Major Project

Dissertation on

"EFFECT OF GEOTEXTILE ON YAMUNA SAND"

Submitted to Delhi Technological University in partial fulfillment of the requirement for the award of Degree of

Master of Technology

In

Geotechnical Engineering

ANSHUL RATHORE

2K13/GTE/03

UNDER THE SUPERVISION OF

Dr. Raju Sarkar

Asst. Professor

Department Of Civil Engineering

Delhi Technological University

Delhi-110042

Department of Civill Engineering
Delhi Technological University
(Formerly Delhi College of engineering)
Bawana Road, Delhi-110042

JULY 2015

CERTIFICATE

DELHI TECHNOLOGICAL UNIVERSITY
(Formerly DELHI COLLEGE OF ENGINEERING)

Date:-__________

This is to certify that report entitled **"EFFECT OF GEOTEXTILE ON YAMUNA SAND"** by **ANSHUL RATHORE** is the requirement of the partial fulfilment for the award of Degree of **Master of Technology (M.Tech)** in **Geotechnical Engineering** at **Delhi Technological University**. This work was completed under my supervision and guidance. She has completed her work with utmost sincerity and diligence. The work embodied in this project has not been submitted for the award of any other degree to the best of my knowledge.

SIGNATURE OF SUPERVISOR ______________

Dr. Raju Sarkar
Asst. Professor
Department of Civil Engineering
DELHI TECHNOLOGICAL UNIVERSITY

ACKNOWLEDGEMENT

First of all, I would like to express my gratitude to God for giving me ideas and strengths to make my dreams true and accomplish this thesis.

To achieve success in any work, guidance plays an important role. It makes us put right amount of energy in the right direction and at right time to obtain the desired result. Express my sincere gratitude to my guide, **Dr. Raju Sarkar**, Asst. Professor, Civil Engineering Department for giving valuable guidance during the course of this work, for his ever encouraging and timely moral support. His enormous knowledge always helped me unconditionally to solve various problems.

I am greatly thankful to **Dr. Nirendra Dev**, Professor and Head, Civil Engineering Department, Delhi Technological University, for his encouragement and inspiration for execution of the this work. I express my feelings of thanks to the entire faculty and staff, Department of Civil Engineering, Delhi Technological University, and Delhi for their help, inspiration and moral support, which went a long way in the successful completion of my report work.

Anshul Rathore

(Roll No-2K13/GTE/03)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

C_C = coefficient of curvature

Cu = coefficient of uniformity

E = Efficiency factor

S = shear strength

б = normal stress on the plane of shearing

б1 = principal stress

б3 = confining stress

Φ = friction angle

Φa = interface friction angle

ABSTRACT

In the present study characterization of Yamuna sand was done by various experiments like X-ray Diffraction Test (XRD), Scanning electron microscope test (SEM), sieve analysis, standard proctor compaction test. After literature study, it has been seen that so many problems are associated with Yamuna sand from the construction point of view and it can be stabilized with the help of various admixtures. For our study both woven and non woven type geotextile are used to see the effect on the strength of Yamuna sand. The total of 37 unconsundrained triaxial tests was performed, out of which 21were successful. Direct shear test was performed to check the bonding of geotextile with Yamuna sand by finding interface friction angle parameter. The main aim of the project is to determine the application of both woven and non-woven geotextile with Yamuna sand.

CHAPTER 1

INTRODUCTION

1.1 Introduction:

Yamuna sand is found near the Yamuna river which starts from Yamunotri glacier and flow through Delhi, the National Capital Terriotory of India. The Yamuna sand found in delhi has weak bearing capacity and is also susceptible to erosion. IF the soil is weak then shallow foundation cannot be constructed in the area and deep foundations are needed to be constructed. The cost of construction of deep foundation is significantly high thus it is better to stabilize the weak soil. There are various methods by which soil can be stabilised like vibrofloatation,, fibre reinforcement and also admixtures like lime, cement etc for stabilization of sand.Geotextiles reinforcement is used in our present study for the stabilization of Yamuna sand because geotextile reinforcement is better than the other methods.

Geotextiles is derived from geo means earth or soil and textile. The textile can either be made of synthetic material like polyester, polypropylene fibre and also with the natural material like jute, coir etc. Basically there are two forms of geotextiles. These are the woven geotextile and the non- woven geotextile. Woven geotextiles are developed from the synthetic or natural fibres by using weaving techniques. By the weaving process in woven geotextile the fibres are arranged in a perpendicular direction to each other. The longitudinal direction in which the fibre runs is called warp. The transverse direction is called the weft. Both mono filament and multifilament yarn can be used for woven geotextile. Non- woven geotextiles are formed by the arrangement of filaments or fibres in a random manner by bonding them together to form a planar structure. The filaments or fibres are first arranged into a loose web and then bonded together. The bonding can be done in the following manner-

a) Thermal bonding- In this method the polymer filaments are spread on a moving conveyor which is then put between the heated rollers.
b) Mechanical Bonding- In this method the group of webbed fibres are put under the machine which has special designed needles.
c) Chemical bonding- These are produced by spraying polymer filaments on to a moving belt and spraying an acrylic resin on the fibrous web. After curing is done, strong bonds are formed between the filaments.

Functions of geotextile -

a) Filtration – Geotextile helps in the movement of water particles through the soil but restricts the movement of fine soil thus prevents washing away of soil.
b) Drainage- It helps in the movement of water along the plain of geotextile which later comes out through the geotextile through its spacing.
c) Separation – It helps in separation of different layers of soil and thus does not allow them to intermix with each other.
d) Reinforcement- It helps in improving the strength of soil mass by providing its tensile strength.

Geotextile reinforcement is better than the rest of the methods because of the following reasons- Geotextiles are synthetic and non biodegradable. They are more flexible in comparison to metal strips and thus compatible with soil deformability. Along with shear strength they also improve ductility unlike admixtures. They are economical and less time consuming. They can be used for various purposes like separation, reinforcement, drainage and filtration. Geotextiles is a newly emerging field in the civil engineering and it also has huge potential in different applications. Geotextiles play an important role in modern design of pavements. Due to their multifunctional characteristics like drainage, fileration, reinforcement etc. They have great scope in future.Geosynthetics reinforced soil (GRS) retaining structures have been widely used in geotechnical engineering projects such as residences, highways, bridge abutments, and slope stabilization. The importance of these retaining structures are that they are pleasing,, cost effective and attractive. They are easy for construction, great seismic performance and have greater capacity to resist larger deformation without structural distress make MSE structures desirable.

1.2 Objective of the present work:

1. To determine the properties of Yamuna sand.
2. To determine the tensile strength of geotextile.
3. To study the Yamuna sand - geotextile interface friction angle and efficiency factor of woven and non-woven geotextile by direct shear test.
4. To study the stress strain response of geotextile reinforced Yamuna sand of woven and non-woven geotextile by triaxial test.
5. To compare the strength ratio of woven geotextile and non woven geotextile in different layers

CHAPTER 2

LITERATURE REVIEW

Ingold and Miller (1983) studied the effect of impermeable and permeable reinforcement. In the study it was concluded that the strength is improved significantly is case of permeable loading of drained test while it decreases in the case of imperable loading of undrained test.

Donald and Talal Al-Refeal (1985) compare the effect of fabric reinforcement and filter reinforcement in sand.For this purpose triaxial tests were conducted in which deviatoreic stress v/s percentage axial strain curve was studied for the random distribution of fibres and continuous orientation of fabric in layers.The effect of variation of different parameters like confining pressure, surface friction, amount of reinforcement was also studied. It was seen that for both fiber and fabric reinforcement the strength was improved and axial strain failure increased while the post-peak strength reduced in most of the cases.A unique feature was seen only in the case of fabric inclusion that there was loss of stiffness at very low strains For both the systems the critical confining pressure was same. The failure pattern was studied and it was seen that the failure envelope for reinforced sand was parallel to unreinforced sand and the strength was increasing in proportion to the amount of reinforcement.For fabric reinforcement the failure was in between the layers while for the fibre it was shear plane failure.

Rao, Kachhawath and Gupta (1987) verified the model developed by Housemann(1976) for metal strips by carrying out test on fine grained uniform sand reinforced with geotextile. It was concluded from the results that geotextiles do not rupture at high confining pressure and also the effect of geotextile decreases with increase in confining pressure.

Saxena and Sarkar (1988) studied the use of polymer geogrids in slope erosion. In this study the soil erosion controlwas checked in cases of surface runoff due to rainfall and flooding of dams, embankments. Geogrid acts like an anchor and stops the failure of soil by slip movement. It provides high tensile and flexible structure which attaches to the soil like a contour. These geogrids does not biodegrade and thus can be used lifelong for various applications.

Al-Omari et al. (1989) performed consolidate drained and consolidated undrained test on clay reinforced with geomesh.IN undrained triaxial test the cohesion intercept was significantly enhanced and the failure envelope was parallel to unreinforced. Whereas in the case of drained triaxial test friction angle was improved significantly and failure envelope showed slight movement.

S.M. Haeri et al. (2000) studied that mechanical properties of soil like post peak strength, axial failure and dilatancy. In this it was concluded Geotextile inclusion enhances peak strength, axial strain at failure and reduces post-peak loss of strength Small-size samples demonstrated higher peak strength, and axial strain at failure and more reduction in the post-peak loss of strength compared to that of large-size samples. The stiffness of reinforced sand is affected substantially by the load-elongation characteristics of geotextile. It may decrease or increase in comparison to unreinforced sand. Increase in the peak strength of the geotextile-reinforced sand is influenced by the coeffcient of friction between geotextile and sand. By increasing this coeffcient, the peak strength also increases. Geotextile inclusion reduces the dilatancy of reinforced sand due to confinement enhancement. Geotextile layers which are properly placed to intercept the failure plane or in the zones of maximum tensile strain in the unreinforced sand are more effective than the same number of geotextile layers placed randomly at other levels.Failure envelopes for reinforced sand are non-linear.

Unnikrishnan et al.(2002) studies have shown that thin sand layer inclusions will result in the dissipation of pore water pressure inside the clay sample and will increase the interface friction between clay and sand reinforcement which will lead to the improvement in the shear strength of clay reinforced with geotextile.It was seen that strength is improved at optimum thickness of sand layer. Deviation from it in either side will provide shear strength less than the optimum value..

G. Madhavi Latha and Vidya S. Murthy (2007) studied the effect of geotextile and geocell reinforcement in sand. In this study the equations were made by conducting the test on larger size mould and were checked for smaller size mould. The results came out were consistent. The efficiency of polyester geocells was much higher than geotextile cells due to the indent formation. Due to the low tensile strength of the seams the cellular reinforcement provided higher strength in comparison to the planar reinforcement of geotextile.

Anubhav and P.K. Basudhar (2013) In this study it was seen that angular sand particles have large friction coefficient in comparison to rounded sand particle and sand interface. Also it was seen that post peak softening is much slower in rounded sand particles in comparison to angular sand particles.

M.D. Nguyen et al.(2013) In this volumetric strain and shear stress variation in Geotextile reinforced sand by triaxial test was determined. It was concluded that Geotextile inclusion increases compressive volumetric strain during initial shearing and the dilatancy during further shearing. The mobilized shear stresses between the geotextile and sand are distributed non-uniformly in the geotextile layer.

Firas A. Salman et al.(2013) Effect on Interface strength by geotextile inclusion was studied and it was concluded that the presence of geosynthetic layer at the facing of the segment i.e., at the interface decreases the shear capacity. This papameter relies on the flexibility of the geosynthetics used int the samples their grid patterns.The flexible geosynthetics enhances the shear transfers across the block surface in comparison to the stiff geosynthetics but it blocks the inter-particle locking completely at the interface plain and thus reduces the shear resistance. The angle of friction of the blocks are more for polyester geogrid inclusion in comparison to the HDPE geogrid and the polyester geotextiles. The geosynthetic layers present in the block minimises the localised stress concentration at the interface.

R. Ziaie Moayed and M. Alibolandi (2014) Dynamic behavior of Reinforced Sand was studied and it was concluded By increasing space between geotextile and cap of sample reinforcement effect on the liquefaction resistance decreases.This indicates that the reinforcement has not significant influence on the liquefaction resistance of soil in the large distance of load applying part (beyond 2H/3). Thus, utilization of geotextile inclusion near the loading part in field is preferable.

Jewel and Wroth (1987), O'Rourke et al. (1990), Palmeira (1988), and Takasumi et al. (1991) showed that apparatus size does not affect significantly the friction angles for cohesionless sands with ratios of mean particle size to length of the box that are in the range of 50–300.

CHAPTER 3

SAMPLE PICTURE

3.1 Yamuna sand

Yamuna sand was brought from dealer in rohini delhi. The sand is cohesionless with fine grain particles and is dark grey in colour.

Fig.1 Yamuna sand

3.2 Geotextile A

Geotextile A was brought from Filter fabs, New Delhi. It is woven type of geotextile made of polyester and had multifilament yarn filaments in their structure and is of white and blue colour.

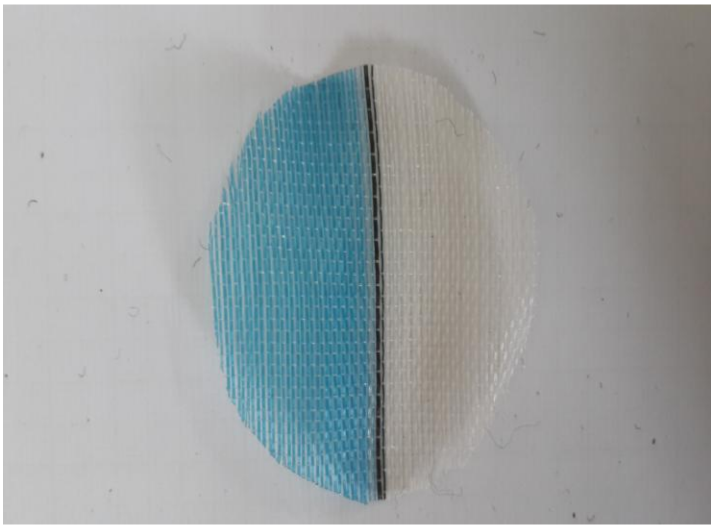

Fig.2 Geotextile A

3.3 Geotextile B

Geotextile B was collected from Filter fabs, New Delhi. It is non-woven geotextile made of polypropylene fibre and is black in colour.

Fig.3 Geotextile B

CHAPTER 4

EXPERIMENTAL STUDIES

The following tests were conducted for this thesis work:

4.1XRD test:

An electron in the alternating electromagnetic field will oscillate with the same frequency as the field. When an X-ray beam will hit the atom, the electrons will start to oscillate with the incoming beam in their frequency. In every direction their will be destructive interference which shows that the combining waves will be out of phase and there will be no resultant energy exiting the solid sample. Although the atoms in a crystal are arranged in a regular pattern, we might have constructive interference in some directions.

The waves will be in phase and there will be well defined X-ray beams leaving the sample at various directions. Therefore a diffracted beam can be described as a beam composed of a large number of scattered rays reinforcing each another mutually. This concept is difficult to solve mathematicallyand we study this through X-ray reflections which form a series of parallel planes inside the crystal. The orientation and inter planar spacing of the planes is defined by the three integers h, k, l. These are called indices.

If a given plane has indices h, k , l then this means that they cut the a-axis of the unit cell in h sections and b axis in k sections and the c axis in l sections respectively. A zero indice will indicate that the planes are parallel to the axis. For example 3, 2, 0 indicates that planes cut the a axes in three and the b axis half and is parallel to the c– axis.

If we use the three dimensional diffraction grating in a mathematical model then the three indices h, k, l will become the order of diffraction along the unit cell axes a, b and c respectively.

Suppose we consider an X-ray beam incident on a pair of parallel planes P1 and P2, separated by an inter planar spacing d.

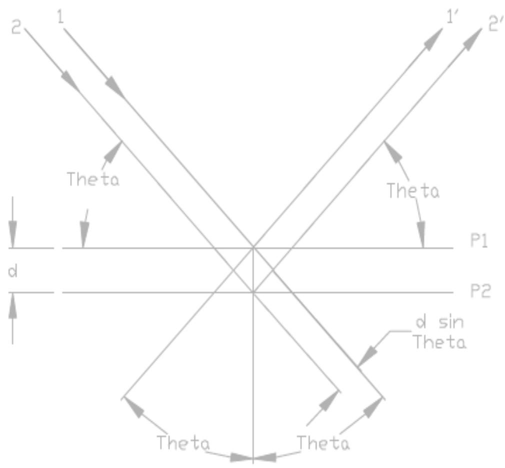

Fig.4 X-ray diffractometer plate

The two parallel incident rays 1 and 2 make an angle theta with these planes. A reflected beam of maximum intensity will be the result of these waves which will be represented by 1' and 2' and are in phase. The difference in path length between 1 to 1' and 2 to 2' will be a multiple of integral number of wavelengths. Mathematically from Bragg's law the relationship is **$2d\sin\theta = n\lambda$**

Fig.5 X-Ray diffractometer

4.2 ScanningElectron Microscope (SEM):

A scanning electron microscope is the one in which takes image of a sample by scanning it with high energy beam of electrons which interact with the atoms of sample which produces signals that contain information about sample surface composition, topography and other properties like electrical conductivity.

The types of signals that can be produced by an SEM are secondary electrons, back scattered electrons, X-Ray, specimen current and transmitted electrons. The signals are a result of the interaction between electron beams at or near the sample surface. In the standard detection mode that is the most common mode, secondary electron imaging can produce very high resolution images of surface revealing details less than 1nm in size. The SEM micrographs are very useful in determining large depth of field yielding characteristic of a three dimensional appearance of surface structure.

A wide range of magnifications is possible i.e., from about 10 times to more than 500,000 times. Back-scattered electrons (BSE) are beam electrons that are reflected from the sample by elastic scattering. BSE is mostly used along with the SEM in the spectra from the characteristic X-rays as the intensity of the BSE signal is significantly related to the atomic number (Z) of the specime. Also the BSE images helps in providing the distribution of different elements present in the sample. Due to this application the BSE imaging is used in image colloidal gold immuno-labels of 5nm and 10 nm diameter. This is very difficult or we can say impossible to detect with the secondary electron images for the biological specimens. Characteristic X-rays are emitted when the electron in the inner shell is removed by the electron beam and higher energy electron fills that shall and energy is released. These characteristic X-rays are used to determine the composition and the percentage of elements present in the sample.

Fig.6 Scanning electron microscope

4.3 Geotextile tensile test:

Geotextile tensile test can be conducted by three methods viz. Grab tensile test, wide width tensile test and tension creep test.The ASTM designation and dimension for these tests are

Table 1 Geotextile tensile test

Property	Standard	Specimen size	Jaw size
Grab-tensile test	ASTM D4632	4”*8”	1”*2”
Wide width tensile test	ASTM D4595	8”*8”	8”*2”
Tensile creep strength	ASTM D5262	8”*8”	8”*2”

4.3.1 Grab tensile test

The grab tensile test (ASTM D4632) is the basic tensile test used within the geotextile industry. It detemines an index for the ultimate strength of the specimen at failure. This behaviour is exhibited by non-woven geotextiles as they show more strength when they are confined for end use applications. In this test, each specimen is clamped by jaws at one inch from the center from the width and then pulled at very fast rate. As this test is very easy to perform and inexpensive and completes in very few minutes. It is an excellent index for the quality control and check the consistency of products with the specifications given by the manufacturer.

4.3.2 Wide width tensile test

The wide-width tensile test (ASTM D4595) takes longer to complete and is a much more expensive test. In the wide-width tensile test each specimen is gripped across their full width and pulled slowly. Unlike the grab tensile test, the wide-width strength results are expressed as a load per unit width. The wide-width tensile test is rarely used for quality control applications because of the time and expense involved in testing. Although, the wide-width test provides a better measure of true tensile strength in woven geotextiles. The test data can be presented in a stress-strain curve, from which the modulus values can be calculated. The wide-width ultimate strength and modulus values can be used for design with woven geotextiles. Because the specimen being tested is not confined, as it would be in its end use, this test does not result in a true design value for nonwoven geotextiles.

4.3.3Tension creep tests

Tension creep tests (ASTM D5262 and D6992) are performed by sustaining a load on a test specimen for up to 10,000 hours. The specimens are gripped across their full width. The creep elongation of the sample is determined by the test period. From these results, the time to rupture at various load levels will cause rupture at a given time will be determined.

4.3.4 Test method application

The grab tensile test is appropriately specified in applications where the end-use tensile force requirements cannot be quantified and the approach to selecting required geotextile tensile strength is, therefore, largely empirical. This category includes roadway, filtration, drainage, permanent erosion control and silt fence applications. The grab tensile test is an efficient construction quality control method for all applications. In applications where the geotextile will be in continuous long-term stress, tension creep is critical. In these cases, the wide-width ultimate strength should be specified in conjunction with the creep limit. In embankments constructed over soft soils, the geotextile tensile stress may decrease over time as the subgrade soils consolidate. Tension creep in this case is not an applicable design parameter. For this application, the wide-width modulus should be specified at a particular strain. In the design, the geotextile strain is limited to be compatible with the strain developed within the soil mass. This value is typically 5% strain.

We have performed grab tensile test to determine the properties of geotextiles : modulus, stress at yield point and stress at break point for both the woven type and non woven type geotextile respectively.

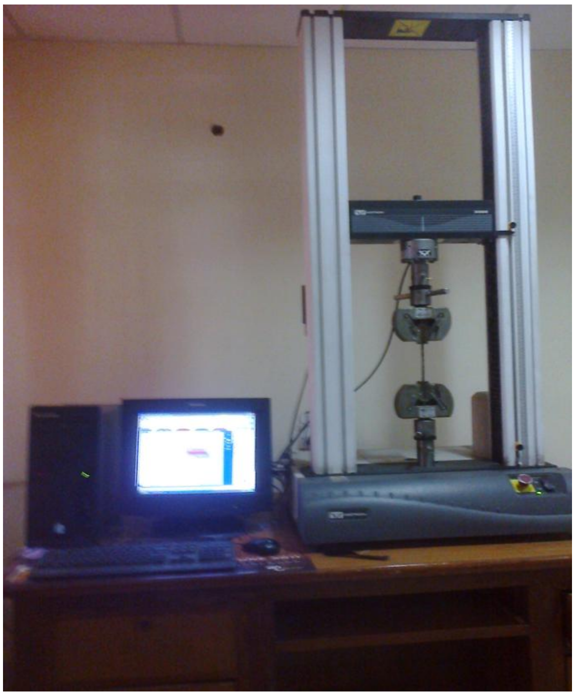

Fig.7 Geotextile tensile test

4.4 Sieve analysis of Yamuna sand

Object: To determine the particle size distribution of Yamuna sand

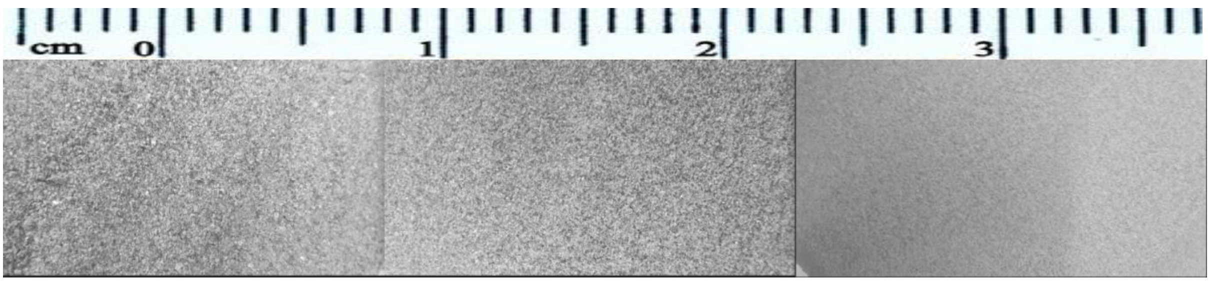

Fig.8 Grain size on a scale

4.5 Density bottle

Object: To determine the specific gravity of Yamuna sand.

Standard Reference:

ASTM D 854-00 – Standard Test for Specific Gravity of Soil Solids by Water Pycnometer

Significance:

The specific gravity of a soil is used to determine the phase relationship of air, water and solids in a given volume of the soil.

Equipment:

Pycnometer, Balance, Funnel.

4.6 Compaction test (Standard proctor):

Object: To determine the optimum moisture content and maximum dry density of Yamuna sand. .

Apparatus:-

1. Cylinder mould
2. Rammer for light compaction (diameter 50 mm., mass of 2.6 kg, free drop 310 mm)
3. I.S. Sieves (20 mm,4.75 mm)
4. Balance
5. Drying oven (temperature 105°C to 11°C)
6. Graduated jars
7. Spatula
8. Scoop

Theory and Applications:-

Compaction can be defined as the process of densification of the soil mass by reducing the air voids. This process is different than the consolidation in which the densification of the soil mass takes place by the expulsion of water rather than reduction in voids under the action of continuous static force applied for a long time.

The degree of compaction of a soil is measured in terms of its dry density. The degree of compaction depends on its moisture content, compaction energy and the soil type. For a particular compaction energy the soil achieves the maximum dry density at a particularr water content which is called as optimum moisture content. In the dry side, water acts as a lubricant and helps in the closer packing of soil grains. In the wet side water starts to occupy the space of soil grains and hinders in the closer packing of grains.

Application:-

Compaction of soils increases their density, shear strength, bearing capacity but reduces their void ratio porosity, permeability and settlements. The results of this test are useful in the stability of field problems like earthen dams, embankments etc. The moisture content at which the soils are compacted in the field is controlled by the value of optimum moisture content can be determined by the laboratory proctor compaction test. The compaction energy to be given by the field compaction unit is also controlled by the maximum dry density determination in the laboratory. The laboratory compaction test results are used to determine the compaction specification for field compaction of soils.

Precautions:-

1. Adequate period is allowed for mixing the water with soil before compaction.

2. The blows should be uniformly distributed over the surface of each layer.

3. Each layer of compacted soil is scored with spatula before placing the soil for the succeeding layer.

4. The amount of soil used should be just sufficient to fill the mould, at the end of compacting the last layer the surface of the soil should be slightly (5 mm) above the top rim of the mould.

5. Mould should be placed on a solid foundation during compaction.

Fig.9 Standard proctor test

4.7 Direct shear test

Object:

To determine the shear parameter of Yamuna sand and to find the interface friction angle and efficiency factor of Yamuna sand with different geotextiles.Procedure:

The geotextile specimens were cut using a sharp cutting edge. A spacer dummy steel block was placed in the lower half of the shear box. To prevent the stretching of the geotextile sample along the smooth dummy base, sandpaper was glued onto the base. After clamping the geotextile in the lower half of the box, the upper half was assembled properly by inserting pins. A known weight of Yamuna sand then was placed over the geotextile in the upper half of the shear box and compacted to a specified height by tamping to achieve the desired relative density of 70%. With the grid plate and top platen, the shear box was placed carefully in a loading frame. After applying a normal load, the specimen was sheared at a displacement rate of 0.125 mm/min. In this assembly, the entire lower box was covered with geotextile, and hence no area correction was required. The test was conducted for both woven and non woven geotextile.

Application:

To determine the interface friction angle of the Yamuna sand with woven geotextile and non-woven geotextile and find the efficiency and interlocking of Yamuna sand with geotextile.

Fig.10 Direct shear apparatus

4.8 Triaxial test

Object:

To determine the effect of geotextile reinforcement on Yamuna sand by UU test.

Procedure:

A series of unconsolidated and undrained triaxial compression tests was performed on unreinforced Yamuna sand and Yamuna sand reinforced with the woven geotextile and non-woven geotextile respectively. All test specimens were 50 mm in diameter and 100 mm high. Dry sand was poured into a rubber membrane stretched inside a split mold former and compacted with a small tamper into several layers. The relative density of sand specimens was maintained at around 70%; unit weight was 16.3 kN/m^3: After compaction and leveling of each sand layer, the reinforcement was placed horizontally in the specimen. After the sample was prepared it was placed in the mould and clamped with the help of rubber tube. The split mould was removed and the machine was set. The cell pressure is then applied at 50 and the failure is seen. The same procedure is repeated at 100 and 150 respectively of single layer, double layer and triple layer for woven geotextile and non woven geotextile respectively.

Fig.11 Triaxial test apparatus

CHAPTER 5

RESULT AND DISCUSSION

5.1 SEM test:

5.1.1 Yamuna sand:

The test was performed at three scales 100 μm, 300 μm and 500 μm respectively. From the figure below it can be observed that sand particles are angular, undergone non unform weathering and have greater silica dissolution.

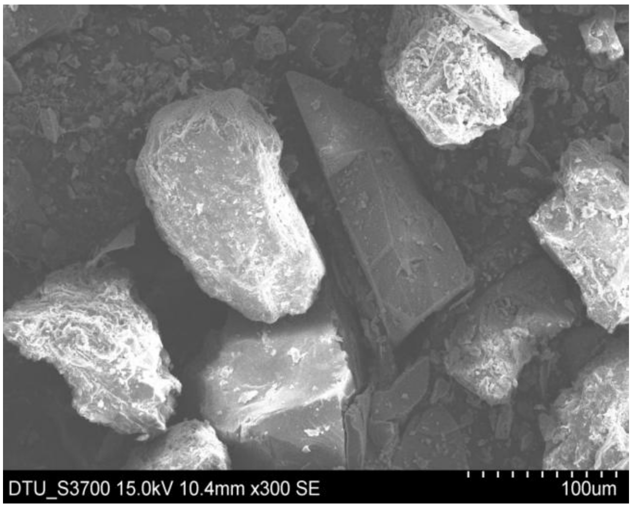

Fig. 12 SEM of sample of Yamuna sand at 100 μm

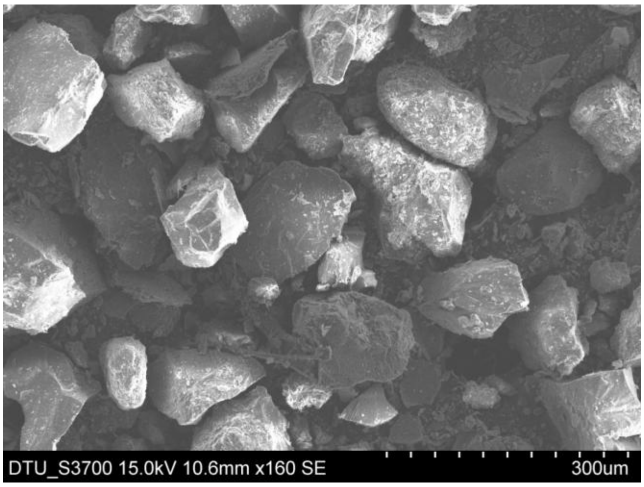

Fig.13 SEM of sample of Yamuna sand at 300 μm

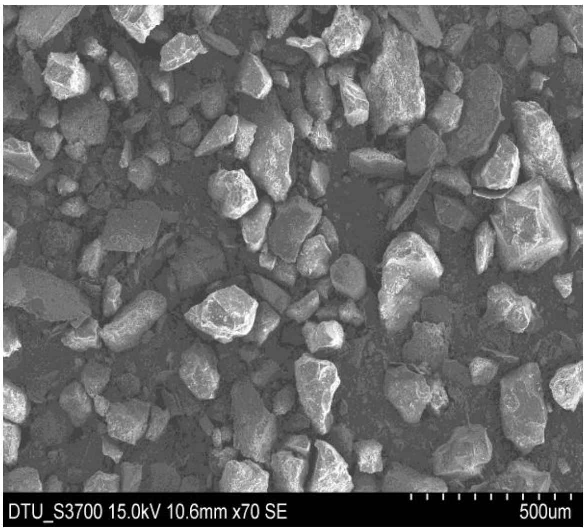

Fig.14 SEM of sample of Yamuna sand at 500 μm

5.1.2 Geotextile A:

The test was performed at two scales 1mm and 2mm.From the figure below it can be concluded that the geotextile is woven type in which warp has double filament and weft along the transverse direction has 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

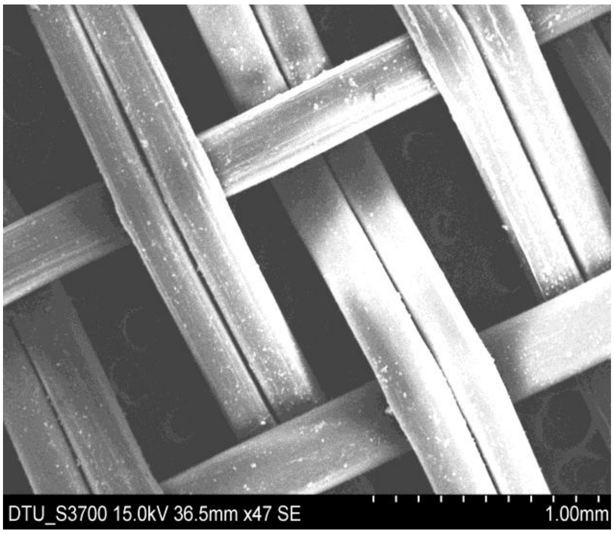

Fig.15 SEM of Geotextile A at 1 mm

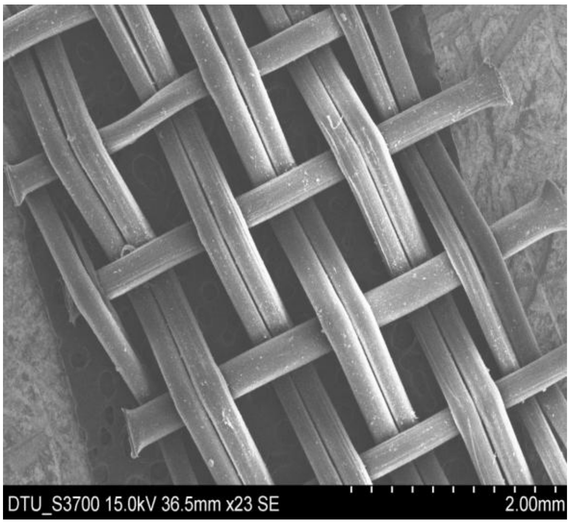

Fig.16 SEM of Geotextile A at 2 mm

5.1.3 Geotextile B:

The test was performed at two scales 1mm and 2mm. The best image was observed at 1mm. From the figure below it can be concluded that the geotextile is non- woven type with strands interlocked with each other.. Fibre arrangement is random and openings are irregular. The aperture size is 0.1mm

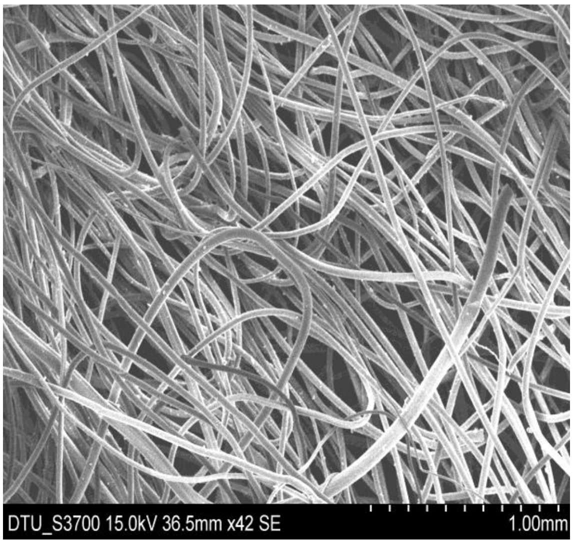

Fig.17 SEM of Geotextile B at 1mm

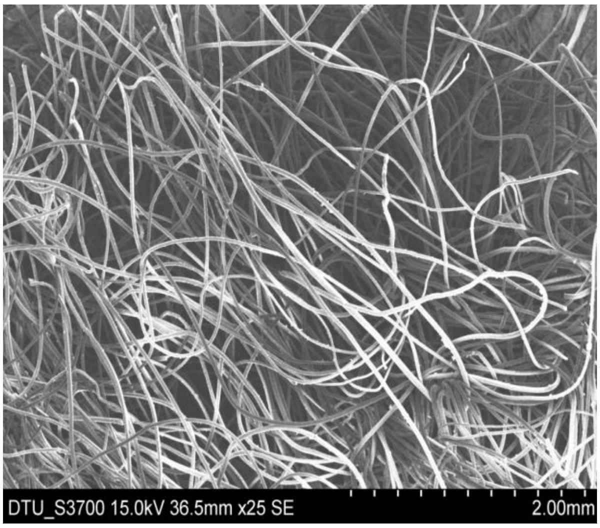

Fig.18 SEM of Geotextile B at 2 mm

5.2 XRD test:-

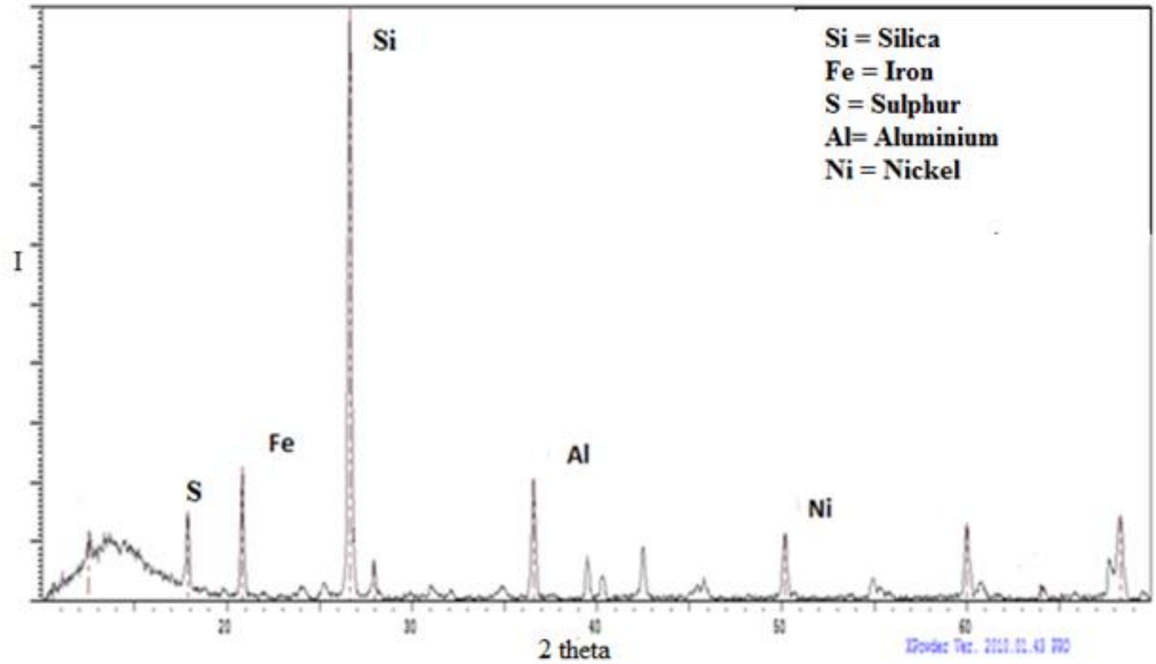

Fig.19 XRD of Yamuna sand

From the XRD the following mineral composition of sand and grain size are determined

$$t = \frac{0.9\lambda}{\beta \cos\theta}$$

where t is grain size, λ is equal to wavelength at which XRD is conducted is equal to 1.540A°. β is equal to full width at middle heightis equal to 0.02cm and θ is angle of incident is equal to 13.324.

Putting the values in eqation we get grain size equal to 70µm.

a. Quartzite
b. Iron
c. Aluminium
d. Nickle
e. Sulphur

5.3 Geotextile tensile test:

5.3.1 Geotextile A: The tensile test was conducted by taking a sample of dimensions: length 200 mm and width 100mm and thickness measured was equal to 0.93mm. The modulus came out equal to 33.24Mpa. The stress at break point and stress at yield point was calculated using the formula

$$\text{stress at break point} = \frac{\text{Maximum extension}}{\text{Final area}} \quad (1)$$

$$\text{stress at yield point} = \frac{\text{Maximum extension}}{\text{Original area}} \quad (2)$$

$$\text{Percentage elongation} = \frac{\text{Maximum extension}}{\text{Original length}} \quad (3)$$

Table2. Tensile test result for Geotextile A

Load at maximum extension(N)	520.14
Maximum extension(mm)	105.2
Final area(mm^2)	13.84
Original area(mm^2)	93
Modulus(Mpa)	33.24
Stress at yield point(Mpa)	5.59
Stress at break point(Mpa)	37.5
Percentage elongation(%)	0.31

5.3.2 Geotextile B: The tensile test was conducted by taking a sample of dimensions: length 200 mm and width 100mm and thickness measured was equal to 0.74mm. The modulus came out equal to 14.11Mpa. The stress at break point and stress at yield point was calculated using the equation (1) and (2)

Table3. Tensile test result for Geotextile B

Load at maximum extension(N)	120.61
Maximum extension(mm)	170.48
Final area(mm^2)	21.17
Original area(mm^2)	74
Modulus(Mpa)	4.11
Stress at yield point(Mpa)	1.62
Stress at break point(Mpa)	5.69
Percentage elongation(%)	0.85

Table.4 Geotextile properties

PROPERTY	WOVEN GEOTEXTILE	NON-WOVEN GEOTEXTILE
Breaking strength	Higher	Lower
Breaking elongation	Lower	Higher
Initial modulus	Higher	Lower

Fig.20 Grab tension test

5.4 Specific gravity of Yamuna sand:

The specific gravity of sand was found with density bottle is equal to 2.6.

Fig.21 Density bottle

5.5 Particle size distribution of Yamuna sand:

The sieve analysis of Yamuna sand is done to determine the particle size distribution of Yamuna sand and classification on the basis of Indian standard codes. The value of coefficient of uniformity C_u and coefficient of curvature C_c is calculated. D_{10} = 0.15, D_{30} = 0.30, D_{60} = 0.38, C_u = 1.26 and C_c= 1.57

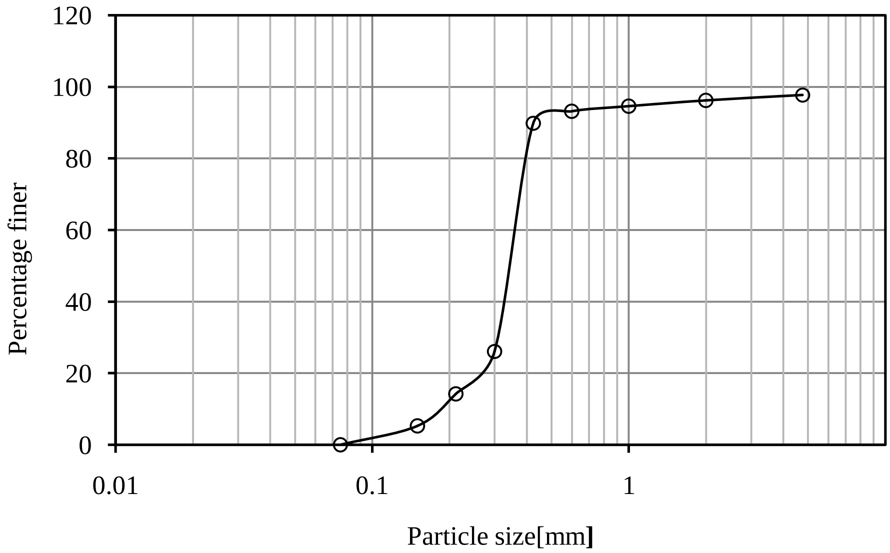

Fig.22 Particle size distribution of Yamuna sand

5.6 Compaction test:

Figure 4.6 shows the relation between water content and dry density the optimum moisture content of Yamuna sand is equal to 10% and maximum dry density has been found $(\rho_d)_{max}$ = 1.77 g/cc.

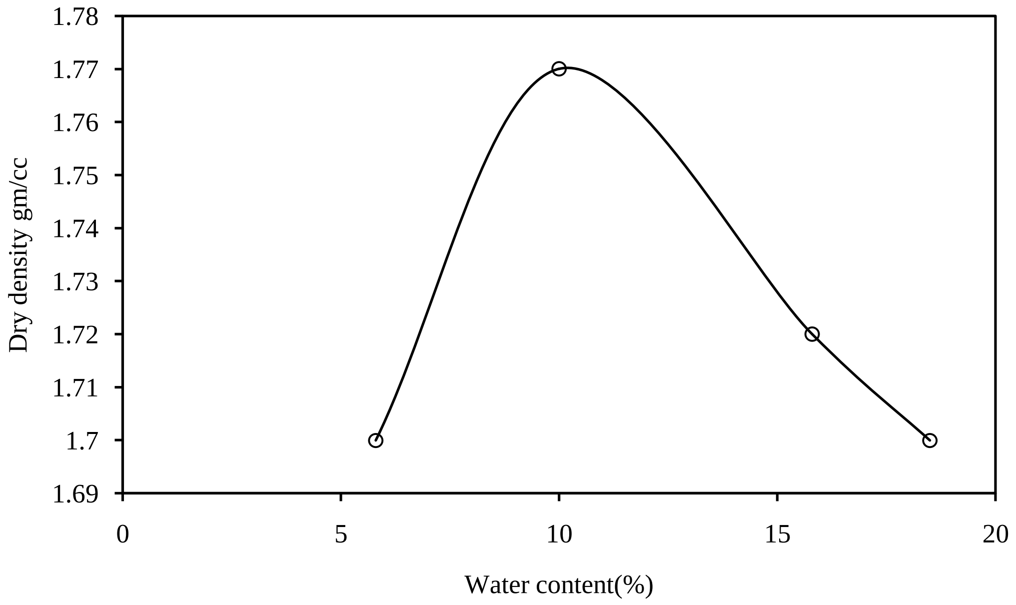

Fig.23 Compaction curve of Yamuna sand

5.7 Direct shear test:

The direct shear test is performed to determine the interface friction angle between Yamuna sand and woven type geotextile and Yamuna sand and non-woven type geotexile. From this angle the efficiency factor is calculated using the formula

$E = (\tan \varphi^a)/\tan\varphi$

Where φ is friction angle of Yamuna sand and φ^a is interface friction angle.

5.7.1 Direct shear test for Yamuna sand

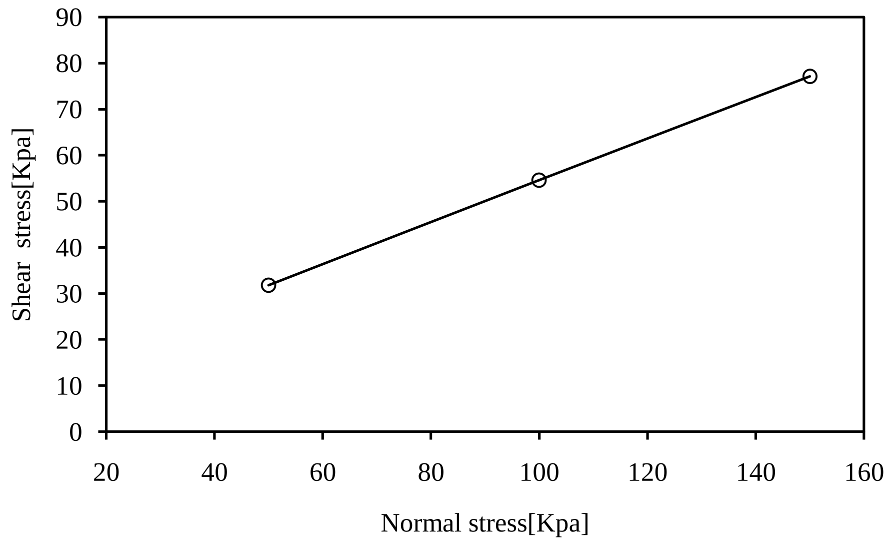

Fig.24 Direct shear test for Yamuna sand

Value of φ is equal to 24.3°

5.7.2 Direct shear test for Yamuna sand with non-woven geotextile placed at top and bottom

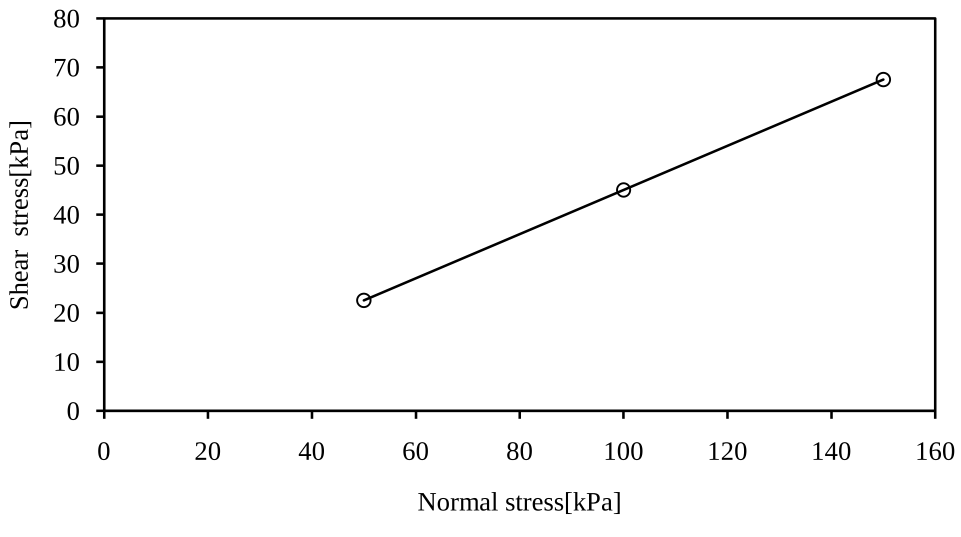

Fig.25 Direct shear test for Yamuna sand with non-woven geotextile

Value of $φ^a$ is equal to 23.4 and E from equation (4) is equal to 0.95

5.7.3 Direct shear test for Yamuna sand with woven geotextile placed at top and bottom

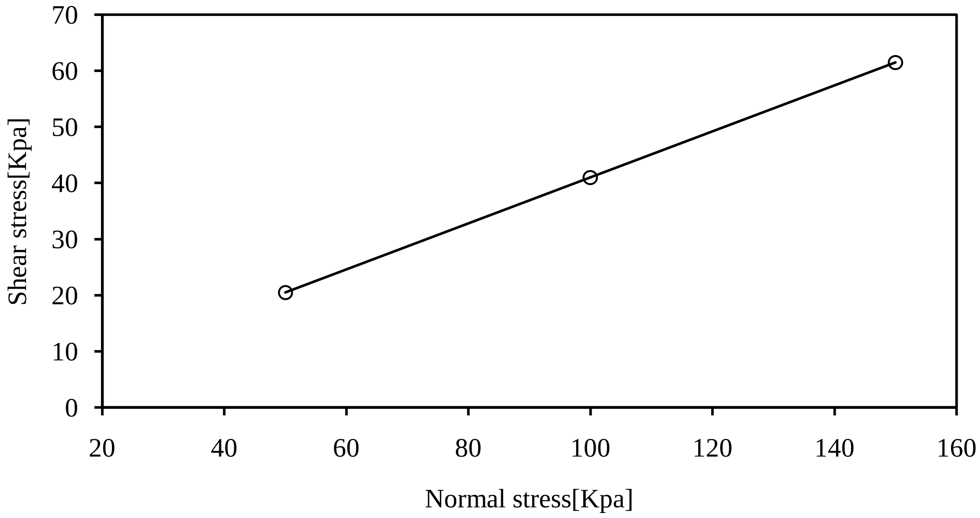

Fig.26 Direct shear test for Yamuna sand with woven geotextile

Value of φ^a is equal to 22.1 and E from equation (4) is equal to 0.91

5.8 Triaxial test:

The triaxial test is performed on Yamuna sand in UU condition with the conditions as follows:

a. Unreinforced Yamuna sand

b. Woven type geotextile in single, double and three layers respectively.

c. Non woven type geotextile in single, double and three layers respectively.

The size of mould used is length equal to 100 mm and diameter 50 mm. The cell pressures applied were 50 kPa, 100 kPa and 150 kPa respectively.

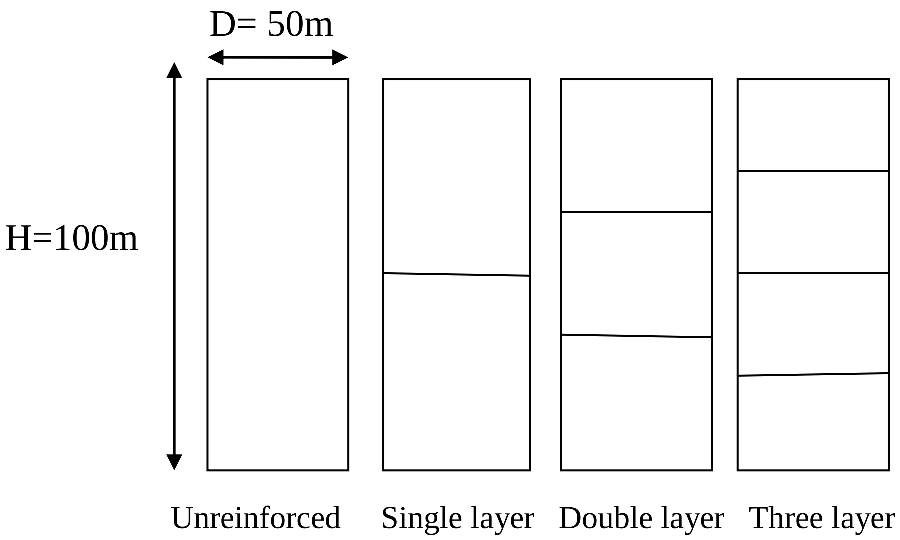

Fig.27 Geotextile arrangement for Triaxial test

5.8.1 Triaxial test on unreinforced Yamuna sand

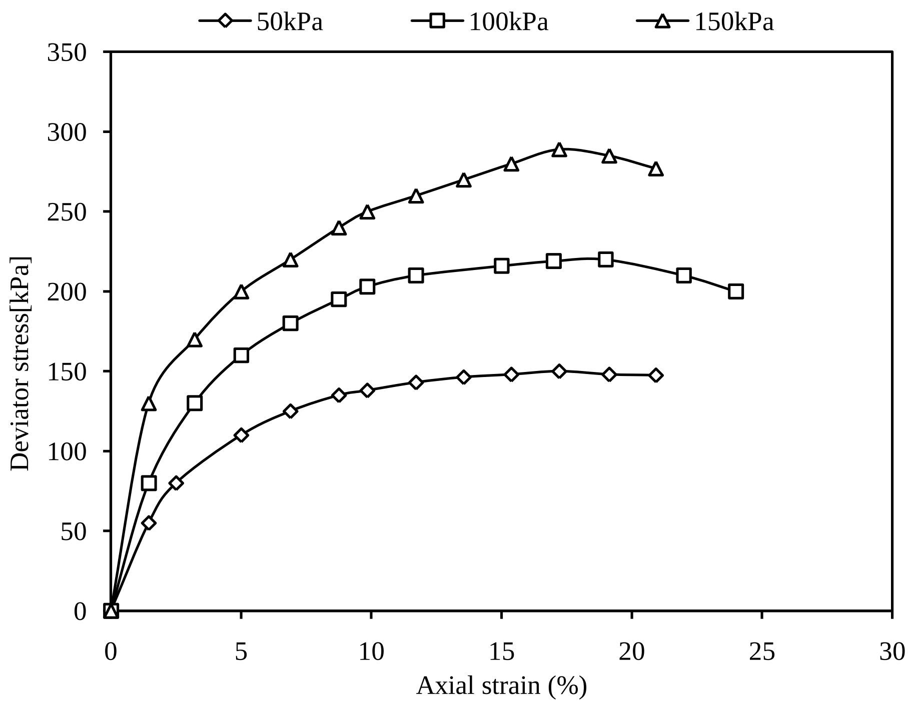

Fig.28 Stress strain for unreinforced Yamuna sand

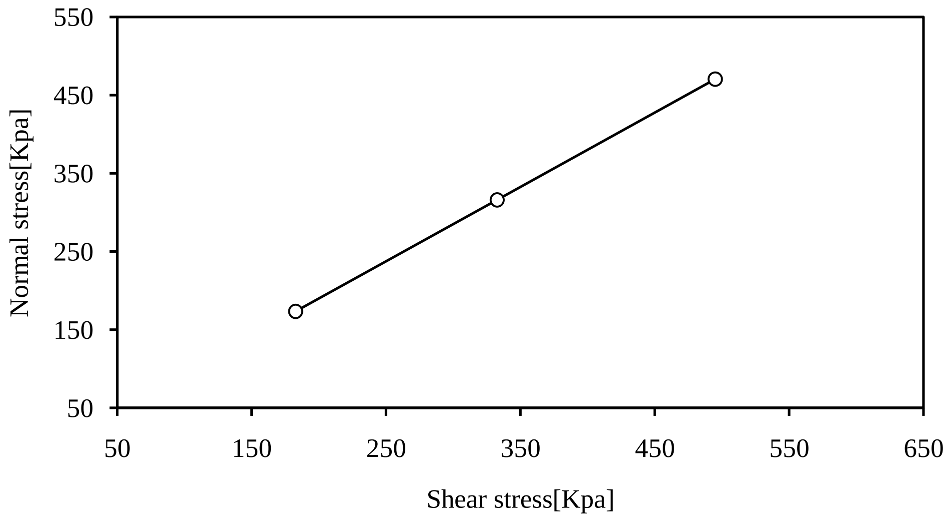

Fig.29 Normal stress-Shear stress for unreinforced Yamuna sand

From the graph value of tanψ= 0.41. From the equation tanψ = sinφ

Value of φ =24.31°.

5.8.2 Triaxial test on Yamuna sand reinforced with woven geotextile in single layer

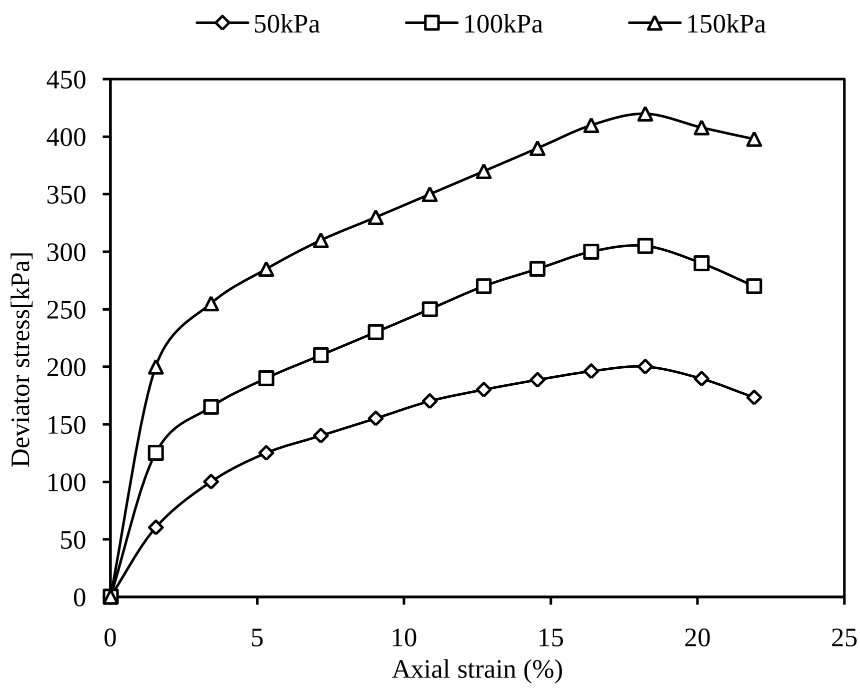

Fig.30 Stress strain for Yamuna sand reinforced with woven geotextile in single layer

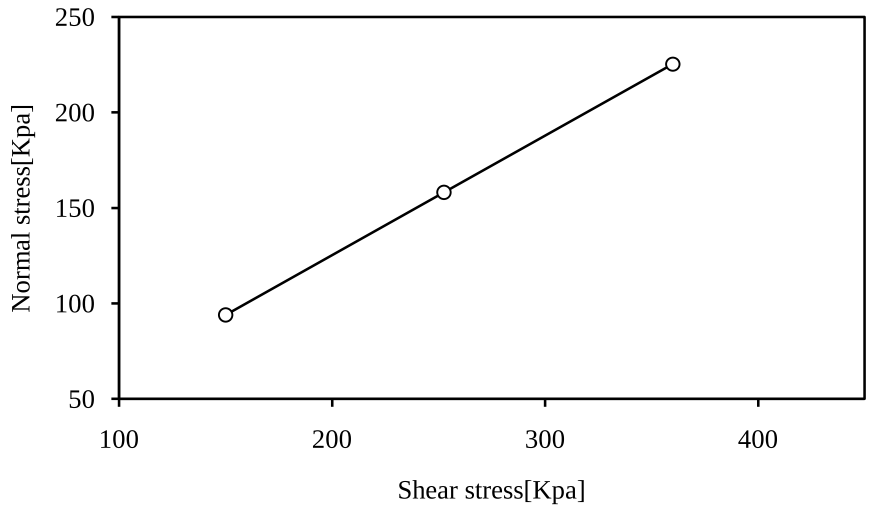

Fig.31 Normal stress-Shear stress forYamuna sand reinforced with woven geotextile in single layer

From the graph value of tanψ= 0.53. From the equation tanψ = sinφ

Value of φ =32.05^o.

5.8.3 Triaxial test on Yamuna sand reinforced with woven geotextile in double layer

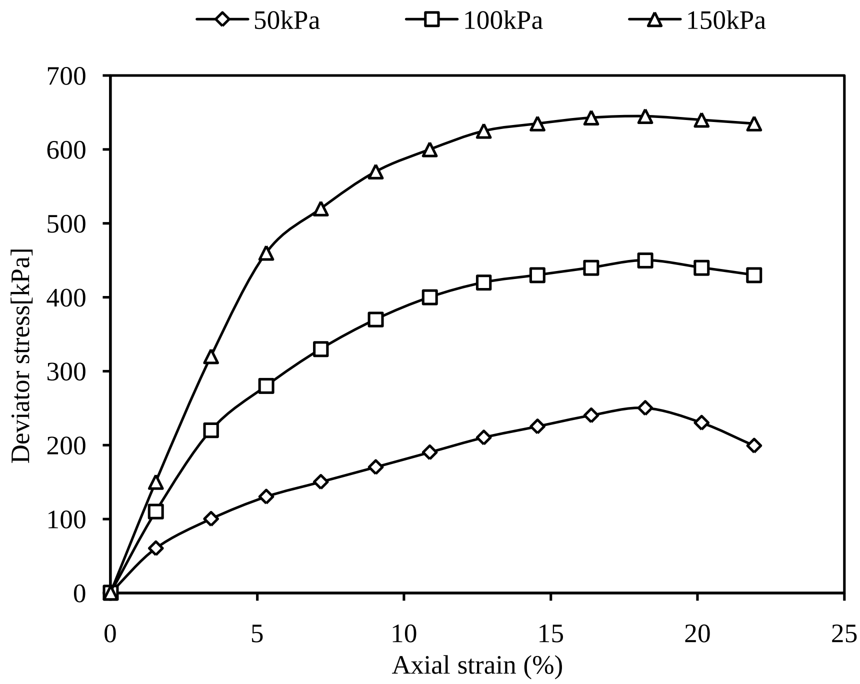

Fig.32 Stress strain for Yamuna sand reinforced with woven geotextile in double layer

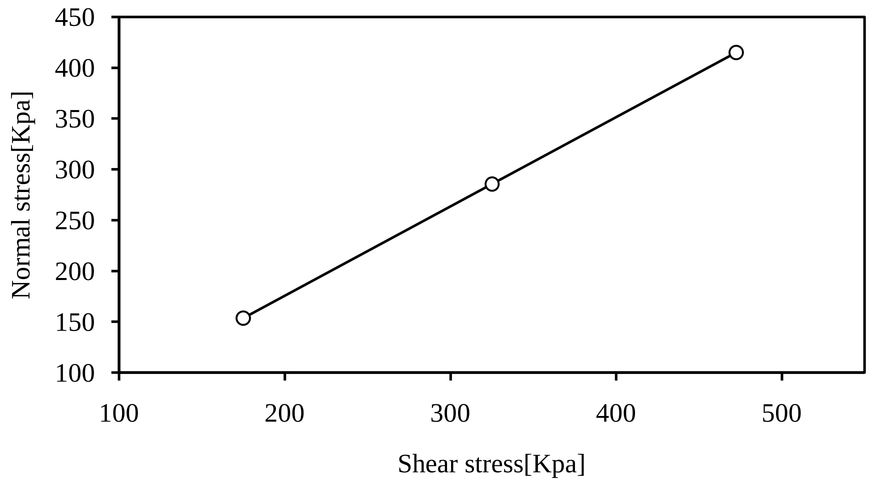

Fig.33 Normal stress-Shear stress forYamuna sand reinforced with woven geotextile in double layer

From the graph value of tanψ= 0.66. From the equation tanψ = sinφ

Value of φ =41.29°.

5.8.4 Triaxial test on Yamuna sand reinforced with woven geotextile in three layer

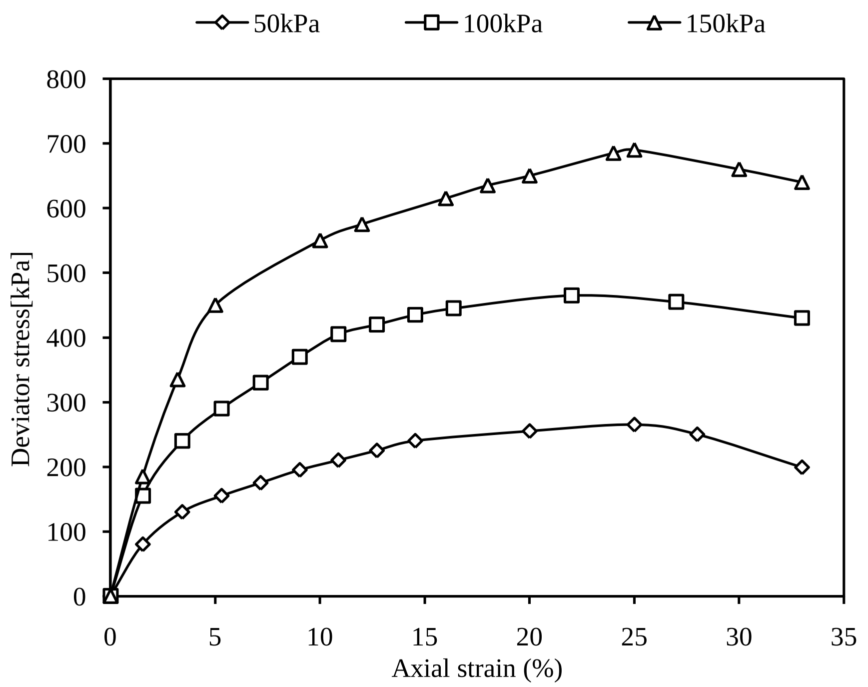

Fig. 34Stress strain for Yamuna sand reinforced with woven geotextile in three layer

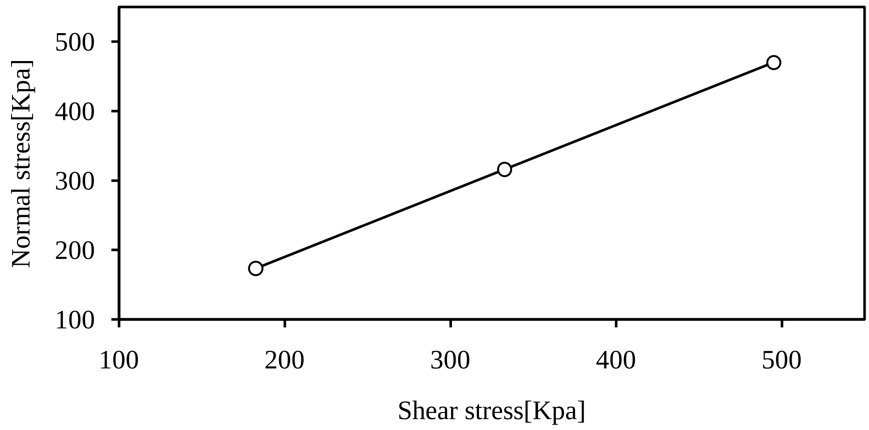

Fig.35 Normal stress-Shear stress forYamuna sand reinforced with woven geotextile in three layer

From the graph value of tanψ= 0.66. From the equation tanψ = sinφ

Value of φ =43.8^{o}.

5.8.5 Triaxial test on Yamuna sand reinforced with non-woven geotextile in single layer

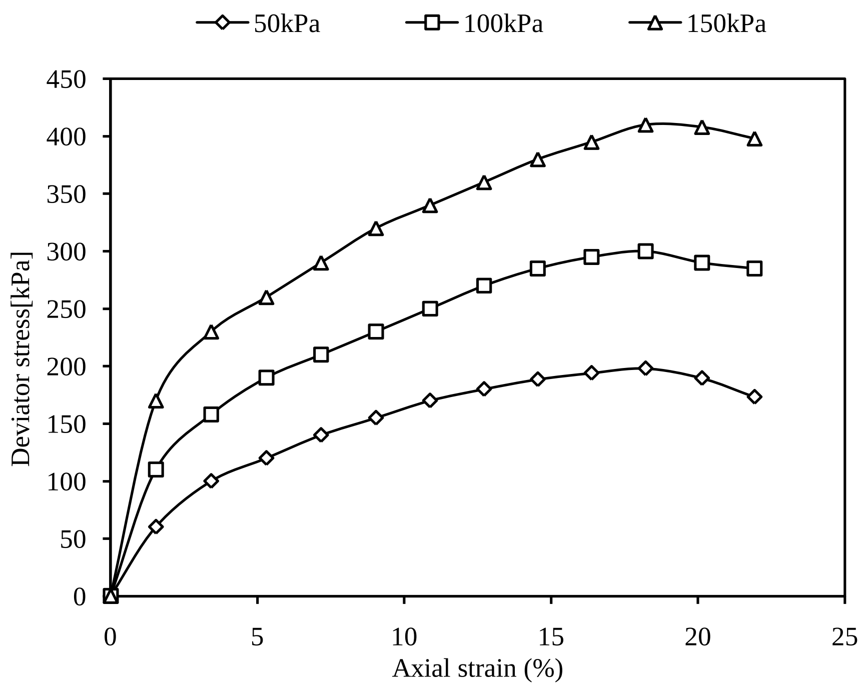

Fig.36 Stress strain for Yamuna sand reinforced with non-woven geotextile in single layer

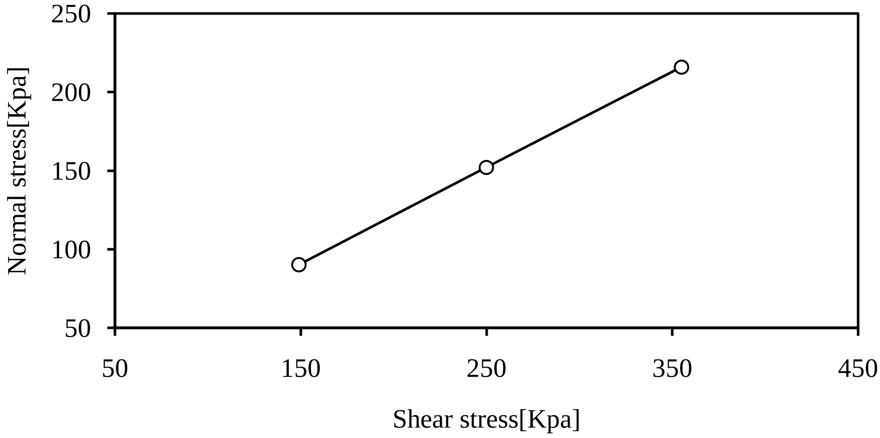

Fig.37 Normal stress-Shear stress forYamuna sand reinforced with non-woven geotextile in single layer

From the graph value of tanψ= 0.52. From the equation tanψ = sinφ

Value of φ =31.5°

5.8.6 Triaxial test on Yamuna sand reinforced with non-woven geotextile in double layer

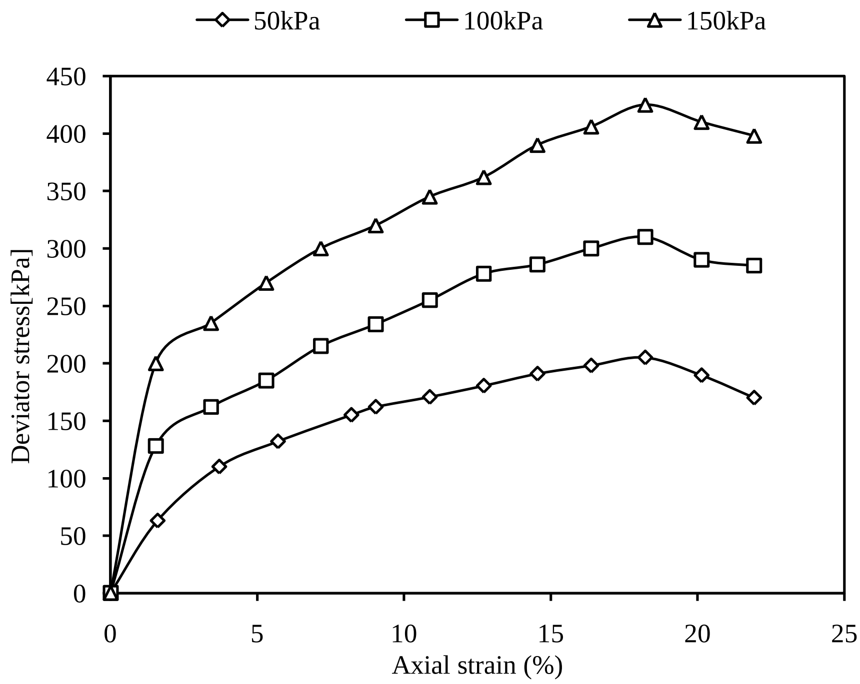

Fig.38 Stress strain for Yamuna sand reinforced with non-woven geotextile in double layer

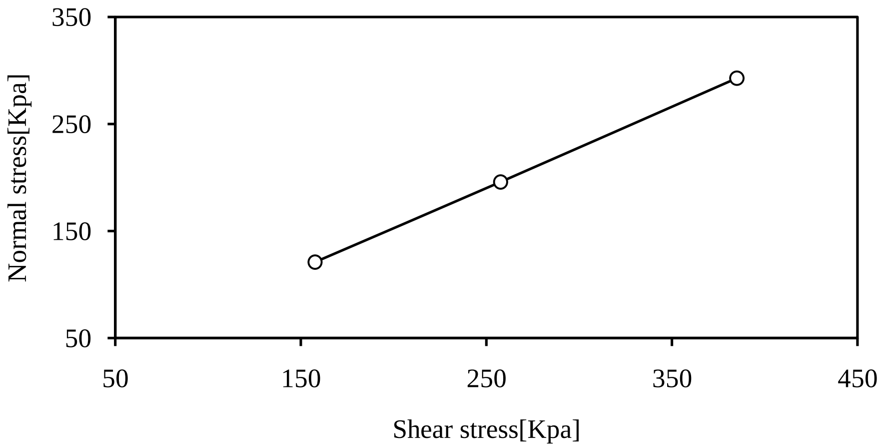

Fig.39 Normal stress-Shear stress forYamuna sand reinforced with non-woven geotextile in double layer

From the graph value of tanψ= 0.61. From the equation tanψ = sinφ

Value of φ =37.5^{o}

5.8.7 Triaxial test on Yamuna sand reinforced with non-woven geotextile in three layer

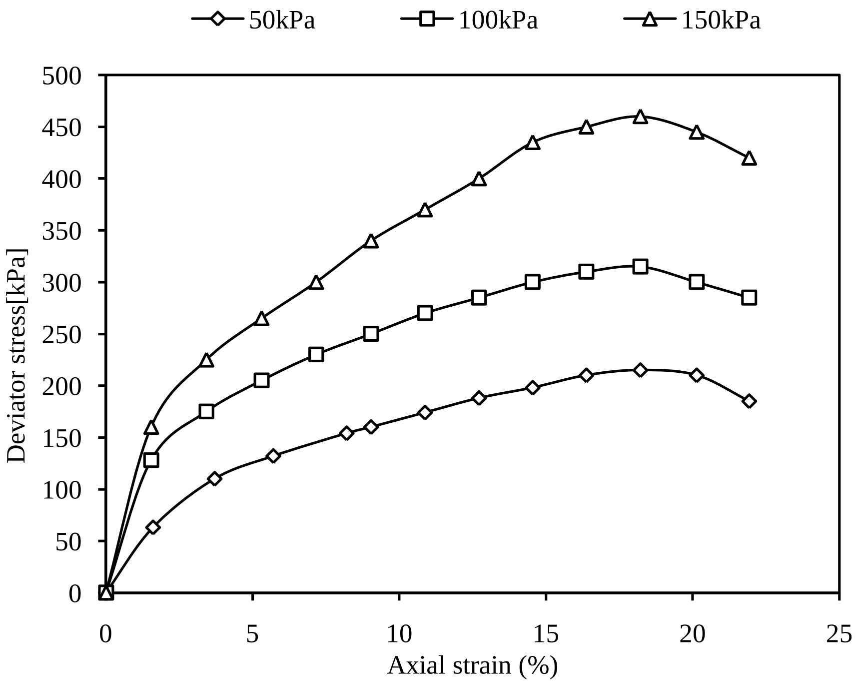

Fig.40 Stress strain for Yamuna sand reinforced with non-woven geotextile in three layer

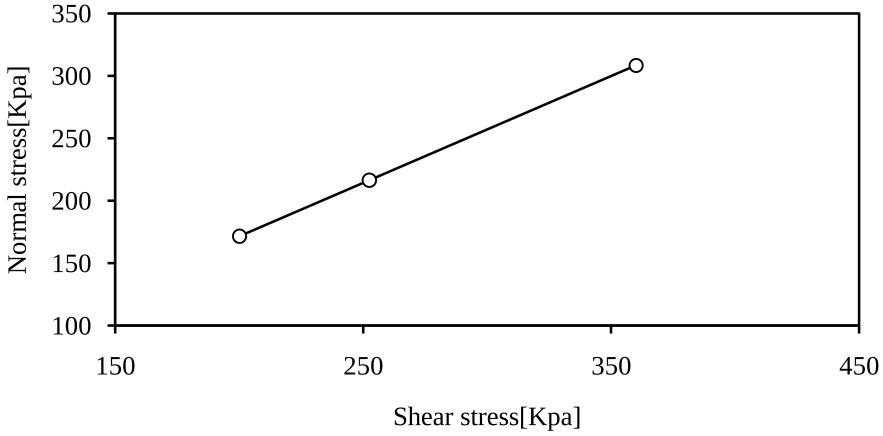

Fig.41 Normal stress-Shear stress forYamuna sand reinforced with non-woven geotextile in three layer

From the graph value of tanψ= 0.65. From the equation tanψ = sinφ

Value of φ =40.6^{o}

Fig.42 Sample before failure

Fig.43 Sample after failure

5.9 Strength ratio:

The strength ratio is defined as the peak deviatoric stress of reinforced specimen to the peak deviatoric stress of unreinforced specimen.

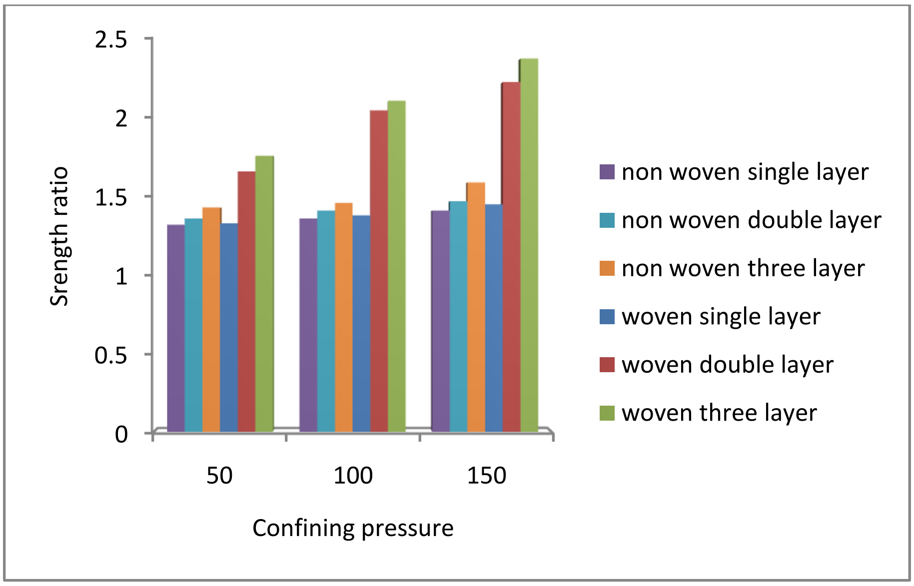

Fig.44 Strength ratio at different confining pressure

5.10 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.5 Strength difference with respect to unreinforced Yamuna sand

Confining pressure[kPa]	Strength difference					
	Woven geotextile			Non-woven geotextile		
	1 layer	2 layer	3 layer	1 layer	2 layer	3 layer
50	51.33	100.87	115.76	48.22	55.87	65.71
100	85.54	230.87	245.65	80.43	90.11	95.72
150	131.01	356.88	401.23	121.24	136.61	171.43

From the table above it can be concluded that the strength ratio increases as the confining pressure increases.With the increase in number of layers the strength increases significantly.

5.11 Interface friction angle:

Interface friction angle is compared for woven and non-woven geotextile. From the graph it can be concluded that non woven geotextile has higher interface angle thus the interlocking of sand particles was more efficient with non-woven geotextile in comparison to woven geotextile.

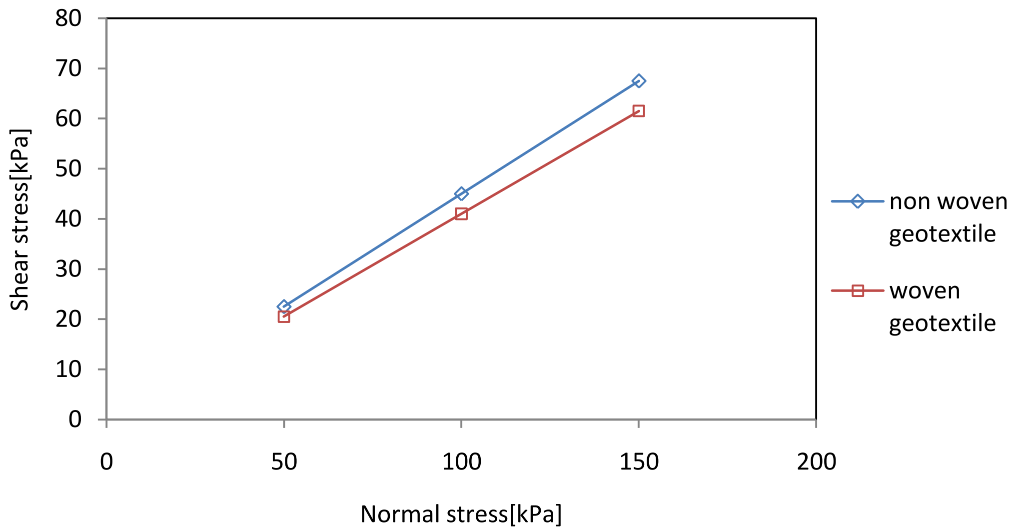

Fig.45 Comparison of interface friction angle

CHAPTER 7

CONCLUSION

As a result of present work it is obtained that the geotextile improves the strength of Yamuna sand through reinforcement. It is also seen that 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 geotextile in comparison to non-woven geotextile. So it can be concluded that depending on the application of geotextile the suitable geotextile can be used . If the geotextile is used as drainage filter, non-woven geotextile can be used as it will be more effective in controlling the sand flow as the aperture size is less and interlocking is very strong and when geotextile is used for the purpose of reinforcement then the woven geotextil e should be used as the shear strength is improved significantly.

REFERENCES

1]Al-Omari, R. R., Al-Dobaissi, H. H., Nazhat, Y. N. & Al-Wadood, B. A. (1989)" Shear strength of geomesh reinforced clay"Journal, Geotextiles and Geomembranes 8, 325–336.

[2] Athanasopoulos, G.A. (1993), "Effect of particle size on the mechanical behaviour of sand geotextile composites", Journal, Geotextiles and Geomembranes 12, 255-273

[3] Ashmawy, A.K., Bourrdeau, P.L., (1998)," Effect of geotextile reinforcement on the stress-strain and volumetric response of sand", Journal, Proceedings of the Sixth International Conference on Geosynthetics, Vol. 2, Atlanta, pp. 1079-1082.

[4] Broms, B.B. (1977), "Triaxial tests with fabric reinforced soil", Journal, Proceedings of the International Conference on the Use of Fabric in Geotechnics, Vol. 3, Ecole Nationale des Ponts et Chaussees, Paris, pp. 129-134

[5]Gray, D.H., Ohashi, H., (1983) , "Mechanics of fiber reinforcement in sand", Journal of Geotechnical Engineering 109 (3), 335–353

[6] Haeri, S.M., Noorzad, R., Oskoorouchi, A.M. (2000), "Effect of geotextile reinforcement on the mechanical behavior of sand", Geotextiles and Geomembranes 18, 385–402

[7] Krishnaswamy, N.R., Issac, N.T. (1995), "Liquefaction analysis of saturated reinforced granular soils", Journal of Geotechnical Engineering ASCE 121 (9), 645-651.

[8] McGown, A., Andrawes, K.Z., Al-Hasani, M.M., (1978), "Effect of inclusion properties on the behavior of sand", Journal, Geotechnique 28 (3), 327-347

[9] IS: 2720 (Part 3) (1980). Methods of Test for Soils: Determination of Specific Gravity, Bureau of Indian Standards, New Delhi, India.

[10] IS: 2720 (Part 4) (1985). Methods of Test for Soils: Determination of Grain Size Analysis, Bureau of Indian Standards, New Delhi, India.

[11] IS: 2720 (Part 7) (1980). Methods of Test for Soils: Determination of Water Content-Dry Density Relation Using Light Compaction, Bureau of Indian Standards, New Delhi, India.

[12] IS: 2720 (Part 13) (1986). Methods of Test for Soils: Determination of Friction angle and cohesion Using Direct shear test, Bureau of Indian Standards, New Delhi, India.