Study on Strength Behaviour of Soil Using Geotextile

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Abstract— *Geosynthetics have become well established construction materials for geotechnical and environmental application in most parts of the world. Because they constitute manufactured materials, new products and applications are developed on a routine basis to provide solution to routine and critical problems alike. This paper focuses on recent advances on geosynthetics products such as geotextiles, applications and design methodologies for reinforced soil and environmental protection works. Geotextiles have been successfully used for reinforcement of soils to improve the bearing capacity. Laboratory California bearing ratio (CBR) tests were performed to investigate the load-penetration behavior of reinforced granular soils with geotextile. Samples of granular soil with different grading are selected and tested without reinforcement. Then by placing geotextile at certain depth within sample height in one and two layers, the effects of the number of geotextile on the increase in bearing capacity of reinforced granular soils and grading on performance of geotextile is discussed. The result of these tests shows that, bearing ratio of reinforced granular soils with geotextile increases. And also done the direct shear test for determine the consolidated-drained shear strength of a sandy to silty soil.*

Keywords— Geosnthetics, Geotextiles, CBR, Granular soils, Direct shear test

I. INTRODUCTION

The uses of geotextile in many engineering applications have become more apparent and have proven to be an effective means of soil improvement. In early applications in roads and airfield construction, emphasis was laid on the separation function of the geotextile. Resl and Werner (1986) carried out the laboratory tests under an axisymmetric loading condition using nonwoven, needle-punched geotextiles. The results showed that the geotextile layer placed between subbase and subgrade can significantly increase the bearing capacity of soft sub grades. Raw materials such as polyester. Polyvinyl alcohol, polypropylene, aramide, polyethylene and polyamide are processed on our modern, efficient production line.

Geosynthetics is applicable in various purpose of constructions such as reinforced retaining walls, coastal protection, river training, highways , airports, urban roads, ground improvements etc.. In this study, the CBR test carried out on nonwoven needle-punched geotextile combines with the granular soils with different grading, the geotextile reinforcement placed between three different subgrade layers and the comparison between bearing capacity of soil with and without geotextile reinforcement under axisymmetric loading condition was investigated.

II. MATERIALS

2.1 Soil

Soil systems have developed over many millions of years and they can be influenced by numerous factors. Some of these factors involve natural influences and others are related to man-induced influences. The primary point is that the soil characteristics in a given geographical area at a given point in time are a function of both natural influences and human activities. The geological features in an area are also a function of natural forces and processes, which have existed or occurred over millions of years. The soil and geological environments are typically associated with the physical and chemical environment. However, they also exhibit fundamental relationships to other environmental components. Different types of soil are used such as gravel soil, black cotton soil, clay soil, red soil.

2.2 Geotextile

Almost all geotextiles available in the United States are manufactured from either polyester or polypropylene. Polypropylene is lighter than water (specific gravity of 0.9), strong and very durable. Polypropylene filaments and staple fibers are used in manufacturing woven yarns and nonwoven geotextiles. High tenacity polyester fibers and yarns are also used in the manufacturing of geotextiles. Polyester is heavier than water, has excellent strength and creep properties, and is compatible with most common soil environments.

FIG.1 GEOTEXTILE

III. PROJECT PROCEDURES

3.1 Proctors Compaction Test

Proctors compaction test is used to find the optimum moisture content of the soil sample in California Bearing Ratio Test.

3.1.1 Test Procedure

- Weigh the standard proctor mould with and without collar. (W_1)
- Take about 2.5kg of soil passing through I.S sieve no 20mm and 4.75mm.
- Take known quantity of water (2% by weight of dry soil) and mix well with soil.
- Attach the collar with proctor mould and filled the mixed soil in the mould in three layer.
- Compact each layer by the rammer if to drop 25 times from the weight of 310mm.
- The total weight of compacted soil should be slightly more than the weight the mould.
- Remove the collar and cut the projected soil to have a leveled with the top of the mould.
- Weight the mould with soil(W_2g)
- Remove the soil from the cylinder and breakup the soil by hand. Now increase the moisture content by 2% and mix thoroughly. Repeat the experiment.
- In the repeating process each times raise the moisture content by 2% until soil becomes very wet and strictly showing considerable of all in the weight of the mould with compacted soil.
- Draw the graph between the dry density and moisture content.
- Find the maximum dry density and optimum moisture content from the graph.

$$\text{Dry density, } \Upsilon_d = \sqrt{\frac{\Upsilon_f}{1+w}}$$

3.2 California Bearing Ratio Test

3.2.1 Object and Scope

The object of the experiment is to determine the California Bearing Ratio (C.B.R) of a soil compacted soil sample in the laboratory, both in soaked as well as unsoaked state. The method also covers the determination of CBR of undisturbed soil sample obtained from the field.

3.2.2 Material and Equipment

- Cylindrical mould(C.B.R mould) with inside diameter 150mm and height 175mm, provided with a detachable extension collar 50mm height and a detachable perforated base plate 10mm thick,
- Spacer disc, 148mm in diameter and 47.7mm in height, along with a handle for screwing into the disc to facilitate its removal
- Steel cutting collar which can fit flush with mould both outside and inside,
- Metal rammers; a) weight 2.6kg with a drop of 310mm (or) b) weight 4.89kg with a drop of450mm,
- Annular slotted weight weighing 2.5kg each 147mm in diameter with a centre hole 53mm in diameter.
- Penetration piston, 50mm diameter and minimum of 100mm long,

- Extension measuring apparatus consisting of: a) perforated plate 148mm diameter, with a threaded stem in the centre, b) adjustable contact head to be screwed over the stem. c) metal tripod.
- Loading device, with a capacity of at least 5000kg and equipped with a movable head or base that travels at a uniform rate of 1.25mm/min; complete with load indicating device,
- Two dial gauges reading to 0.01mm,
- Sieve: 4.75mm and 20mm IS sieves,
- Miscellaneous apparatus, such as a mixing bowl, straight edges, scales, soaking tank or pan, drying oven, water content determination tins, filter paper etc.

3.2.3 Test procedure

- Take about 6 to 7kg of soil passing through IS sieve 4.75mm.
- Take optimum moisture content 8% (To determine by the proctors compaction test) and mix it thoroughly the soil.
- Weight the empty CBR mould.
- Fix the extension collar to the top of the mould and the base plate to its bottom.
- Insert the spacer disc over the base of the mould.
- Put a disc of a coarse filter paper on the top of the displacer disc.
- Compact the mixed soil in the mould using either the light compaction (or) heavy compaction.
- Compact the soil in three layers, each layer being given 56 blows.
- Remove the collar and level of the top of the surface.
- Turn the mould upside down and remove the base plate and displacer disc.
- Weight the mould with the compacted soil.
- Put filter paper on the top of the compacted soil and clamp the perforated base plate on it.
- Immerse the mould assembly and weights etc. in a tank of water allowing free access of water to the top and bottom of the specimen.
- Keep the setup undisturbed for 96 hours (4 days). Maintain constant water level in tank.
- Mount the tripod of the expansion measuring device on edge of the mould and note down the initial reading of the dial gauge.
- Take the final reading at the end of period, remove the tripod and take out the mould.

$$\text{CBR Value} = \frac{Test\ Load}{Standard\ Load} \times 100$$

FIG.2. MOULD IS PLACED ON WATER

FIG.3 APPLIYING LOAD

3.3 Direct Shear Test

3.3.1 Purpose

This test is performed to determine the consolidated-drained shear strength of a sandy to silty soil. The shear strength is one of the most important engineering properties of a soil, because it is required whenever a structure is dependent on the soil's shearing resistance. The shear strength is needed for engineering situations such as determining the stability of slopes or cuts, finding the bearing capacity for foundations, and calculating the pressure exerted by a soil on a retaining wall.

3.3.2 Significance

The direct shear test is one of the oldest strength tests for soils. In this laboratory, a direct shear device will be used to determine the shear strength of a cohesionless soil (i.e. angle of internal friction (£). From the plot of the shear stress versus the horizontal displacement, the maximum shear stress is obtained for a specific vertical confining stress. After the experiment is run several times for various vertical-confining stresses, a plot of the maximum shear stress versus the vertical (normal) confining stresses for each of the tests is produced.

3.3.3 Test procedure

- Weigh the initial mass of soil in the pan.
- Measure the diameter and height of the shear box. Compute 15% of the diameter in millimeters.
- Carefully assemble the shear box and place it in the direct shear device. Then place porous stone and a filter paper in the shear box.
- Place the sand into the shear box and level off the top. Place a filter paper, a porous stone, and a top plate (with ball) on top of the sand.
- Remove the large alignment screws from the shear box! Open the gap between the shear box halves to approximately 0.0025 in. using the gap screws, and then back out the gap screws.
- Weigh the pan of soil again and compute the mass of soil used.
- Complete the assembly of the direct shear device and initialize the three gauges (Horizontal displacement gage, vertical displacement gage and shear load gage) to zero.
- Set the vertical load (or pressure) to a predetermined value, and then close bleeder valve and apply the load to the soil specimen by raising the toggle switch.
- Start the motor with selected speed so that the rate of shearing is at a selected constant rate, and take the horizontal displacement gauge, vertical displacement gage and shear load gage readings. Record the readings on the data sheet. (Note: Record the vertical displacement gage readings, if needed.)
- Continue taking readings until the horizontal shear load peaks and then falls, or the horizontal displacement reaches 15% of the diameter.

$$\text{Shear Stress} = \frac{Load}{Area}$$

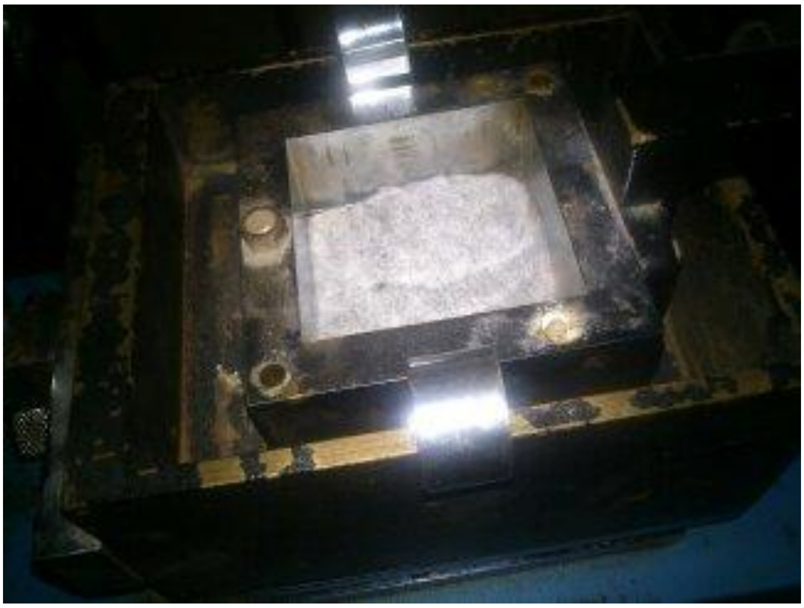


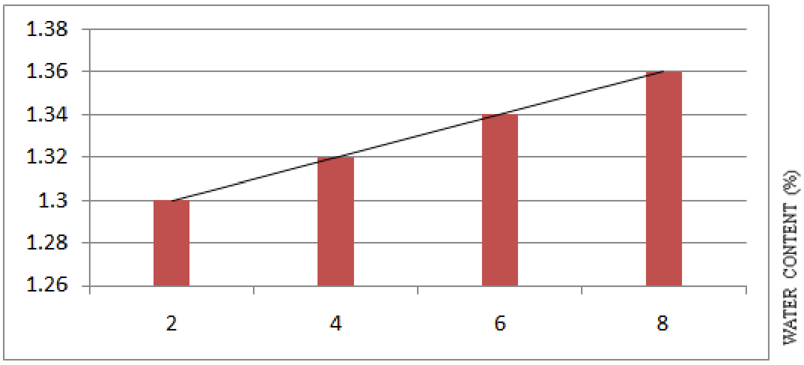
FIG.4: GEOTEXTILE PLACED IN SHEAR BOX

IV. RESULTS AND GRAPHS

4.1 Proctors Compaction Test

TABLE 1
PROCTORS COMPACTION TEST

SL.NO	DESCRIPTION	1	2	3	4
1	Mass of compacted wet soil + mould(g)	6218	6423	6384	6541
2	Mass of wet soil (w_L)	1.7kg	1.8kg	1.9kg	2.0kg
3	Bulk density $\Upsilon_f = \frac{W_{L}\times 1000}{V}$	1.73	1.83	1.93	2.03
4	Water content (%)	2%	4%	6%	8%
5	Dry density(Υ_d)(g/cc)	1.3	1.32	1.34	1.36



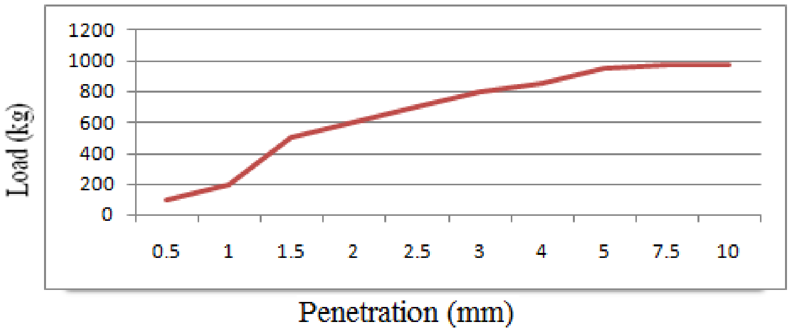
GRAPH 1: PROCTORS COMPACTION TEST

From graph, Optimum moisture content = 8%.

4.2 California Bearing Ratio Test

4.2.1 Using Gravel Soil

Readings	Penetration (MM)	Corrected Load(kg)
9.39	0	0
9.89	0.5	1363.59
10.39	1	1020.24
10.89	1.5	480.69
11.39	2	13.83.21
11.89	2.5	274.68
12.39	3	578.79
13.39	4	824.04
14.39	5	1128.15
16.89	7.5	441.45



GRAPH 2: CALIFORNIA BEARING RATIO TEST USING GRAVEL SOIL

From graph:

For 2.5mm, CBR Value = 49.63%

For 5mm, CBR Value = 41.85%

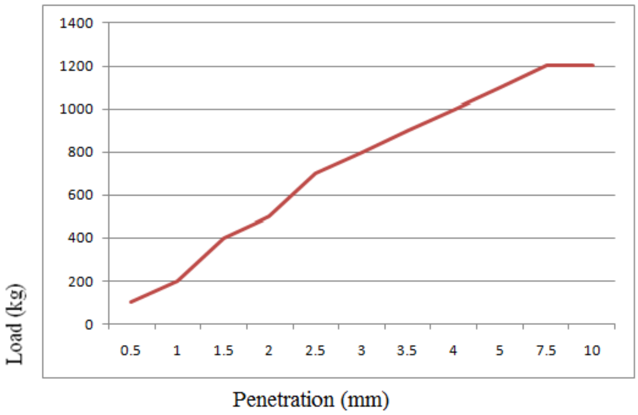
It shows the value of 2.5mm is greater than 5mm.

Then the CBR value = 49.63%. ≈ 50%

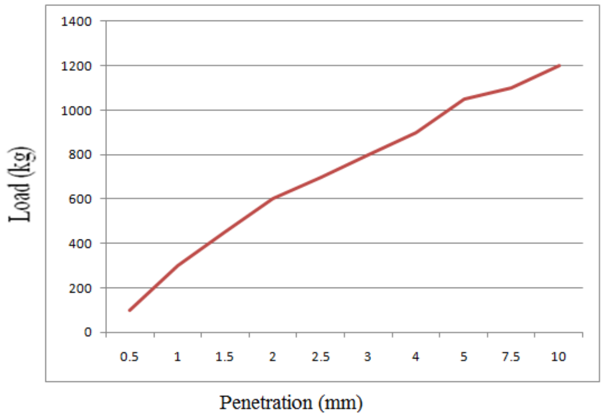
The following observation using geotextile in gravel soil by three layers confirms the strength mobilization principle of the geotextile in general which emphasized that the strength mobilization of reinforcing geotextile materials material very much depends on the range of CBR of soil sample. The smaller the soil sample CBR the more effective the strength mobilization effects of geotextile material in general.

TABLE 3
USING GEOTEXTILE IN GRAVEL SOIL

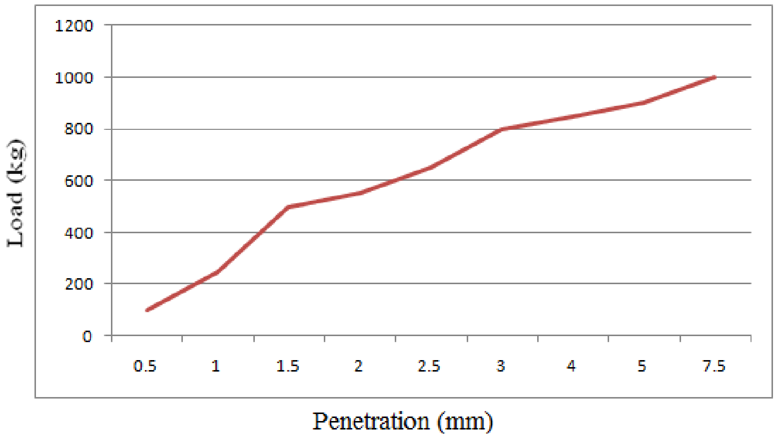
NUMBER OF GEOTEXTILE LAYER	GRAVEL SOIL
ONE LAYER (BOTTOM)	57%
ONE LAYER(MIDDLE)	54%
ONE LAYER(TOP)	50%



GRAPH 2: CALIFORNIA BEARING RATIO TEST USING GEOTEXTILE BOTTOM LAYER



GRAPH 3: CALIFORNIA BEARING RATIO TEST USING GEOTEXTILE MIDDLE LAYER



GRAPH 4: CALIFORNIA BEARING RATIO TEST USING GEOTEXTILE TOP LAYER

4.3 Direct Shear Test

4.3.1 Using Gravel Soil

1 div = 2.9N
1 kg = 9.81N

TABLE 4
DIRECT SHEAR TEST READING IN GRAVEL SOIL

Sl.no	Normal stress (kg/cm²)	Shear load				Shear stress (N/Cm²)	
		Without geotextile		With geotextile		Without geotextile	With geotextile
		Div	N	Div	N		
1	0.5	18	52.2	29	84.1	1.45	2.33
2	1.0	30	87	35	101.5	2.41	2.81
3	1.5	41	118.7	42	121.8	3.30	3.38
4	2.0	52	150.8	54	156.6	4.18	4.35
5	2.5	61	176.9	63	182.7	4.91	5.075

Size of Shear box = 6×6cm =36cm²
Using gravel soil, Shear Stress =1.45N/cm²
Using Gravel Soil with Geosynthetics, Shear Stress = 2.33N/cm²

4.3.2 Using Black Cotton Soil

TABLE 5
DIRECT SHEAR TEST READING IN BLACK COTTON SOIL

Sl.no	Normal stress (kg/cm²)	Shear load				Shear stress (N/Cm²)	
		Without geotextile		With geotextile		Without geotextile	With geotextile
		Div	N	Div	N		
1	0.5	6	17.4	9	26.1	0.48	0.72
2	1.0	10	29	15	43.5	0.8	1.20
3	1.5	18	52.2	22	63.8	1.45	1.77
4	2.0	21	60.9	28	81.2	1.69	2.25
5	2.5	29	23.3	35	101.5	2.33	2.81

Using gravel soil, Shear Stress =0.48N/cm²
Using Gravel Soil with Geosynthetics, Shear Stress = 0.72N/cm²

4.3.3 Using Clay Soil

TABLE 6
DIRECT SHEAR TEST READING USING CLAY SOIL

Sl.no	Normal stress (kg/cm²)	Shear load				Shear stress (N/Cm²)	
		Without geotextile		With geotextile		Without geotextile	With geotextile
		Div	N	Div	N		
1	0.5	6	17.4	29	84.1	0.48	2.33
2	1.0	1	23.2	46	133.4	0.64	3.77
3	1.5	1.5	31.9	58	168.2	0.88	4.67
4	2.0	2	40.6	65	188.5	1.12	5.23
5	2.5	2.5	46.4	73	211.7	1.28	5.88

Using gravel soil, Shear Stress =0.48N/cm²
Using Gravel Soil with Geosynthetics, Shear Stress = 2.33N/cm²

4.3.4 Using Red Soil

TABLE 7
DIRECT SHEAR TEST READING USING CLAY SOIL

Sl.no	Normal stress (kg/cm²)	Shear load				Shear stress (N/Cm²)	
		Without geotextile		With geotextile		Without geotextile	With geotextile
		Div	N	Div	N		
1	0.5	10	29	22	63.8	0.805	1.77
2	1.0	25	72.5	28	21.2	2.01	2.25
3	1.5	30	87	34	98.6	2.416	2.73
4	2.0	36	104	41	108.9	2.90	3.30
5	2.5	41	118	45	130.5	3.30	3.62

Using gravel soil, Shear Stress =0.48N/cm²
Using Gravel Soil with Geosynthetics, Shear Stress = 1.77N/cm²

V. CONCLUSION

In this study it is evident that geotextile soil techniques enchances the strength properties of the well designed earthern structures. This is being proved in this study conducting tests in poor soil.For flexible pavement the stregt of the soil can be improve by means of reinforcement geotextile this has being proved by the CBR test conducted in this study. The shear strength property of the soil strength increases for the soil reinforced with geotextile compared with respect to un reinforced. Finally we conclude that the using of geotextile strength properties of all black cotton soil and other poor soil can be increased to many field. So we can use geotextile inn various earthhernn structures in various applications.

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