Soil Stabilisation by using Nonwoven Geotextiles

P. Sabir Ahamed, V. Akhila, P.N.S.Durga Prasad, N.Murli Mohan
Student, Student, Student, Adhoc Lecturer
Department of Civil Engineering
Jawaharlal Nehru Technological University Anantapur College of Engineering
(Autonomous) Pulivendula A.P. (INDIA)

ABSTRACT:

Soil Stabilisation is the process of improving the index and Engineering properties of soil to make the structure more stable and durable. Usage of geotextiles is one of the methods to stabilise the soil in order to improve the service life of the structures. Geotextiles are the geosynthetics which are manufactured from polymeric materials like polyester, polypropylene, etc., which are used along with soil to improve the stability. These are of two types woven and nonwoven. These are playing very important role in civil engineering works from the last three decades.

The aim of the project is to discuss the functions of nonwoven geotextiles and their effect on shear strength parameters (c&ϕ) of the soil. These are light in weight and mainly used for filtration to prevent piping, drainage to prevent flow of water into the subgrade and reduce hydrostatic pressure and separation to avoid the migration of two dissimilar materials in pavements. It's effect on shear parameters of soil are known by conducting direct shear test in which geotextiles of shear box sizes are placed on the top and bottom of the soil and the results are compared with shear parameters of normal soil

Keywords: Soil Stabilisation, Geosynthetics, Nonwoven Geotextiles, reinforcement, filtration, drainage, separation, shear strength.

INTRODUCTION:

Geo Synthetics: Geo Synthetics are the Natural or artificial products which are used along with soil , rock in geo technical constructions to solve geo technical problems. The Natural products are coir, jute, hemp etc. and Artificial products are manufactured products from polymers like polyesters , polypropylene etc and metallic products.These provides the innovate thoughts to solve geo technical problems. Geotextiles, Geogrids, Geomembranes and geonets are some of their types.

Geotextiles: Geotextiles a newly emerging field in civil engineering and other fields, offers greater potential in varied areas globally. Soil can be stabilized by introducing geotextiles which are made of synthetic materials such as polythene, polyester nylon etc., they are manufactured in different thickness up to 10mm, available in rolls of length up to 600m and width up to 10m. they are economical and more flexible. They are quite permeable and the permeability is comparable to that of fine sand to core sand, they are not affected even in hostile soil environment, increasingly used for soil environment, soil stabilization and other relative works.
These are very porous and allow the flow of liquid along their plane. Their main functions are Separation, Drainage, Filtration and for reinforcement of soil. Geo Textiles improves safety factor, performance, stability and durability of the structure. Geotextiles are generally identified by the type of the polymer, type of fibre or yarn, GSM, physical properties and their functions in construction.

Types of Geotextiles: Geotextiles types are determined by their function, manufacturing method and their texture. They are mainly three types Woven, Non-woven and knitted fabrics.

Woven Geotextiles: These are manufactured by weaving process by the use of monofilament, multifilament and fibrillated yarns. They possess high tensile strength and mainly used for reinforcement and separation purpose. They are most commonly used along with soil in pavements in application to increase stabilization and improves road ways long term use with lower maintenance cost.

Nonwoven Geotextiles: Nonwoven geotextiles are produced by needle punching (mechanical bonding), thermal bonding (by heat) and chemical bonding of different types of yarns of different polymers. These are light in weight and able to perform filtration and drainage functions for stabilization of soil. These are commonly used in ditches, drains and around the pipes, possess high permeability and transmittivity.

Knitted fabrics:- These are manufactured by the process adopted from textile industry. In this process inter locking of loops of yarns together is made, all these geotextiles are formed by knitting technique and performs the functions same as woven geotextiles.

LITERATURE REVIEW:

Alao, Olukayode Olawale carried out a brief study on usage of geosynthetics as soil stabilizers and highlighted the usage of Geo Textiles in pavements.

Danny Jose , Pedro Ariel , Gonzalo Martin carried out an experimental study by conducting Direct Shear Test to know the shear strength behaviour of soils reinforced with different geosynthetic materials. Out of them geotextiles gives the better performance as reinforcing materials as they posses high tensile strength. There will be increase in Shear Strength parameters like Cohesion and Friction Angle by the inclusion of geotextiles.

Akaolisa , Akinola , Jack studied the mechanism of Reinforced Earth by using geotextiles as reinforcing material and conclude that the reduction in earth pressure in retaining walls is due to friction developed in the layer of geotextile at the time of stress transfer between soil and geotextile.

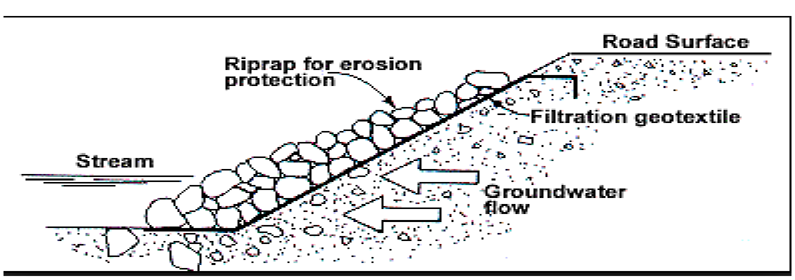
METHEDOLOGY:

Non-woven geotextiles are the oldest geotextile fabrics. These were first used in around 3500-3000BC, which were manufactured from hairs of different animals. They possess number of applications in modern Technology. They are mainly used in civil engineering works for Separation, Filtration and Drainage purposes.

Functions of Non-Woven Geotextiles:

Separators: In roads, as times passes, number of traffic loads increases. This causes the crushing of sub base aggregates and they migrate into the subgrades because there is lack of support given by the sub grade. To prevent the disintegration and migration of aggregates, a flexible porous geotextile material is provided between the two dissimilar materials so that the integrity and functioning of both materials remains undisturbed and service life of the road improved.

Filtration: Geotextiles as filter should retain the particles of base soil to be filtered. It avoids piping., i.e., loss of fine particles from sub grade. It has to allow the free movement of flow of water as it is more permeable.



Here geotextile acts as both filter and separator in canals

Drainage Layer: They provide the smooth disposal of water to prevent the Sub grade of pavements and backfill of retaining structures from adverse effects of hydrostatic pressure.

Materials used: Required Materials selected for the study are

Red Soil: Soil Sample is taken from two different places in JNTUA college of engineering and make it suitable for Testing.

Non-Woven Geo Textile-Needle Punched: Non-woven Geotextile bought from FIBERTEX company suppliers Bangalore.

Property	Specifications
Thickness(mm)	2
GSM(g/m^2)	120
Grab Tensile (KN)	0.41
Trapezoid Tear(KN)	0.197
CBR Puncture Resistence(KN)	1.37
Permitivity(sec^{-1})	2.1
Transmitivity(m^3/m-s)	2.1*10^{-6}
Pemeability(m/s)	3.5

Stone Dust: It is used as fine aggregate for preparation of mortor which is used for construction of sub base soil model

Cement: 43 Grade cement is used for preparation of mortor.

LABORATORY TESTS:

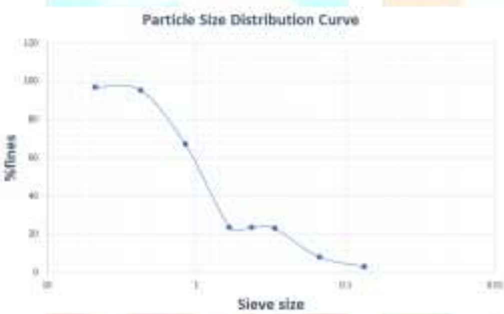
Following Laboratory tests are carried out on two different types of soils as per ASTM standards as follows:

i. Grain Size Analysis
ii. Atterberg Limits (Liquid and Plastic Limit).
iii. Specific Gravity of soil
iv. Standard Proctor Compaction Test
v. California Bearing Ratio Test
vi. Aperture Opening Size of geotextile(Hydrodynamic Test)
vii. Direct Shear Test.
viii. Direct Shear Test by placing geotextile on top and bottom of soil specimen.

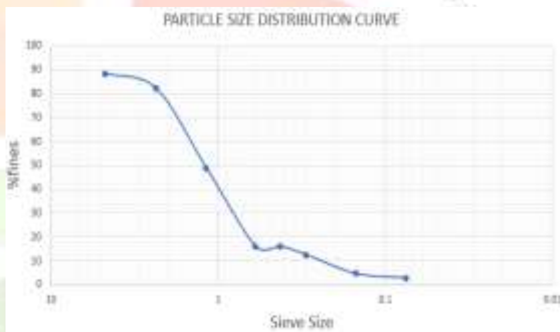
Pavement Model: To know the effectiveness of the geotextile and it's function in civil engineering construction, a model of pavement is constructed. Soil for subgrade and mortar of stone dust and cement with ratio 3:1 for subbase are used. Four wooden moulds of length 30cm, width 10cm, height 30cm with a opening at top of the mould are used. For each type of soil two moulds are prepared, one is with geotextile and other is without geotextile.

RESULTS AND DISCUSSIONS:

Grain Size Analysis: Particle size distribution Curve is plotted and following results are obtained.



Soil Sample 1



Soil Sample 2

Table: 1

Particulars	Soil Sample 1	Soil Sample 2
Coefficient of Uniformity	6.1764	10
Coefficient of Curvature	2.5148	2.844

As fines i.e., $R_{4.75mm}$/ $R_{75\mu}$ (fines)= 0<5% and $C_u > 6$, $C_c = 1\text{-}3$., As per IS 1498,The above two soil samples are classified as well graded soil (SW) with little clay and organic content.

Atterberg Limits: Soil Atterberg Limits are as follows: **Table 2**

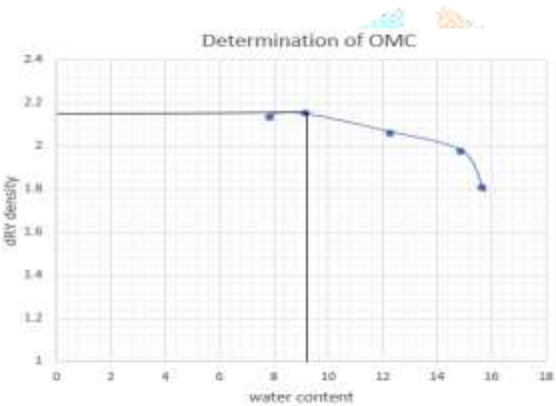
Particulars	Soil Sample 1	Soil Sample 2
LIQUID LIMIT(%)	28	33.7
PLASTIC LIMIT(%)	18.215	19.9218

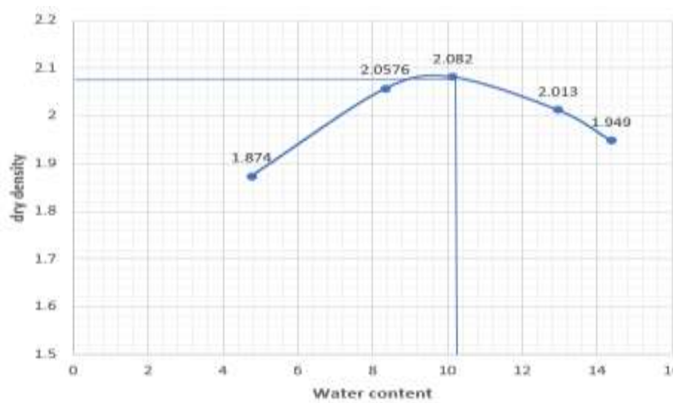
PLASTICITY INDEX	9.785	13.7782

Specific Gravity of Soil: Hence Specific gravity test for the two soil samples is conducted and following results are obtained.

Description	Soil Sample 1	Soil Sample 2
Specific Gravity	2.792.	2.566

Standard Proctor Compaction Test: Hence Standard Proctar Compaction Test is performed and following Results for soil samples 1 & 2.





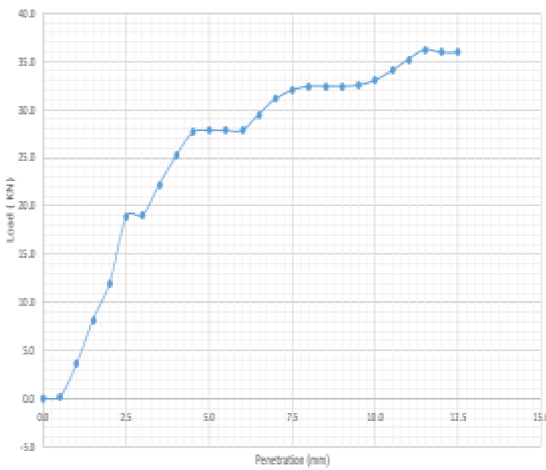
Description	Soil sample 1	Soil Sample 2
Optimum Moisture Content(%)	9.163	10.14
Maximum Dry Density(gm/cc)	2.153	2.082

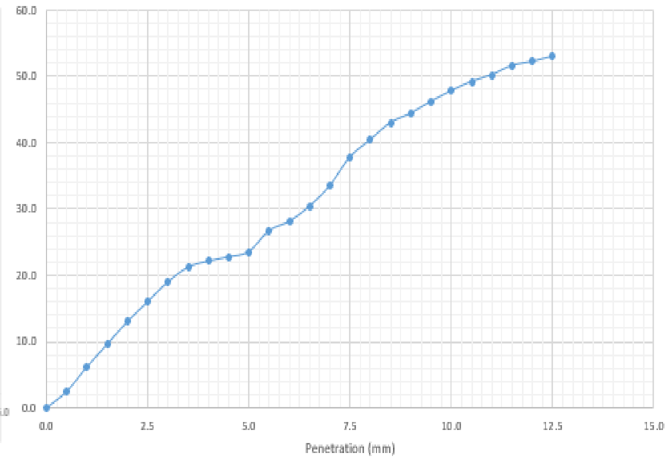
California Bearing Ratio Test:

CBR Test for two soil sample is conducted and following results are obtained

Description	Soil Sample 1	Soil Sample 2
CBR value	6.27	5.42

Graph: Relationship between penetration(mm) and Load(KN)



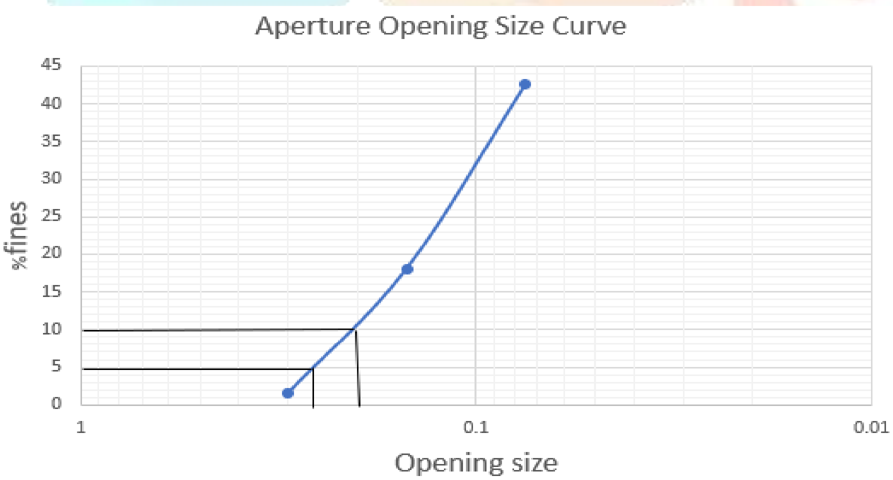


Soil Sample 1 **Soil Sample 2**

Hence the two soil samples have low CBR values , hence to protect the subgrades strength, Geo Textiles are necessary because for effective drainage and strength purposes.

Aperture Opening size of geotextile (Hydrodynamic Test):

Hydrodynamic Test on geotextile layer is conducted and graph between opening sizes and percentage retain of sand is drawn to get aperture opening size



$O_{10} = 200\mu$

$O_5 = 270\mu$

Hence Aperture Opening Size of the GeoTextile is $O_5 = 270\mu$

Pavement Model:

Separation:

Soil Sample 1

Soil Sample 2

Here particles of subbase migrated into the subgrade, which reduce the service life of pavement and cause deformations and undulations in pavement. As subgrades of both soil samples have low CBR values, Separation of the two dissimilar materials is very important to protect the subgrade from deformations. Hence by introducing geotextile as a separator, it separates the two different materials and improve the stability and service life of the pavement.

Drainage:

To know the effectives of geotextile, Water contents of soil samples collected from the subgrades of four moulds are determined and following results are obtained as follows:

TABLE:3

Description	Soil Sample 1		Soil Sample 2	
	With Geotextile	Without Geotextile	With Geotextile	Without Geotextile

Weight of wet soil (w_1) (gms)	66	50	33	58
Weight of dry soil (w_2) (gms)	57	42	28	47
Weight of water (w_1-w_2) (gms)	9	8	5	11
Water content ((w_1-w_2) /(w_2))*100 (%)	15.789	19.047	17.85	23.40

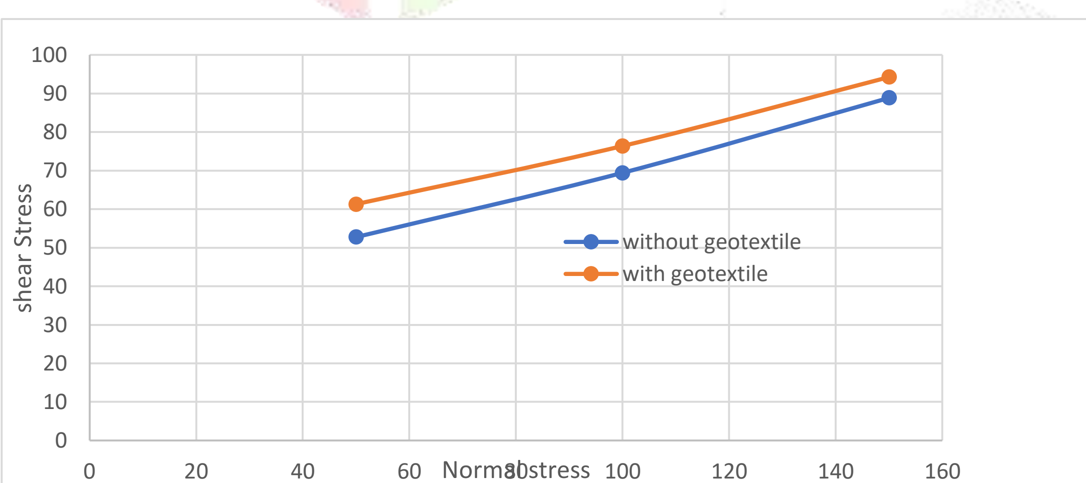
From the table it is clear that the samples which have geotextiles layers have less water content as compared to the samples having without geotextiles because due to their Transmitivity property. Geotextile absorb some portion of water before the water enters into subgrade and improve the subgrade strength.

Direct Shear Test: Soil Sample 1

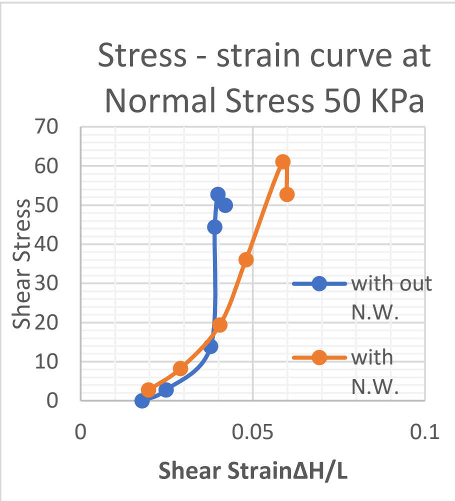
Table:3 shows the values of shear stresses at failure for soil sample without and with having geotextiles, here graph is drawn between normal stress and shear stress to get shear parameters.

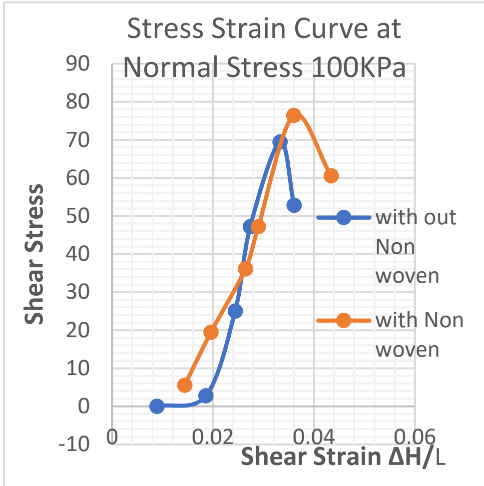
Test No	Shear Deformation	Normal Stress	Shear Stress(τ)
1	2.67	50	52.77
2	2.24	100	69.44
3	2.57	150	88.88

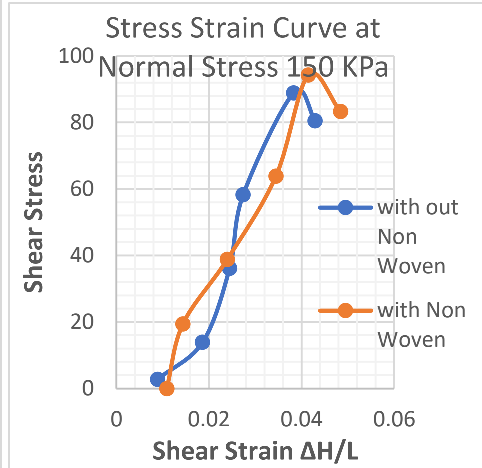
Test No	Shear Deformation	Normal Stress	Shear Stress(τ)
1	3.98	50	61.3
2	2.45	100	76.4
3	2.81	150	94.3



fro o







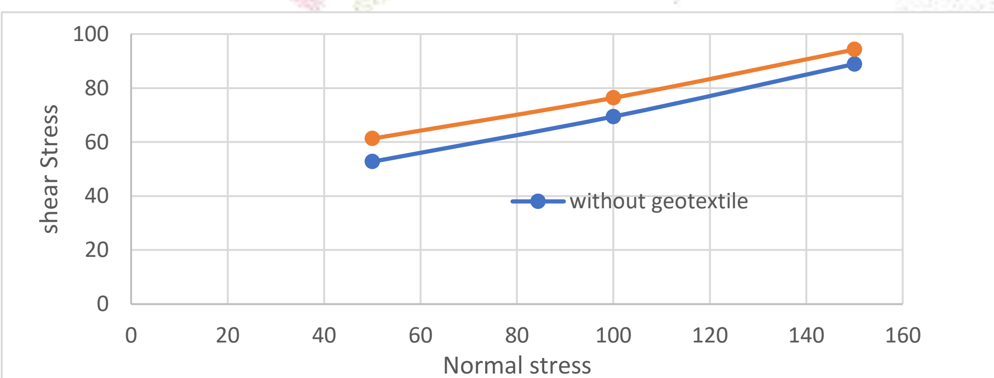
Stress - Strain Curve behaviour of the soil sample with and without using Non woven Geotextile at different Normal Stresses

Soil Sample 2:

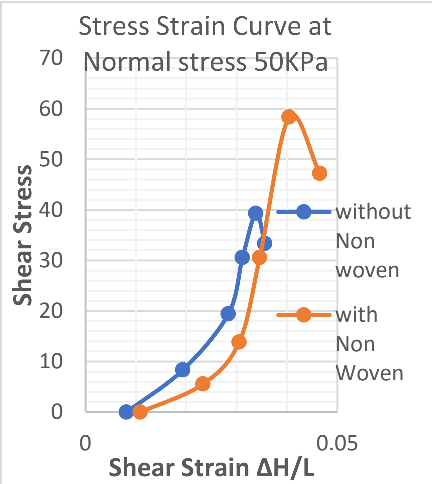
Table:4 shows the values of shear stresses at failure for soil without and with using geotextile, here graph is drawn between normal stress and shear stress.

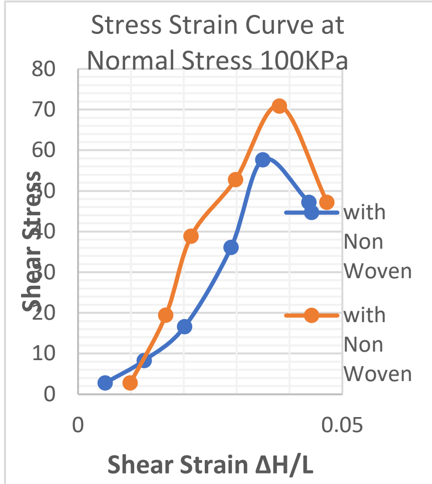
Test No	Shear Deformation	Normal Stress	Shear Stress(τ)
1	2.29	50	39.332
2	2.37	100	57.7
3	2.84	150	67.25

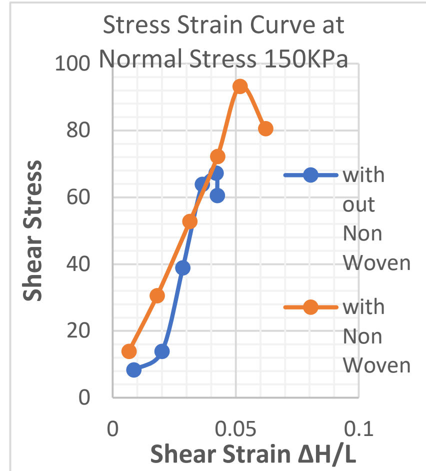
Test No	Shear Deformation	Normal Stress	Shear Stress(τ)
1	2.58	50	58.33
2	2.74	100	71.9
3	3.51	150	93.21



from graph, without geotextile c= 28KPa, ϕ= 37^{o} and with geotextile c= 38KPa, ϕ= 40^{o}







Stress - Strain Curve behaviour of the soil sample with and without using Non woven Geotextile at different Normal Stresses:

Table 5: Effects in shear parameters with the introduction of geotextiles:

Particulars	Soil Sample 1		Soil Sample	
	Without geotextile	With geotextile	Without geotextile	With geotextile
Cohesion(c)KPa	33	42	28	38
Friction angle(ϕ)	39º	43º	37º	40º
Shear Strength(τ) KPa	113.978	135.251	106.128	121.90
Percentage increase in Shear Strength(%)	13.66		11.86	

Effect of Non-Woven Geotextiles on shear strength parameters of soil:

From Table 5, it is clear that the shear parameters of soil are greatly affected by the introduction of non-woven geotextiles. Soil is weak in tension and good in compression. Here geotextile has good tensile strength as compared with soil. When shear stresses developed in soil, the stress is transferred from soil to the geotextile layer. Later it deforms and develops internal frictional résistance and control the deformations and tension developed in the soil. In this way the shear parameters like frictional angle and cohesion of the soil increases. Non-woven geotextiles have good friction though it has less tensile strength as compared with woven geotextiles. It also acts as a good binding material with soil particles which in turn increase the friction angle and load bearing capacity of the soil.

Stress Strain curves of two soil samples at different normal stresses shows that as strain increases, there will be apparent increase in shear stress of soil which increases to peak value and then it slowly decreases and attains as ultimate shear stress. Peak stress achieved in case of reinforced soils is greater as compared with unreinforced ones which conclude that as providing geotextile as reinforcement there will be increase in shear strength of the soil.

Non-woven geotextile has less tensile strength as compared with woven geotextiles but offers apparent cohesion and friction angle in case of well graded soils. They absorb the pore water in soil and make the soil sample to achieve greater strength.

CONCLUSIONS:

- **i.** Laboratory tests on two soil samples with and without using geotextiles are conducted and results are plotted. From the results it is clear that by the usage of non-woven geotextiles, the properties of the soil increases.
- **ii.** Effectiveness of the geotextile is known from pavement model. Non-woven geotextiles works effectively as the drainage and separation layers.
- **iii.** They acts as excellent filters in order to prevent piping.
- **iv.** Non-woven geotextiles have good friction though it has less tensile strength. They develops internal frictional résistance and control the deformations and tension developed in the soil, It also acts as a good binding material with soil particles In this way the shear parameters like frictional angle and cohesion of the soil increases.
- **v.** From stress strain curves behaviour , the curve gradually goes on increasing in case of reinforced soil rather than unreinforced soil which indicate the increase in shear strength of soil.
- **vi.** Hence detailed study was done on various functions of nonwoven geotextiles in Civil engineering.

REFERENCES:

- Palmeira EM (2008) Soil-geosynthetic interaction: modelling and analysis.
- “Field Performance of Retaining Walls reinforced with Woven and Non-woven Geotextiles” by F.H.M.Portelinha, J.G.Zoonberg.
- “ Non-woven Technology” by Millin Patel & Dhruvkumar Brambhat.
- “ Shear strength behaviour of different geosynthetic reinforced soil structures from Direct Shear Test” by Danny Jose Useche Infante
- “Geosynthetics for soil Reinforcement” by R.D.HOLTZ.
- “Use of Geosynthetics in Road Construction” by ALAO , OLUKAYADE.
- “Geosynthetics and Reinforced Soil Structures” NPTEL by Prof. K.Raja Gopal.
- “Soil Mechanics and Foundation Engineering” by Dr.K.R.Arora.