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Study on application of geosynthetics for strengthening of soil

Simmanapudi Naveen Kumar
snr.kumar007@gmail.com
Gokul Group of Institution, Bobbili, Andhra Pradesh

Chappa Damodar Naidu
m.santosh945@gmail.com
Gokul Group of Institution, Bobbili, Andhra Pradesh

ABSTRACT

Geosynthetics have been widely used in recent thirty years for separation, reinforcement, filtration, drainage, and containment functions of the pavement design. The use and sales of geosynthetics materials are increasing 10% to 20% per year. This paper reviews research into the application of geosynthetic materials such as geogrids, geotextiles, geocomposites, geonets, geomembranes, geosynthetic clay liners, geofoam, and geocells in for strengthening of soil by focusing on the literature review, basic useful characteristics and basic information collection of geosynthetics. Among them, the study focuses on the reduction of base course thickness by using the geogrid material in the base course layer without changing the load carrying capacity and the performance of the pavement. Modified AASHTO design result shows that about 20% to 40% base course reduction is possible using geogrid in pavement design, with a greater percentage reduction for stronger subgrade materials. have been defined by the American Society for Testing and Materials (ASTM) Committee D35 on geosynthetics as planar products manufactured from polymeric materials used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure or system. Geosynthetics is the term used to describe a range of polymeric products used for Civil Engineering construction works. The term is generally regarded to encompass eight main products categories. The most popular geosynthetics used are the geotextiles and geomembrane. Geomembrane is an essentially impermeable membrane in the form of the manufactured sheet used widely as cut-offs and liners. They are often used to line landfills.

Keywords— *Geosynthetics, Geogrids, Geotextiles, Geocomposites, Geonets, Geomembranes, Geosynthetic clay liners, Geofoam and Geocells, Geosynthetics*

1. INTRODUCTION

The aim of this research work is to assess the different types of geosynthetics available and to evaluate the effectiveness of the geotextile in road construction and maintenance. To achieve this aim, the following objectives have been identified:

- To classify the available geosynthetics in the country.
- To determine the constituent material used in producing the geotextile, one of the geosynthetic materials.
- To incorporate the geotextile in some collected soil materials and assess performance.

2. LITERATURE REVIEW

Each year floods pose a major problem throughout the world. Many lives are taken and costs due to damages typically run well into the hundreds of millions of dollars. Many different methods can be used to prevent flooding.

In North America, according to Landis (2000), sandbagging is a standard method used for flood protection and is quite successful. During the events of flooding, bags are filled with sand and are stacked in a pyramid type arrangement. The walls constructed by the sandbags are indeed stable and provide a secure structure to withstand the forces of the rising headwater due to flooding. Although the method of sandbagging accomplishes the goal of protecting the community from rising floodwaters, it is labor intensive and there is always a problem concerning the disposal of the sandbags. Few studies have been conducted on geosynthetic tubes. Recently the need to research the tubes has grown popular since they have the potential to replace sandbags indefinitely. The following literature review discusses some facts on geosynthetic material, products that are available on the market, and some uses of the tubes in the field. In addition, previous research is also discussed below.

3. TYPES OF GEOSYNTHETICS

- Geotextiles
- Geogrids
- Geonets
- Geomembrane

- Geocomposite
- Geocells
- Geosynthetic clay liner

4. SOIL EXPLORATION

The field and laboratory investigations require to obtain the necessary data for the soil for proper design and successful construction of any structure at the site are collectively called soil exploration.

4.1 Purpose of soil exploration

- Selection of foundation type.
- Design of foundations.
- Contractors to quote realistic and competitive tenders.
- Planning construction techniques.
- Selection of appropriate construction equipment (especially for excavation and foundations).
- Feasibility studies of the site.
- Estimating development cost for the site.
- Study of the environmental impacts of the proposed construction.

4.2. Method of soil exploration

The methods to determine the sequence, thickness and lateral extent of the soil strata and, where appropriate the level of bedrock. The common methods include

- Test Pits
- Shafts and audits
- Boring or drilling

Test Pits:

- The excavation of test pits is a simple and reliable method.
- The depth is limited to 4-5m only.
- The in-situ conditions are examined visually
- It is easy to obtain disturbed and undisturbed samples
- Block samples can be cut by hand tools and tube samples can be taken from the bottom of the pit.

5. GENERAL USES OF GEOSYNTHETICS

- Separation
- Filtration
- Drainage
- Reinforcement
- Barrier (containment or sealing)
- Protection
- Erosion control

6. FUNCTIONS OF GEOSYNTHETICS

The primary functions performed by geosynthetics are separation, filtration, drainage, reinforcement, provision of a fluid barrier, and environmental protection and erosion control, as detailed above. Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different end use. The function in view for each end user will determine the appropriate type of geosynthetic to be employed. The primary functions most suited to the various geosynthetic subgroups are as follows:

6.1. Geotextiles

The geotextiles have found widespread use in diverse areas of application. Geotextiles can generally be used for any function, as long as the proper synthetic and composition are selected. The fabric always performs at least one of the five discrete functions of separation, reinforcement, filtration, drainage and erosion control.

In separation, they can be used at the boundary between different soil materials to maintain a separation (hinder the penetration of fine particles into coarse-grained soil under load) but still permits the movement and passage of water. Also, the use of thick non-woven geotextiles for cushioning and protection of geomembranes is in this category.

6.1.1 Geogrids: The geogrids function almost exclusively as a reinforcement material. However, they can also be used in some special cases of separation.

6.1.2. Geonets: The geonets are the net-like structure and they are exclusively used for the drainage function as well as to strengthening the soil and for erosion control.

6.1.3. Geomembranes: These find application primarily within the containment or barrier function and within the drainage function. Geomembranes are usually impermeable or with low permeability. They are therefore used for containment or barrier function as protective liners and covers. They may be used as buried or exposed linings to prevent seepage or infiltration into reservoir and impounding areas.

6.1.4. Geosynthetic Clay Liner (GCL)

Type of Geosynthetic (GS)	Separation	Reinforcement	Filtration	Drainage	Containment
Geotextile (GT)	X	X	X	X	
Geogrid (GG)		X			
Geonet (GN)				X	
Geomembrane (GM)					X
Geosynthetic Clay Liner (GCL)					X
Geopipe (GP)				X	
Geofoam (GF)	X				
Geocells (GL)		X		X	
Drainage cell (DC)		X`	X	X	
Geocomposite (GC)	X	X	X	X	X

Being rolls of thinly layered bentonite clay sandwiched between two geotextiles or bonded to a geomembrane, these products are used as a composite component beneath a geomembrane or by themselves as primary or secondary liners (to fulfill the containment or barrier function).

7. APPLICATION OF GEOSYNTHETICS

7.1. Applications of the geosynthetic subgroups in infrastructure development

The functions of the geosynthetics subgroups, in conjunction with the advantages they offer, have made them suitable for a wide range of applications and have caused them to be vastly used in many, if not all, areas of infrastructure development. The products have been and are currently being used in many civil, geotechnical, transportation, geoenvironmental, hydraulic and private development applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture, and agriculture.

8. RESEARCH METHODOLOGY

8.1. Sample collection

8.2. Laboratory test

The materials that were used for this investigation are clayey, organic and lateritic soils. For the laboratory tests, three soil samples were collected. We collect the clayey soil from the college. The materials were gotten in polythene to prevent loss of moisture to the atmosphere. The analysis was carried out in order to ascertain the physical and engineering properties of the samples.

Tests implemented or performed on natural clayey, organic and lateritic soils collected for this project include particle size distribution, grain size analysis, moisture content, Atterberg limits and California Bearing ratio tests (CBR) in order to assess their geotechnical properties

8.2.1. Soil particle-size distribution: The natural soil samples were crushed respectively and 500grams of each sample was measured. The sieves were arranged in decreasing order of hole size and the soil samples retained on each sieve was weighed to determine the individual weight.

Thereafter, the soil was placed in an array of sieves in the manual shaker and shaken for 15minutes. The sieves were then weighed independently along with the soil retained. The percentage retained in each sieve was determined after which the distribution curves were plotted. The particle size distribution of the soil to be protected should be determined using test method ASTM D 422. The grain size distribution curve is used to determine parameters necessary for the selection of numerical retention criteria.

8.2.2. Soil Atterberg limits: The test was carried out on natural soil samples in order to classify into standard groups and these limits include liquid, plastic and shrinkage limits. Some useful information obtained from knowledge of these limits are:

- It enables to identify and classify the soil.
- Shear strength of soil can be inferred from these properties.
- Results of the liquid limit can be useful in the assessment of the settlement of soil.
- For fine-grained soils, the plasticity index (PI) should be determined using the Atterberg Limits test procedures 1377-2.

8.2.2.1. LIQUID LIMIT: The liquid limit of a soil is defined as the moisture content of which the soil passes from plastic to liquid state as determined in accordance with the standard procedure, BS 1371, London, 1961.

This procedure consists of a portion of air-dried soil, which was pulverized in order to make it pass through sieve 425um. 250grams of the soil passing was mixed with water to form a thick, homogenous paste. The paste was placed in a Casagrande cup and leveled parallel to the base of the cup. The paste was divided into two halves using the grooving tool and blows were given to the paste till it closed in. small samples of the paste were collected into containers and oven-dried for 24hrs. Other pastes were collected by varying the moisture content of the paste for the three samples.

The relationship between moisture content and the number of blows were plotted and the best straight line between these points was drawn. The moisture content corresponding to 25blows on the graph was taken as the liquid limit.

8.2.2.2. Plastic limit: The plastic limit of a soil is defined as the moisture content at which the soil becomes too dry to be in the plastic condition or the minimum water content at which a soil can be rolled into threads of 3mm diameter between the palm of the hand. The soil thread at plastic limit crumbles under the rolling action. At this stage, moisture was added again and the average value of the moisture content was taken as the plastic limit of the soil.

The numerical value between the liquid and the plastic limits of the soil is known as the plasticity index. This is a measure of how much water a soil can absorb before dissolving into a solution. The higher the value, the more plastic and weak the material is. Plastic soil containing clay has PI of 10 to 50 or more.

8.2.2.3. Shrinkage limit: Shrinkage due to drying is significant in clays, but less in silt and sands. These tests enable the shrinkage limit of clay to be determined i.e the moisture content below which clay ceases to shrink. They also quantify the amount of shrinkage likely to be experienced by soils in terms of the shrinkage ratio, volumetric shrinkage, and linear shrinkage.

8.2.3. Specific gravity: Natural soils for the three samples were collected and oven-dried and the natural moisture was determined. Three specific gravity bottles were weighed empty and the bottles were filled with water and reweighed. 50grams of the soil samples to be used were also weighed and poured inside the bottles. Distilled water was poured inside the three specimens. The particles inside the water were stirred and left to settle for about 15minutes to get rid of the air bubbles. On settling, more water was added to the brim of the bottle and it was covered with the lid. The outer part of the bottles was dried and weighed. The sample was reweighed after 24hours and the values of their respective specific gravities were determined.

8.2.4. Proctor compaction test: In the standard Proctor test, 3000g of the sample was oven-dried. Proctor mould was set and clamped. The soil was poured in a tray and 8% of water was added to it. It was properly mixed with the hand and placed in the mould in three layers with 25 blows given to each layer with a 2.5kg rammer. The extension collar of the mould was removed and the excess specimen in the mould was leveled with the edge of the mould and the specimen was weighed.

The specimen was removed from the mould and part of it was removed from the top and bottom with the spatula and the moisture content was determined. 10%, 12%, 14% of water was subsequently added to the sample and equally compacted and weighed. The amount of water added increased arithmetically until there was a reduction in the weight of the mould and the sample.

8.2.5. Determination of the maximum allowable geotextile opening size: The last step in determining soil retention requirements is evaluating the maximum allowable opening size (O95) of the geotextile which will provide adequate soil retention. The O95 is also known as the geotextile's Apparent OpeningSize (AOS) and is determined from test procedure ASTM D 4751. AOS can often be obtained from the manufacturer's literature.

8.2.6. Determination of the moisture content of the soil: The test procedure used was BS 812-109 1990 Part 109: Methods for determination of moisture content. About 15g of the in-situ soil was placed in a can and weighed. It was then placed in an oven to remove the moisture. The cans were re-weighed after 24hours and the moisture content was determined.

8.2.7 California Bearing Ratio (CBR): The test procedure was according to BS 1377-4: Soils for civil engineering purposes: Part 4: Compaction related tests. Includes: the California bearing ratio, and the various methods of determining the dry density, moisture content relationship of soil. 3kg of the oven-dried sample was thoroughly mixed with an appropriate amount of water and placed in a mould. The extension collar and base plate were fixed. The soil in the mould was compacted in 3 equal layers, each layer compacted with 25blows of the 2.5kg rammer. The collar was removed and the soil was trimmed off. The base plate and displacer disc were removed and the mould was weighed with the compacted soil. The penetration piston was placed at the center of the specimen with the smallest possible load so that full contact between the piston and the sample was established. The strain and stress dial gauge was set to zero and load was applied on the piston and records were taken after every 30secs. The maximum load corresponding to the penetration was determined when there was no increase in the value of the dial reading. The mould was detached and about 15g was taken from the top to determine the moisture content.

8.2.8. Pavement modeling: In modeling for the pavement, four (4) wooden mouldswere constructed, three to contain the different soil layers and the geosynthetic material and the last one without geotextile. The mould had dimensions length = 40cm, breadth = 20cm and height = 50cm to accommodate for the height of the three sections of the pavement which are the base-course, sub-base and sub-grade all 150mm in height with a camber of 4 percent for drainage.

In compaction of the sub-grades, the moulds were marked with the respective dimensions and consideration was given to the camber and with the aid of a hammer, it was compacted with several blows. The compacted soils were left to consolidate for a week and then the geotextile was laid on the surface on the sub-grade.

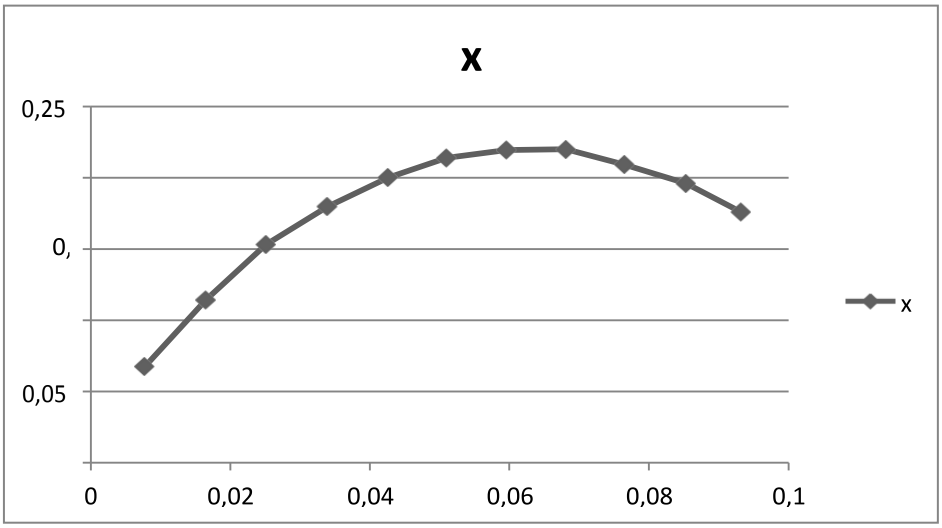
The sandcrete which is the sub-base had a mix ratio of 3:1. 3 head-pans of stone dust to 1 head-pan of cement was thoroughly mixed without the presence of water and placed in the mould and compacted then sprinkled with water for 7 days to cure and to attain maximum strength. Finally, the granite chippings used for the base course was placed and compacted also with the ramming rod with the camber still maintained.

9. RESULTS AND DISCUSSIONS

9.1 Observations

9.1.1 For simple

Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per-kg (P)	Compressive Stress Kg/Cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	59	0.0077	11.43	0.77	0.77	0.0673
1	126	0.0165	11.54	1.32	1.32	0.1143
1.5	191	0.0251	11.64	1.78	1.78	0.1529
2	258	0.0339	11.74	2.11	2.11	0.1797
2.5	324	0.0426	11.85	2.37	2.37	0.2000
3	388	0.051	11.95	2.55	2.555	0.2138
3.5	453	0.0596	12.06	2.645	2.645	0.2193
4	518	0.0681	12.16	2.675	2.675	0.2199
4.5	582	0.0765	12.29	2.57	2.57	0.2091
5	649	0.0853	12.4	2.43	2.43	0.1959
5.5	709	0.0932	12.51	2.22	2.22	0.1758

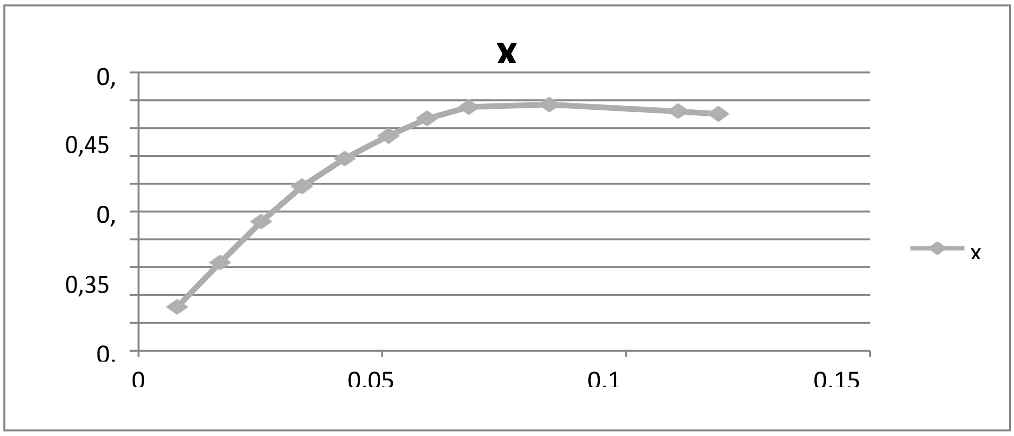


X-Axis = Compressive stress in Kg/cm^2 Y-Axis = Strain in %
P_U = 0.2199
C=0.1099

9.1.2 Using geonets

- **Using one layer of geonet**

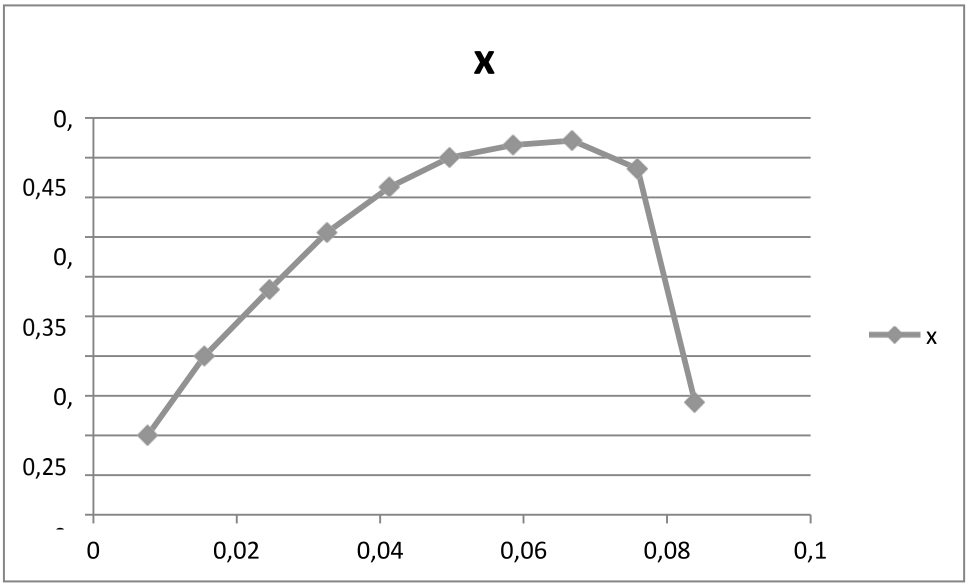
Elapse Time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	61	0.008	11.43	0.9	0.9	0.079
1	128	0.0168	11.54	1.83	1.83	0.159
1.5	192	0.0252	11.64	2.7	2.7	0.232
2	256	0.0336	11.74	3.47	3.47	0.296
2.5	322	0.0423	11.85	4.09	4.09	0.345
3	390	0.0513	11.95	4.62	4.62	0.386
3.5	450	0.0592	12.06	5.03	5.03	0.417
4	516	0.0618	12.16	5.33	5.33	0.438
4.5	641	0.0843	12.29	5.48	5.48	0.442
5	842	0.1107	12.4	5.49	5.49	0.43
5.5	905	0.1190	12.51	5.48	5.48	0.425



X-Axis = Compressive stress in Kg/cm^2 Y-Axis = Strain in %
P_U = 0.4422 ,
C=0.2211

- **Sample with two layers of geonet**

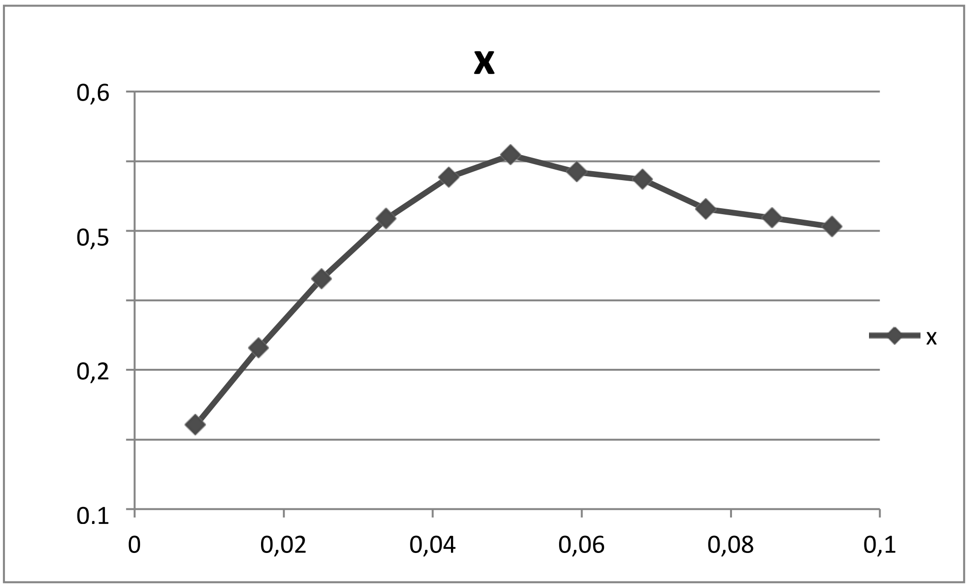
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per-kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	0	0	11.35	0	0	1
1	58	0.0076	11.43	1.15	1.15	2.15
1.5	118	0.0155	11.52	2.3	2.3	3.3
2	187	0.0246	11.63	3.3	3.3	4.3
2.5	248	0.0326	11.73	4.17	4.17	5.17
3	314	0.0413	11.83	4.88	4.88	5.88
3.5	378	0.0497	11.94	5.37	5.37	6.37
4	446	0.0586	12.05	5.67	5.67	6.67
4.5	508	0.0668	12.16	5.73	5.73	6.73
5	577	0.0759	12.28	5.35	5.35	6.35
5.5	638	0.0839	12.36	1.75	1.75	2.75



X-Axis = Compressive stress in Kg/cm^2 Y-Axis = Strain in %
P_U = 0.4712, C=0.2356

- **Sample with three layer of geonet**

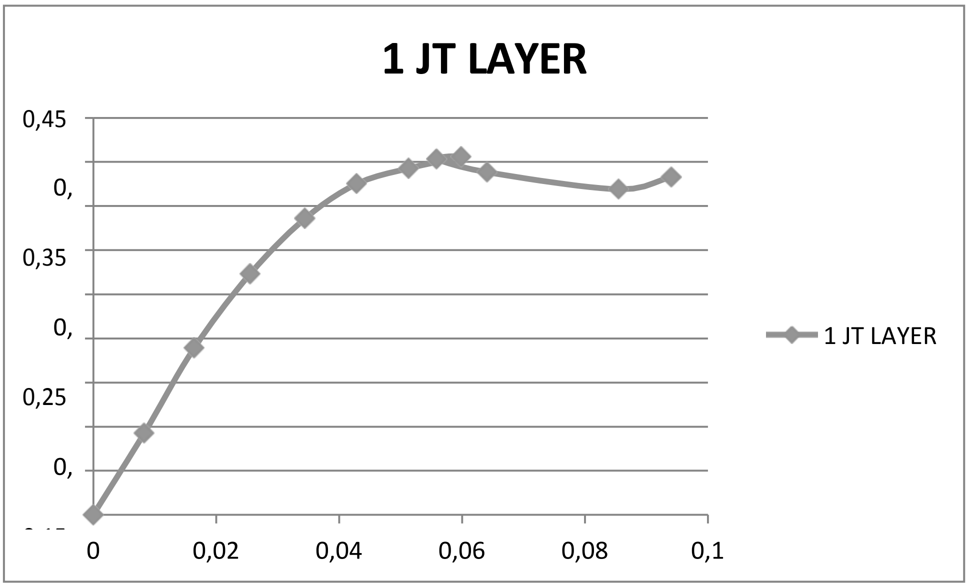
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	63	0.0082	11.43	1.38	1.38	0.1206
1	127	0.0161	11.54	2.67	2.67	0.2313
1.5	191	0.0251	11.64	3.85	3.85	0.3307
2	257	0.0338	11.74	4.9	4.9	0.4173
2.5	321	0.0422	11.85	5.65	5.65	0.4767
3	384	0.0505	11.95	6.08	6.08	0.5087
3.5	452	0.0594	12.06	5.84	5.84	0.4842
4	519	0.0682	12.16	5.77	5.77	0.4737
4.5	583	0.0767	12.29	5.3	5.3	0.4312
5	651	0.0856	12.4	5.19	5.19	0.4182
5.5	712	0.0936	12.52	5.08	5.08	0.4057



X-Axis = Compressive stress in Kg/cm^2 Y-Axis = Strain in %
P_U = 0.5087 , C=0.2543

9.2 Using jute bag
9.2.1 Using one layer of jute bag

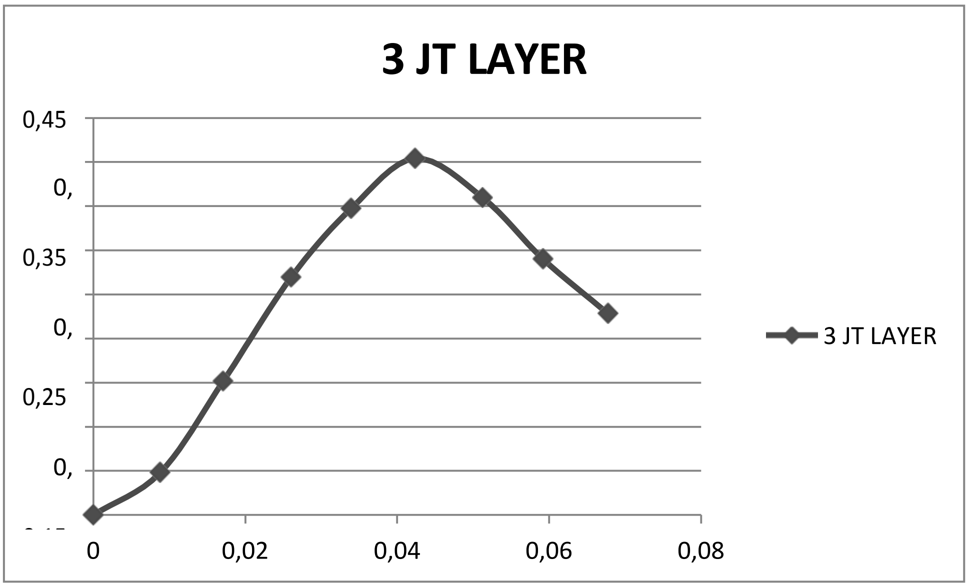
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	63	0.0083	11.4449	1.06	1.06	0.09262
1	125	0.0164	11.5398	2.185	2.185	0.18934
1.5	194	0.0255	11.6473	3.18	3.18	0.27302
2	262	0.0345	11.7552	3.95	3.95	0.33602
2.5	326	0.0429	11.8587	4.45	4.45	0.37525
3	390	0.0513	11.9639	4.7	4.7	0.39285
3.5	455	0.0599	12.0728	4.9	4.9	0.40587
4	425	0.0559	12.0223	4.85	4.85	0.40342
4.5	487	0.0641	12.1271	4.71	4.71	0.38839
5	650	0.0855	12.4115	4.58	4.58	0.36901
5.5	715	0.0941	12.5287	4.8	4.8	0.38312



X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) P_U= 0.4058
C = 0.2029

9.2.2 Using three layer of jute bag

Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per-kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	67	0.0088	11.4509	0.55	0.55	0.0480
1	130	0.0171	11.5475	1.75	1.75	0.1515
1.5	198	0.0261	11.6536	3.14	3.14	0.2694
2	258	0.0339	11.7488	4.08	4.08	0.3473
2.5	322	0.0424	11.8522	4.79	4.79	0.4041
3	390	0.0513	11.9639	4.3	4.3	0.3594
3.5	450	0.0592	12.0643	3.5	3.5	0.2901
4	515	0.0678	12.1750	2.78	2.78	0.2283

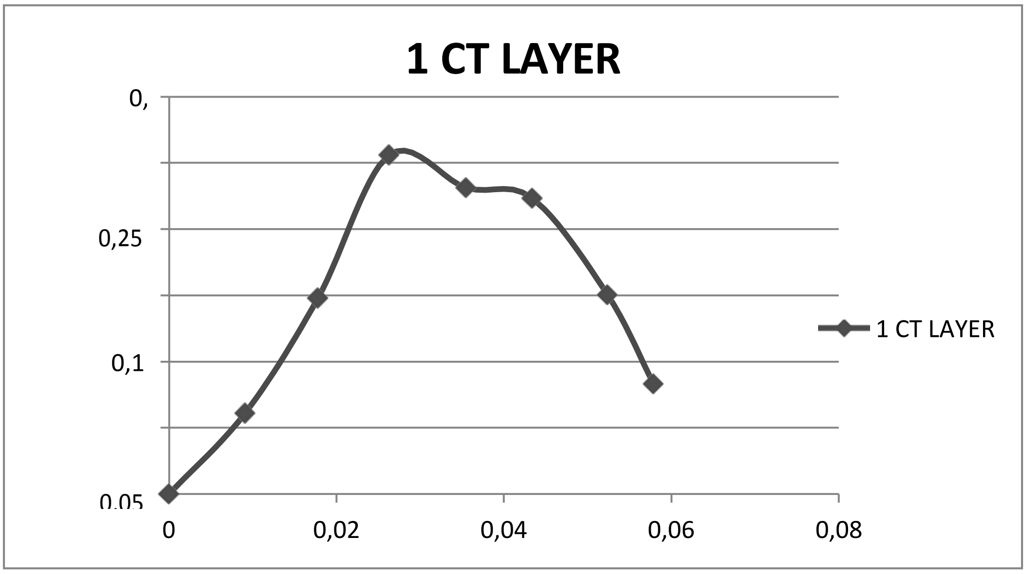


X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) P_U = 0.4041
C = 0.2020

9.3 Using geotextile

9.3.1 Using one layer of geotextile

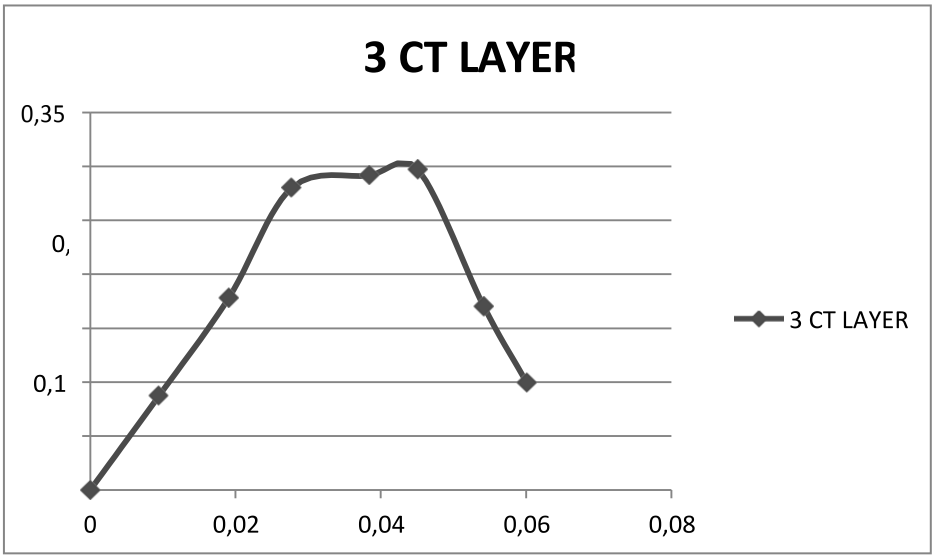
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per-kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	69	0.0091	11.45	0.7	0.7	0.0611
1	135	0.0178	11.55	1.71	1.71	0.1480
1.5	200	0.0263	11.64	2.98	2.98	0.2560
2	270	0.0355	11.76	2.72	2.72	0.2312
2.5	330	0.0434	11.86	2.65	2.65	0.2234
3	398	0.0524	11.97	1.8	1.8	0.1503
3.5	440	0.0579	12.04	1	1	0.0830



X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) P_U = 0.2560
C = 0.128

9.3.2 Using three layer of geotextile

Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	72	0.0095	11.4500	1	1	0.0873
1	145	0.0191	11.5700	2.06	2.06	0.1780
1.5	211	0.0278	11.6700	3.27	3.27	0.2802
2	292	0.0384	11.8000	3.44	3.44	0.2915
2.5	343	0.0451	11.8800	3.53	3.53	0.2971
3	412	0.0542	12.0000	2.04	2.04	0.1700
3.5	457	0.0601	12.0700	1.2	1.2	0.0994

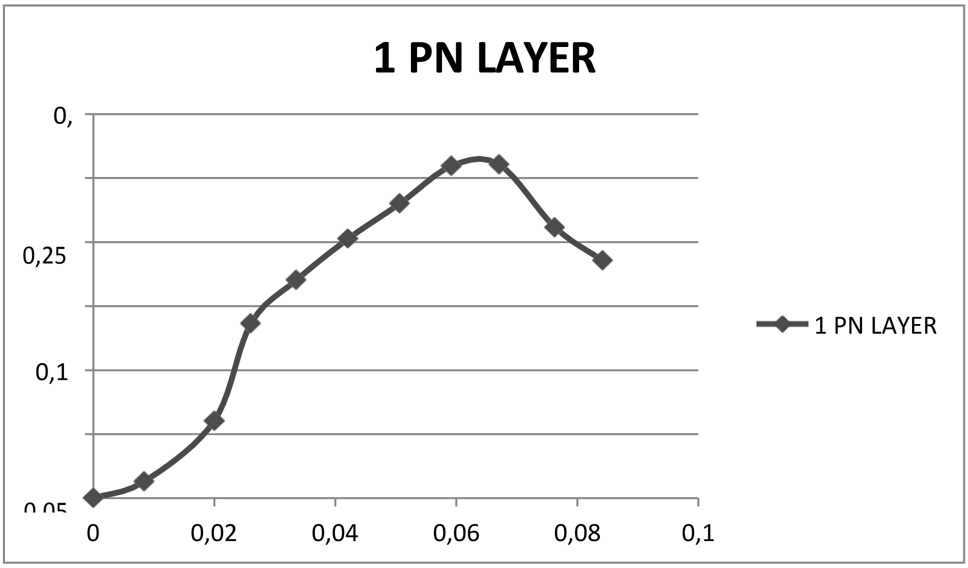


X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) $P_U = 0.2971$
C = 0.1485

9.4 Using plastic nets

9.4.1 Using one layer of plastic net

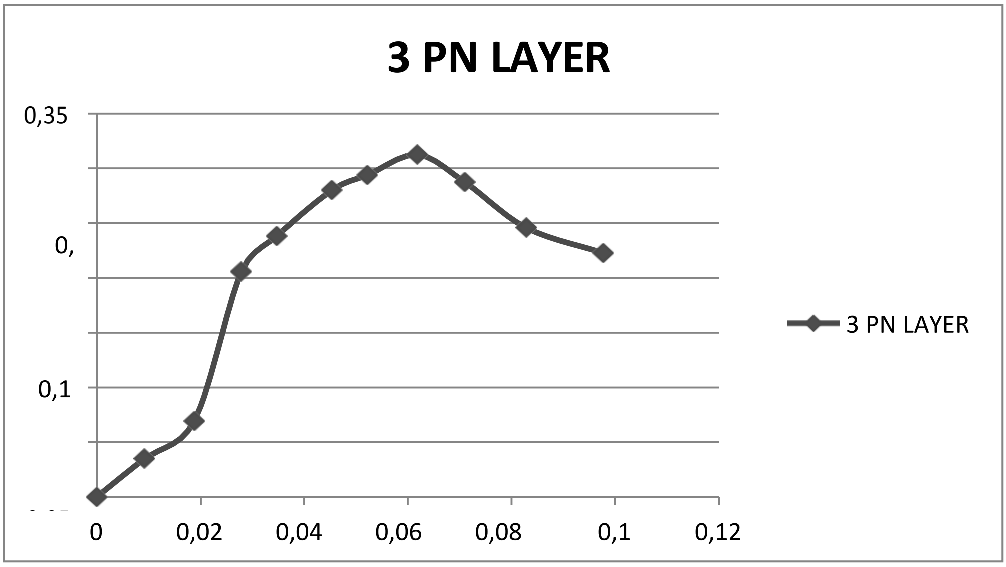
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A_C)
0	0	0	11.35	0	0	0
0.5	64	0.00842	11.4464	0.15	0.15	0.0131
1	152	0.02000	11.5816	0.7	0.7	0.0604
1.5	198	0.02605	11.6536	1.59	1.59	0.1364
2	255	0.03355	11.7440	2	2	0.1703
2.5	320	0.04211	11.8489	2.4	2.4	0.2026
3	385	0.05066	11.9556	2.75	2.75	0.2300
3.5	450	0.05921	12.0643	3.13	3.13	0.2594
4	510	0.06711	12.1664	3.17	3.17	0.2606
4.5	580	0.07632	12.2877	2.6	2.6	0.2116
5	640	0.08421	12.3937	2.3	2.3	0.1856



X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) $P_U = 0.2606$
C = 0.1303

9.4.2 Using three layer of plastic nets

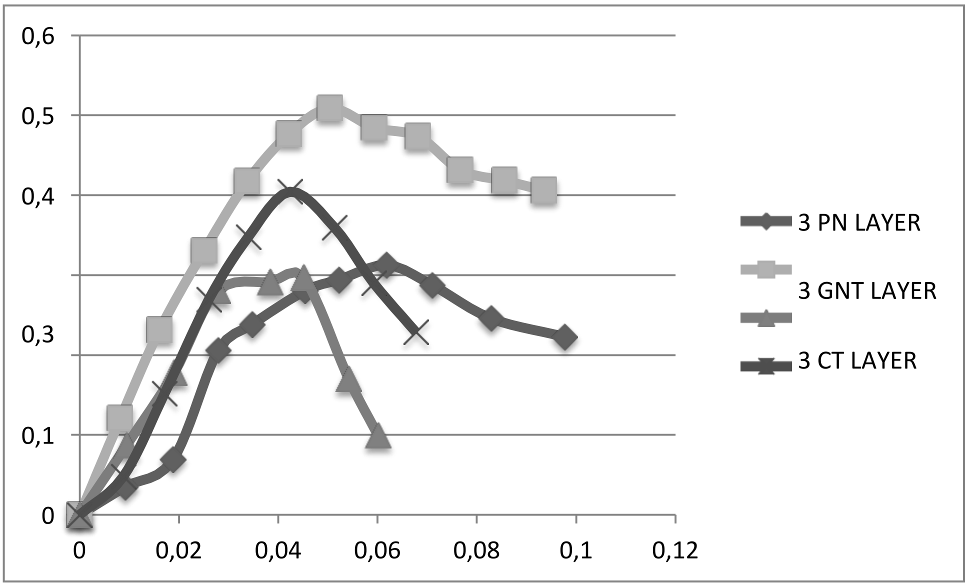
Elapse time	Compression dial gauge (ΔL)	Strain (ε=ΔL/L)	Area (Ac=Ao/1-ε)	Proving ring reading	Axial load per- kg (P)	Compressive stress kg/cm^2 (P/A$_C$)
0	0	0	11.35	0	0	0
0.5	70	0.0092	11.4555	0.4	0.4	0.0349
1	143	0.0188	11.5677	0.8	0.8	0.0692
1.5	212	0.0279	11.6757	2.4	2.4	0.2056
2	264	0.0347	11.7585	2.8	2.8	0.2381
2.5	345	0.0454	11.8897	3.33	3.33	0.2801
3	397	0.0522	11.9756	3.52	3.52	0.2939
3.5	470	0.0618	12.0982	3.78	3.78	0.3124
4	540	0.0711	12.2181	3.51	3.51	0.2873
4.5	630	0.0829	12.3759	3.04	3.04	0.2456
5	743	0.0978	12.5798	2.8	2.8	0.2226



X-Axis = Strain
Y- Axis = Compression stress in (Kg/cm2) P$_U$ = 0.3124
C = 0.1562

9.5 Result by combination of graphs

From the above analysis we can conclude that geosynthetics using one layer and two layers will not have many variations they are approximately equal but by using three layers will give a maximum result, hence it is recommended that using three layers of geosynthetics will give maximum unconfined compressive strength.



X-Axis = Compressive stress in Kg/cm^2 Y-Axis = Strain in %
$P_{UMAX} = 0.5087$
$C = 0.2543$

10. CONCLUSION OF THE PROJECT

- The rapid growth in the geosynthetics market the world over has lent confidence to the civil engineer in their use. One should not be tempted to imagine geosynthetic are magical material to yield excellent results, without due consideration of the problem of geosynthetic interaction such a blind approach could lead to disaster. The futures appears to be more promising with stronger and more durable geosynthetic emerging into the market along with a fibrous system to be mixed with soil for giving more hope as well as a change to the geotechnical engineers in the years to come.
- From the Unconfined compression test (UCC) we can conclude that geonet using one layer and two layers will not have many variations they are approximately equal but by using three-layer will give maximum result, hence it is recommended that using three layers of geosynthetic will give maximum ultimate strength of soil by the test we can conclude that the three layers of geonet will give the maximum value of unconfined compressive stress of soil .
- As this test will not give the ultimate bearing capacity of soil but gives the unconfined compression value of soil which will help to find out the ultimate bearing capacity of soil as we can say that this test is the base test to find out the ultimate bearing capacity of the soil.
- From the California bearing ratio (CBR) test we can conclude that geonet using one layer will give the maximum CBR value as compared to the three layers of the geonet, geonet will give the maximum value when it is compared to the values of the geogrid.
- This test shows that as the depth of the soil increases, the number of geonet should be increased. This test is directly related with the strength of the soil as CBR value of the soil increases the strength of the soil increases or we can say that soil having high CBR value will have more strength.

11. REFERENCES

[1] ASTM. 1994. ASTM Standards and Other Specifications and Test Methods on theQuality Assurance of Landfill Liner Systems. ASTM, 1916 Race Street, Philadelphia, PA. April.
[2] ASTMD5101-90, “Standard test method for measuring the soil-textile system clogging potential by the gradient ratio”, American Society for Testing and Materials, Philadelphia, PA, USA.
[3] Bergado, D.T., &Abuel-Naga, H.M (2005), Tsunami devastations and reconstruction with geosynthetics. The Free Library, http://www.thefreelibrary.com/Tsunami+devastations+and+reconstruction+with+geosynthetics- a0155784117.
[4] Cazzuffi, D. (2000), Geosynthetics in dams, IGS Education Committee Mini-Lecture Series on Geosynthetics, International Geosynthetics Society, Retrieved May 25, 2011, from http://geosynthetics.net/tech_docs/igs_dams_lecture.pdf
[5] Chen W.F. and Richard Liew J.Y., The Civil Engineering Handbook Second Edition,(Boca Raton: CRC Press LLC 2003)
[6] Guyer J.P (2009), An Introduction to Geotextiles in Pavement and Drainage Applications, Course No. C02-019, Continuing Education and Development, Inc., Stony Point, NY, 34 pp. Retrieved May 25, 2011, from http://www.cedengineering.com
[7] Industrial Fabrics Association International (2009). Geotextile tubes help stabilize shorelines. Geosynthetics magazine Specialty Fabrics Review, September 2009, http://geosyntheticsmagazine.com/articles/09109_rv.html
[8] Joint Departments of the U.S Army and Air Force (1995).
[9] Engineering Use of Geotextiles, Technical Manual TM 5-818-8/AFJMAN 32-1030, 58 pp.
[10] Kercher, A. (2010) Geosynthetics: What are they and why should we use them.Kercher Engineering, Inc. Retrieved May 25, 2011, http://www.kercherei.com/pw_institute/geosynthetics/geo.html
[11] Meccai, K. A., & Al-Hasan E. (2004, March 14-18). Geotextiles in Transportation applications, Paper presented at the Second Gulf Conference on Roads, Abu Dhabi. Retrieved May 25, 2011, http://www.alyaf.com/Geotextiles%20in%20Transportation%20Applications.pdf
[12] Okunade, E.A (2010), “Reducing the Cost of Infrastructure in Nigeria through the Use of the Construction Geosynthetics”, paper submitted to the Dept. of Civil Engineering, Univ. of Ado Ekiti, Nigeria, 2010.