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Influence of geotextiles in enhancing the shear strength of Yamuna sand

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Abstract

The present study exhibits the characterization of Yamuna sand through various experiments like SEM, sieve analysis and triaxial tests. The literature study puts forth the numerous complications associated with Yamuna sand from construction point of view. The continual conduct of any construction project chiefly depends on the engineering quality of underlying soil. Hence, its highly imperative to check these complications, which can be mitigated with the help of soil reinforcements such as soil nailing, fiber reinforcement, geosynthetic reinforcement, and soil stabilizers like bitumen, cement etc. The current study delineates the impact of both woven and non-woven type geotextiles on the shear strength of Yamuna sand. In totality, thirty-seven consolidated drained triaxial tests were brought about, of which twenty-one were successful. The principal focus of the study was to determine the application of both woven and non-woven geotextiles with Yamuna sand.

Keywords: Yamuna Sand, Triaxial test, Scanning Electron Microscopic (SEM).

INTRODUCTION:

The present study investigated upon Yamuna sand found along the Yamuna River, India. The river originates from Yamunotri glacier and also flows through Delhi, National Capital Territory of India. The Yamuna sand found in Delhi possesses weak shear strength moreover, it is also susceptible to erosion. If the soil is weak in shear then shallow foundation cannot be constructed in the area and deep foundations are adopted. The cost of construction of deep foundation is considerably immense, thus it is more fitting to stabilize the weak soil. There are various methods by which shear strength of sandy-soil can be improved like vibrofloatation, fiber reinforcement and also through admixtures like bitumen, cement etc. Geotextile reinforcement is used in our present study for the soil reinforcement because it has been seen by literature study that it is very effective alternative for soil reinforcement. Geotextiles is derived from the words geo-soil and textile-fiber. The textile can either be conceived of synthetic material like polyester, polypropylene fiber or with the natural material like jute, coir etc. In essence there are two forms of geotextiles namely woven and non-woven geotextile. Woven geotextiles are fabricated from the synthetic or natural fibers by employing weaving techniques in which the fibers are arranged in a perpendicular direction to each other. The fiber, which runs along longitudinal direction, is called as warp whereas along transverse direction, it is called as weft (Sarsby, R. W.) [1]. Both monofilament and multifilament yarn can be used for woven geotextile. Non- woven geotextiles are composed by the random arrangement of filaments or fibers by bonding them together to form a planar structure. Bonding can be accomplished by in the form of Thermal, Chemical and Mechanical bonding.

Many researchers have instigated to elevate the strength of Yamuna Sand with distinct types of Geotextile to best of their results. M.D. Nguyen et al. [2] proffered the volumetric strain and shear stress variation in Geotextile reinforced sand by triaxial test. It was culminated that Geotextile comprisal increases compressive volumetric strain during initial shearing together with dilatancy after farther shearing. The mobilized shear stresses between the geotextile and sand are distributed non-uniformly in the geotextile layer. R. Ziaie Moayed et. al. [3] thought-through dynamic behavior of reinforced sand and premeditated that by augmenting space between geotextile and cap of sample reinforcement, the liquefaction resistance attenuates. Latha and Murthy [4] studied the parameter geotextile & geocell effect on reinforced sand and they observed that the Polyester geocells proved to be highly efficient in improving the strength of sand compared to geotextile cell because of indent formation. Ojha et. al [5] checked the shear strength behavior of Yamuna sand based on relative compaction and relative density, and they found that the sensitivity of shear strength parameter significantly contributes to evaluation of shear strength of Yamuna sand. Limited researches are available regarding the utilization of woven and non-woven geotextiles as a soil reinforcement to improve the shear strength of Yamuna sand.

MATERIALS:

Yamuna Sand

For the present study, Soil sample has been amassed Okhla, Delhi. The top layer of the soil has been withdrawn with the help of a shovel up to a depth of 0.5m before gathering the soil sample. The soil was cohesionless with fine-grained particles and is dark grey in colour. The Geotechnical properties of Yamuna sand is shown in table I

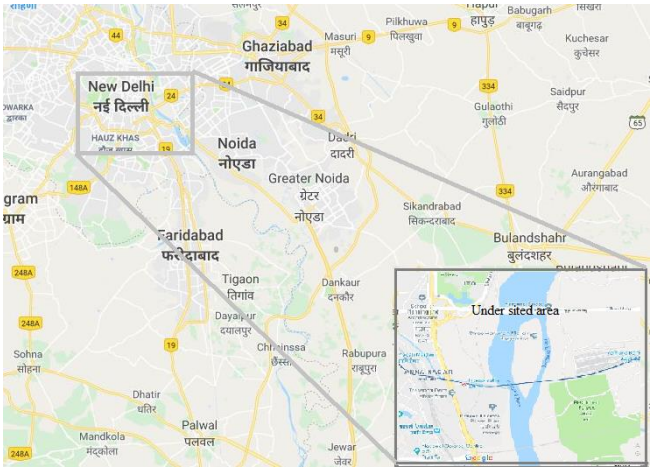

Figure 1. Location of the understudied site area

Table I. Geotechnical Properties of Yamuna Sand

Properties	Value
Specific gravity	2.60
Maximum dry unit weight (kN/m^3)	17.77
Optimum moisture content (%)	10
Coefficient of uniformity (C_u)	1.26
Coefficient of curvature (C_c)	1.57
Angle of friction (Φ)	24.3

Geotextiles

Two types of Geotextiles have been put to use in our study of which woven type of geotextile is made of polyester together with multifilament yarn, furthermore is bluish-off white in colour. While the non-woven geotextile is made of polypropylene fiber as well as black in colour. For the characterization of geotextile, Scanning Electron Microscope test (SEM) and tensile tests had been conducted. Table II shows the properties of Geotextiles.

Table II. Tensile Test Results of Woven and Non-woven types of Geotextile

Parameters	Woven type	Non-woven type
Load at maximum extension (N)	520.14	120.61
Maximum extension (mm)	105.2	170.48
Modulus (MPa)	33.24	4.11
Stress at yield point (MPa)	5.59	1.62
Stress at break point (MPa)	37.5	5.69
Percentage elongation (%)	0.31	0.85

Table III. Tensile properties of Geotextiles

Property	Woven Geotextile	Non-woven Geotextile
Breaking strength	Higher	Lower
Breaking elongation	Lower	Higher
Initial modulus	Higher	Lower

EXPERIMENTAL INVESTIGATIONS

The collected soil sample was characterized in Geotechnical laboratory of Delhi Technological University. Tests were conducted to determine the geotechnical properties of soil sample. The Triaxial tests were performed on Yamuna sand in Consolidated drained (CD) condition with the following conditions:-s

- Unreinforced Yamuna sand
- Yamuna sand reinforced with woven type geotextile in single, double and triple layers respectively.
- Yamuna sand reinforced with non-woven type geotextile in single, double and triple layers respectively.

The dimensions of mould were 100 mm in length and 50 mm in diameter. The cell pressures were applied at 50 kPa, 100 kPa and 150 kPa respectively.

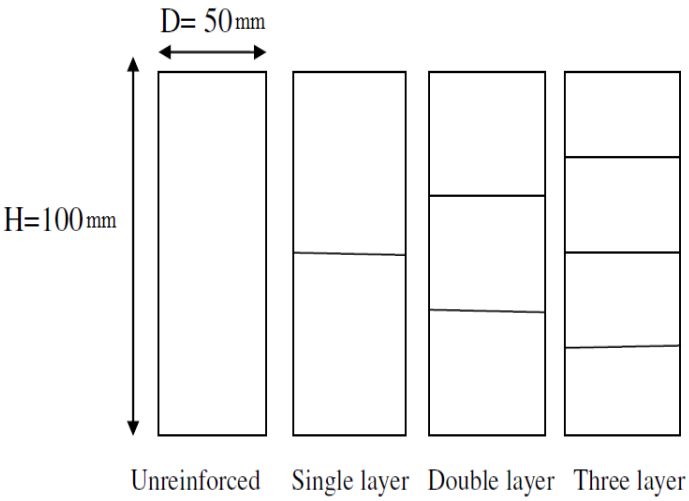

Figure 2. Geotextile arrangement in Triaxial Test

Sample Preparation

Triaxial tests were performed on soil sample having two Length-diameter ratios. Soil samples were prepared in split mould and the sample was compacted by means of static compaction at optimum moisture content. In case of reinforced soil sample, the diameter of geotextiles layer was kept less than the mould diameter and geotextile layers were placed horizontally in compacted soil.

DETAILS OF TESTS CONDUCTED

Specific gravity

The specific gravity of the soil was determined as per the Indian standard specifications [14].

Grain size distribution

The grain size distribution of soil was carried out as per the Indian standard specifications [15].

Compaction characteristics

Light (standard Proctor) test were carried out to determine the maximum dry density (MDD) and optimum moisture content (OMC) of virgin and reinforced soil as per Indian standard specifications [16].

TEST RESULTS AND DISCUSSION

Specific Gravity

The specific gravity of Yamuna Sand was found 2.6.

Morphology

The morphology of Yamuna sand and Geotextile were analyzed by Scanning Electron Microscopic (SEM) Hitachi S 3700. From figure 3 (a), it can be concluded that the geotextile is woven type in which warp has double filament and weft along the transverse direction having a single strap. Both the layers are interlocked with each other. The fibre arrangement is orthogonal and the openings are regular. The aperture size is 0.2m. Whereas in fig 3 (b), it can be concluded that the geotextile is of non- woven in nature having strands interlocked with each other. Fibre arrangement is random and openings are irregular. The aperture size is 0.1mm. While fig 3 (c) shows that sand particles are angular, undergone non-uniform weathering and have greater silica dissolution.

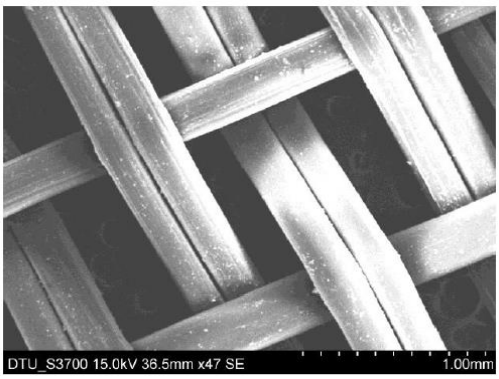

Figure 3 (a)

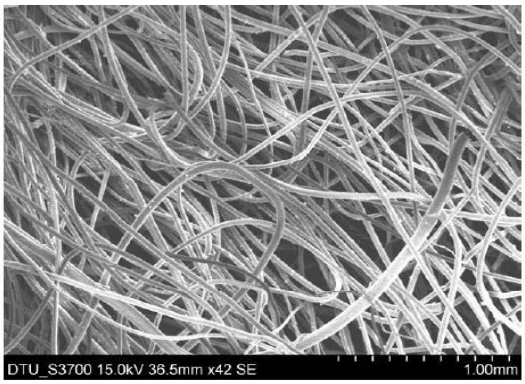

Figure 3 (b)

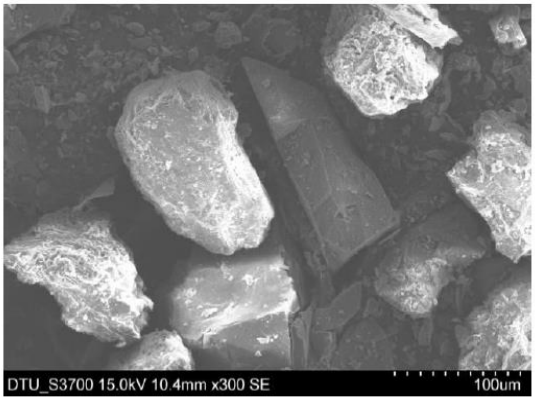

Figure 3 (c)

Tri-axial analysis:

A series of Triaxial tests were conducted in laboratory to check the effect of reinforcement on the properties of sand. The test condition was consolidated drained condition and the tests were performed on both unreinforced and reinforced soil. Figure 4 (a) shows the variations of stress-strain at different confining pressures i.e. 50,100 and 150 (kPa) respectively. Figure 4 (b-d) revels the maximum shearing strength of woven geotextile reinforced sand while Figure 4 (e-g) shows the maximum shearing strength in respect of nonwoven geotextile reinforced soil. Reinforced soil with woven geotextile gives better performance than the Nonwoven geotextile, it may be due to more stiffness and more proper bonding between the sand particles and woven geotextile apertures.

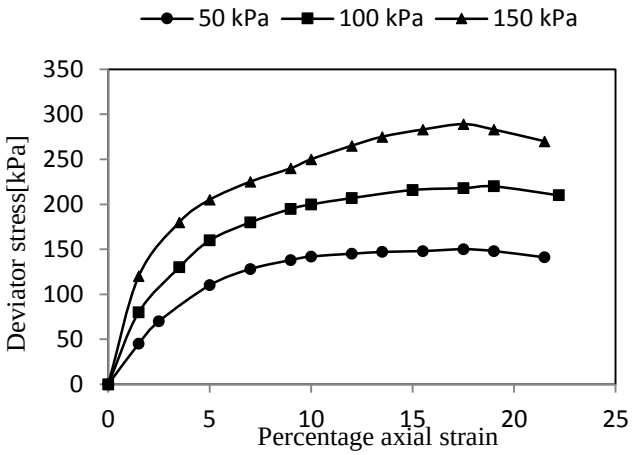

Figure 4 (a). Variation of stress vs. strain in unreinforced Yamuna Sand

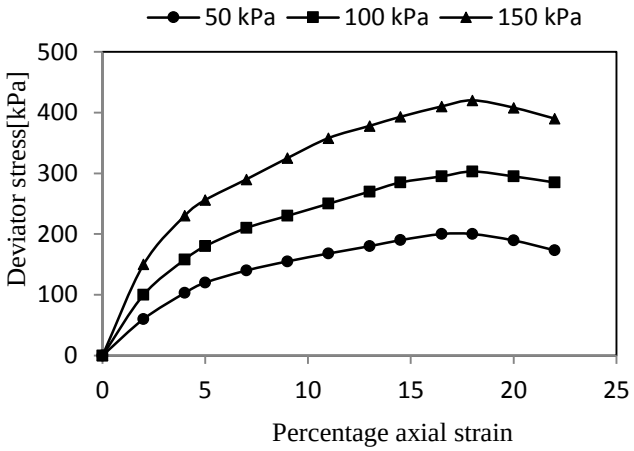

Figure 4 (b). Placement of two layers of woven geotextile in Yamuna sand

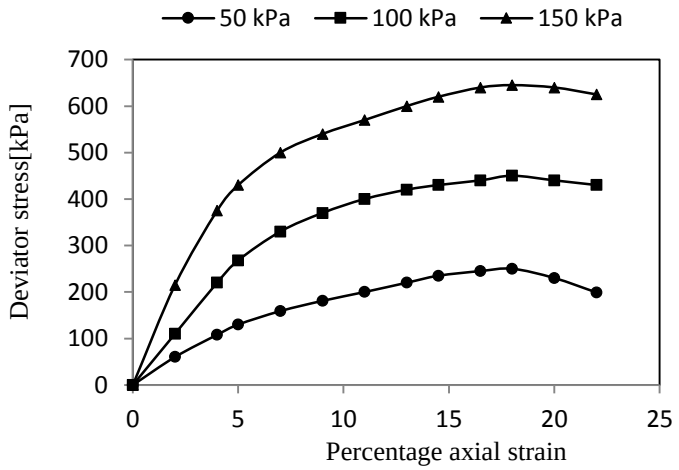

Figure 4. (c)placement of two layers of woven geotextile in Yamuna sand

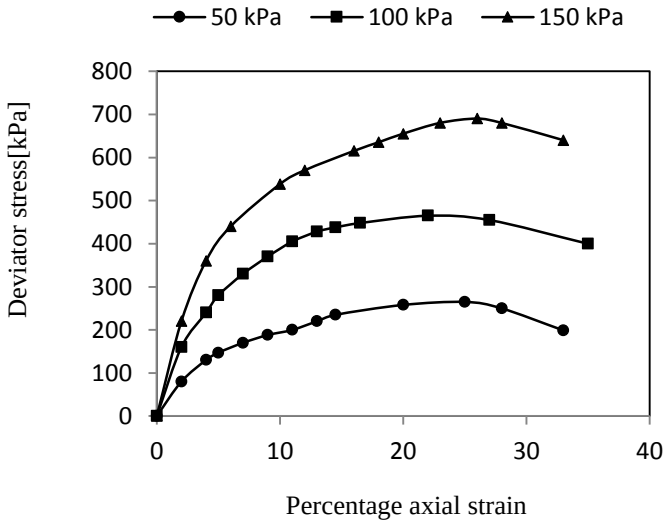

Figure 4. (d) placement of three layers of woven geotextile in Yamuna sand

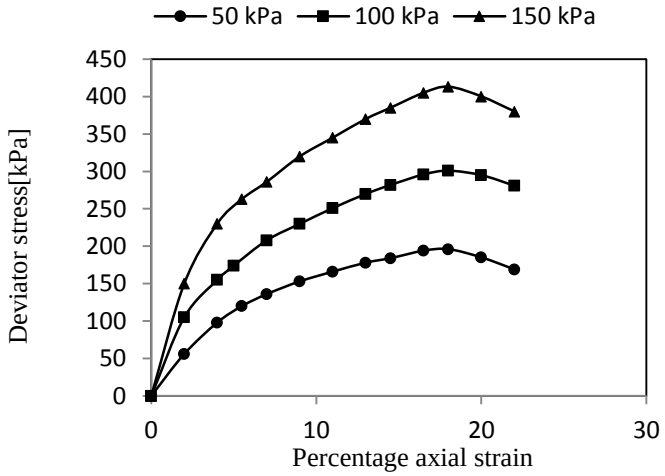

Figure 4. (e) Triaxial test on Yamuna sand reinforced with non-woven geotextile in single layer

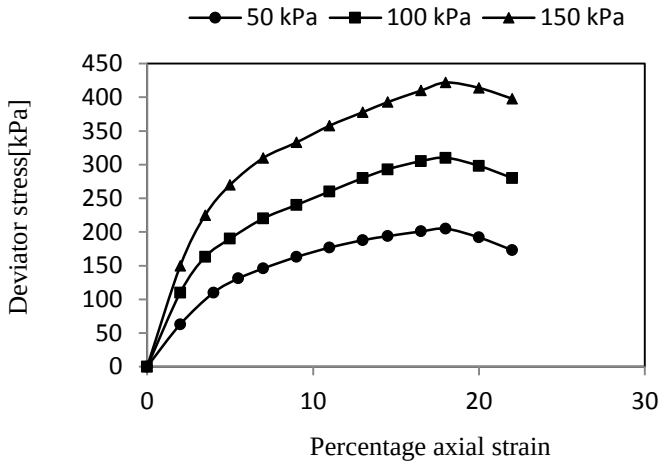

Figure 4. (f)Triaxial test on Yamuna sand reinforced with non-woven geotextile in double layer

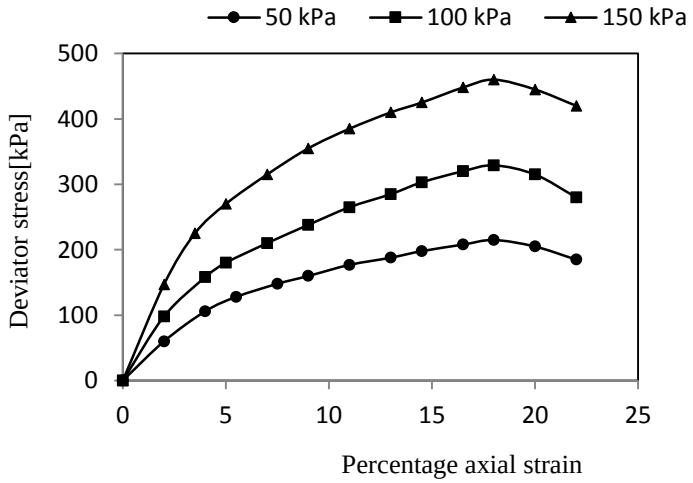

Figure 4. (g) Triaxial test on Yamuna sand reinforced with Non-Woven Geotextile in three layer

Strength ratio:

The strength ratio is defined as the peak deviator stress of reinforced specimen to the peak deviator stress of unreinforced specimen. From figure 5 (a-b) it is cleared that the strength ratio increases as reinforcement layers increases but at third layer all values of strength ratios become constant.

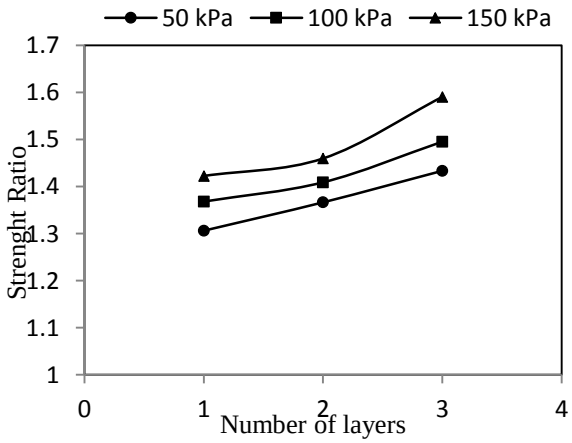

Figure 5 (a). Strength ratio of Non woven geotextile reinforced soil,

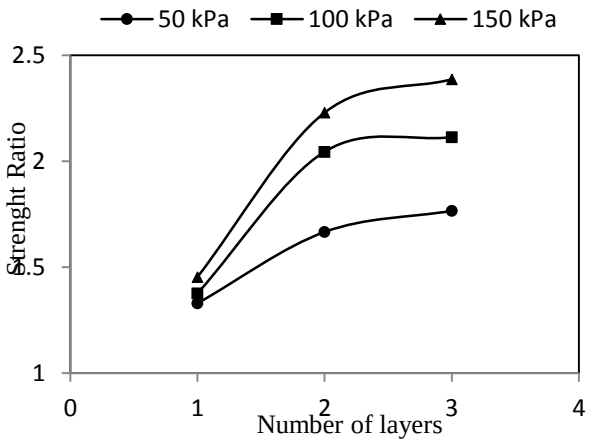

Figure 5 (b). Strength ratio of woven geotextile reinforced soil

Table V. Strength difference with respect to unreinforced Yamuna sand

Confining Pressure (kPa)	Strength difference					
	Woven Geotextile			Non woven Geotextile		
	1 layer	2 layers	3 layers	1 layer	2 Layers	3 Layers
50	51.33	100.8	115.7	48.22	55.8	65.7
100	85.54	230.8	245.6	80.43	90.1	95.72
150	131.01	356.8	401.2	121.2	136.	171.4

Strength difference:

The strength difference $\Delta\sigma 1$ is defined as the difference between shear strength of reinforced soil and that of unreinforced soil under the same confining pressure, which also indicates the net strength improvement by reinforcement. Table V shows the Strength difference with respect to unreinforced Yamuna sand

Interface frictional angle:

From the graph shown in figure 6, it can be seen that the non-woven has higher interface angle than woven geotextile and hence the interlocking of sand is better with non-woven geotextile.

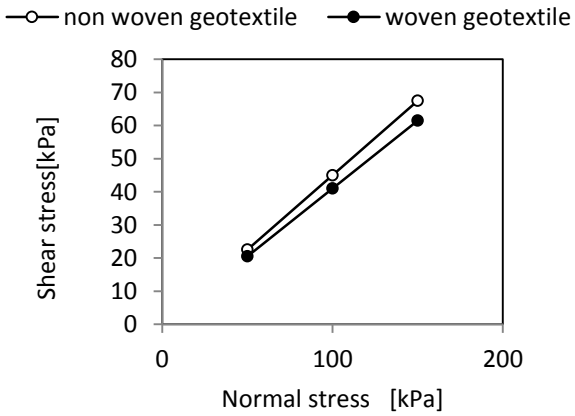

Figure 6. Comparison of interface friction angle

CONCLUSIONS

From the Triaxial analysis, it is clear that the geotextile improves the strength of Yamuna sand. In comparison with woven geotextile, the bonding of non-woven geotextile is more with Yamuna sand in comparison to woven geotextile, but the strength of Yamuna sand is enhanced more if reinforced with woven Geo textile. So it can be concluded that depending on the application of Geo textile, the suitable geotextile can be used. For the purpose of Reinforcement the woven Geo textile should be used as the shear strength is improved significantly.

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