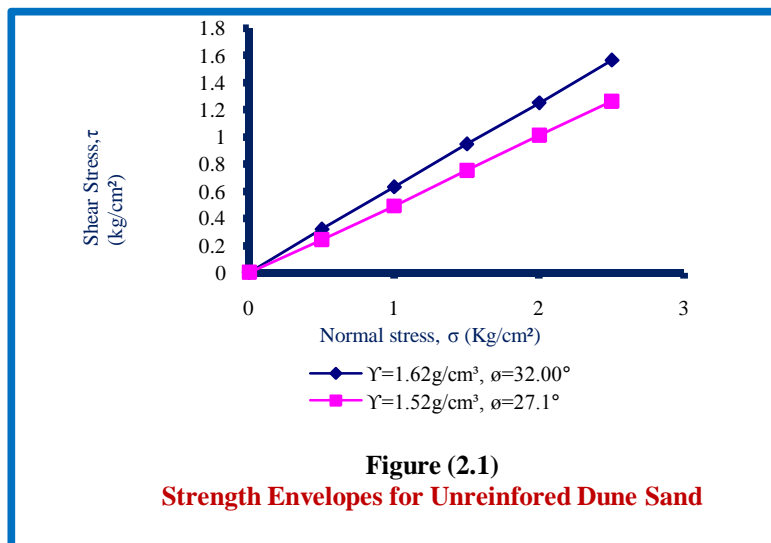
**TABLE (2.2)**  
**Normal Stress V/S Shear Stress (Kg/cm<sup>2</sup>)**  
Matrix Density  $\gamma_m = 1.62 \text{ g/cm}^3$

<b>Fibres Content</b>					
<b>0.5%</b>		<b>1%</b>		<b>1.5%</b>	
<b>Normal Stress</b>	<b>Shear stress</b>	<b>Normal Stress</b>	<b>Shear stress</b>	<b>Normal Stress</b>	<b>Shear stress</b>
0.5	0.318	0.5	0.3332	0.5	0.3574
1.0	0.629	1.0	0.6740	1.0	0.6984
1.5	0.945	1.5	1.0100	1.5	1.0547
2.0	1.268	2.0	1.3520	2.0	1.3945
2.5	1.561	2.5	1.7140	2.5	1.7614
$\phi = 32.82^\circ$		$\phi = 34.62^\circ$		$\phi = 35.18^\circ$	

The shear strength has been determined for an arbitrarily chosen value of normal stress,  $\sigma = 1.25 \text{ kg/cm}^2$ . The computed values of shear strength (Kg/cm<sup>2</sup>) and increases of Shear Strength (%) are given in table (2.3). A graph between normal stress and shear strength (Kg/cm<sup>2</sup>) is shown in Figure (2.2). The Figure shows that the shear strength of dune sand reinforced with nylon fibres increases as the nylon fibres increase. A graph between fibres content (%) and increase in shear strength (%) is shown in Figure (2.3). The Figure shows that the Shear strength increases by 12.81% on addition of 1.5% nylon fibres at sand matrix density of  $1.62 \text{ gm/cm}^3$ .

**TABLE (2.3)**  
**Observed Shear Strength of Sand Reinforced with varying Fibres Content**  
Normal Stress  $\sigma = 1.25 \text{ kg/cm}^2$ , Matrix Density  $\gamma_m = 1.62 \text{ g/cm}^3$

<b>Fibre Content (%)</b>	<b>Shear Strength (Kg/cm<sup>2</sup>)</b>	<b>Increase in Shear Strength (%)</b>
0.0	0.78125	0
0.5	0.8075	03.40
1.0	0.8630	10.51
1.5	0.8811	12.81

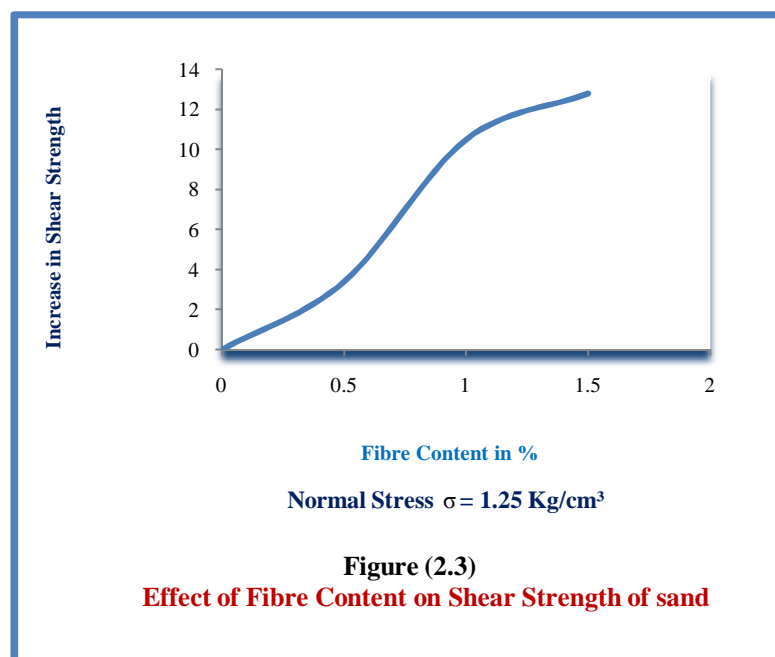
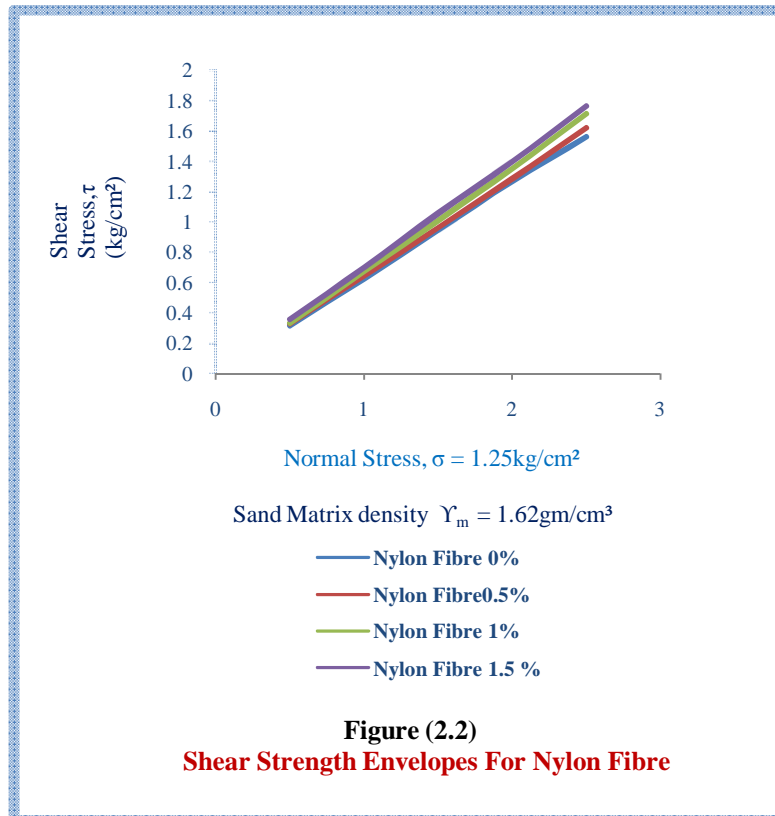


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## III. CONCLUSIONS

The laboratory investigations were carried out to study the use of nylon fibres as a reinforcing material to increase the shear strength. Based on the experimental investigations and the test results obtained the following conclusions are made as follows:

1. Strength envelopes for loose or medium dense sand matrix are linear in the range of normal stresses applied.
2. The angle of internal friction of dune sand increases with addition of nylon fibres. The angle of internal friction of unreinforced dune sand at a density of  $1.62\text{gm/cm}^3$  is  $32^\circ$ ; it increases to as large as  $35.18^\circ$  on addition of 1.5 % nylon fibres at the above density of matrix.
3. Addition of nylon fibres to dune sand causes an increase in its shear strength. Shear strength increases by 12.81% on addition of 1.5% nylon fibres at matrix density of  $1.62\text{gm/cm}^3$ .

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