Geosynthetics Used In Road Construction

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Abstract- *To increase performance, roads are sometimes reinforced with geosynthetic polymer materials, including geogrids and geotextiles. Geogrids consist of polymers formed into relatively rigid, gridlike configurations. They are commonly placed between the subgrade and base or base and subbase layers of roads to add strength and stiffness and to slow deterioration. Geotextiles are polymer fabrics that may also provide some reinforcement, but are used primarily to:*

- *Facilitate filtration and water drainage through road foundation soils without the loss of soil particles.*
- *Provide separation between dissimilar base materials, improving their integrity and functioning.*
- *Provide a stable construction platform over soft or wet soils, facilitating the movement of equipment and the process of soil compaction.Of several kinds of geotextiles, Type V is the most commonly used in Minnesota, primarily as a separator. Despite the relatively widespread use of geosynthetics in reconstructing paved county roads and state trunk highways as well as in constructing new roads, their performance has not been well documented in Minnesota. Research was needed to obtain field data that would indicate whether geosynthetics extend the service lives of roads and reduce the need for maintenance.*

I. INTRODUCTION

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. They include geotextiles, geogrids, geonets, geomembrane, geosynthetic clay liners, geofoam, geocells and geocomposite. The most popular geosynthetics used are the geotextiles and geomembrane.

The American Society for Testing and Materials Committee (ASTM-1994) defines geotextiles as permeable textile materials used in contact with soil, rock, earth or any other geotechnical related material as an integral part of civil engineering project, structure, or system.Geotextiles have proven to be among the most versatile and cost-effective ground modification materials. Their use has expanded rapidly into nearly all areas of civil, geotechnical, environmental, coastal, and hydraulic engineering.

1.1 AIM AND OBJECTIVES

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:

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

To analyse the results and make appropriate recommendations for optimal use

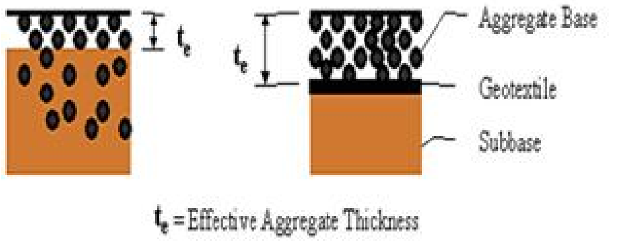
II. LITERATURE REVIEW

- **P.B.Ullagaddi, T.K.Nagaraj** presented an **"Investigation on geosynthetic reinforced two layered soil system"** which says that investigation has been carried out with different thickness configuration of the two soils and three types of woven and non-woven geotextiles, having different physical and mechanical properties**.** Based on experimental work it infers that there is improvement in CBR Value and therefore increases bearing capacity.Due to increase in bearing capacity, thickness of soil layer can be reduced to serve the same functioning. Based on U.S .corps and IRC method, woven geotextile found to be more effective in increasing CBR value than non-woven geotextile.
- **A.K.Choudhary, K.S.Gill and J.N.Jha (2011)** presented on "**Improvement in CBR values of expansive soil sub-grades using geo-synthetics"** which says that expansion ratio decreases when number of reinforcing layer is increased.CBR value increases by increasing number of reinforcing layer. Reinforcing efficiency: Geo-grid better than jute geo-textile
- **Dr. P .senthil kumar and R .rajkumar studied about "Effect of Geotextile on CBR Strength of Unpaved Road with Soft Subgrade"** which concludes that it's more advantageous for unpaved road and provide more resistance at lower penetration. It also enhances CBR value.

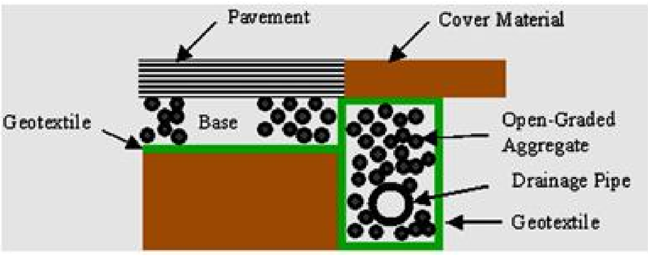
2.1 GENERAL USES OF GEOSYNTHETICS

Four of the most common general uses of geosynthetics for local agencies are:

1. Separation: Separation is the placement of a flexible geosynthetic material, like a porous geotextile, between dissimilar materials so that the integrity and functioning of both the materials can remain undisturbed or improved.



2. **Filtration**: In ths type of application, the geosynthetic acts as a filter by preventing material from washing out while allowing the water to flow through. The most common uses of this application are: geotextiles which wrap around an edge drain (see Plate2), geotextiles placed under erosion control devices, and geotextiles used behind structures such as retaining walls.



3. **Drainage**: Although filtering applications are commonly referred to as drainage applications, they are different. Drainage applications refer to situations where the water flows within the plane of the geosynthetic product (in-plane drainage). In filtration applications, the water flows across the plane of the material.

4. **Reinforcement**

the structural stability of the soil is greatly improved by the tensile strength of the geosynthetic material. This concept is similar to that of reinforcing concrete with steel

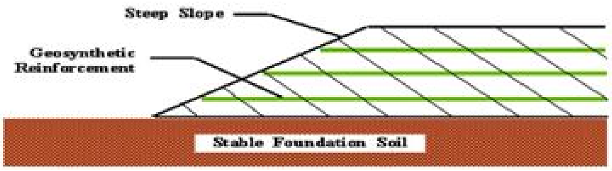


Plate 3 – Soil Reinforcement of an Embankment using a Geosynthetic(*Kercheret.al*

III. RESEARCH METHODOLOGY

The designed methodology is based on previous years of research and experience in geotextile filtration design. The approach presents a logical progressionthrough four steps.

Step 1: Defining the Application Filter Requirements
Step 2: Defining Boundary Conditions
Step 3: Determiningthe Soil Retention Requirements

3.1 SAMPLE COLLECTION

The materials that were used for this investigation are clayey, organic and lateritic soils. For the laboratory tests, three soil samples were collected. Organic soil and clayey soil were gotten from Apatapiti layout, Akure and Laterite gotten from Akure-Lagos Expressway opposite FUTA North Gate. The materials were gotten in polythene to prevent loss of moisture to the atmosphere. Analysis was carried out in order to ascertain the physical and engineering properties of the samples.

3.2 LABORATORY TEST

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.

3.2.1 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 determinedusing test method ASTM D

422. The grain size distribution curve is used to determineparameters necessary for the selection of numerical retentioncriteria.

3.2.2 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:

1. It enables to identify and classify the soil.
2. Shear strength of soil can be inferred from these properties.
3. Results of the liquid limit can be useful in assessment of the settlement of soil.

For fine-grained soils, the plasticity index (PI) should be determined usingthe Atterberg Limits test procedure BS 1377-2.

(i).**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 levelled 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.

(ii)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.

(iii.)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.

3.2.3 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 was 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 were dried and weighed. The sample was reweighed after 24hours and the values of their respective specific gravities were determined.

3.2.4 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 levelled 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 till there was a reduction in the weight of the mould and the sample.

3.2.5 Determination of the Maximum Allowable Geotextile Opening Size

The last step in determining soil retention requirements is evaluating the maximumallowable opening size (O95) of the geotextile which will provideadequate soil retention. The O95 is also known as the geotextile's Apparent OpeningSize (AOS) and is determined from test procedure ASTM D 4751. AOS canoften be obtained from manufacturer's literature.

3.2.6 Determination of the Moisture Content of the Soil

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.

3.2.7 California Bearing Ratio (CBR)

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 oven-dried sample was thoroughly mixed with an appropriate amount of water and placed in a mould. The extension collar and base plate was 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 was removed and the mould was weighed with the compacted soil.

The penetration piston was placed at the centre 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.

IV. RESULTS AND DISCUSSION

For the purpose of identification, classification and determination of engineering characteristics of the materials used, the laboratory tests were performed on the three samples collected. After which the samples were used as test sub-grades in the pavement model.

4.0 PARTICLE-SIZE DISTRIBUTION

This test was performed on the natural soils and the results are shown in the appendix. They were used for the classification of the samples.

Figure 1: Particle size distribution graph for Sample A

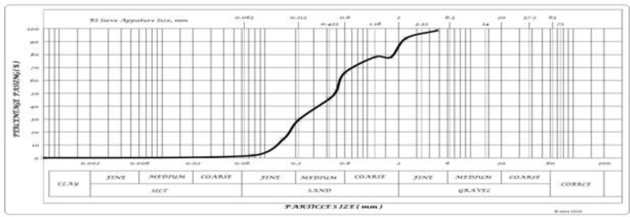


Figure 2: Particle Size distribution graph for Sample B

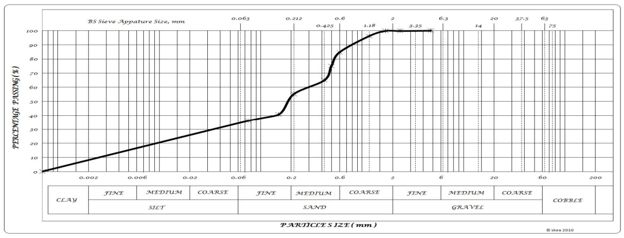


Figure 3: Particle Size distribution for Sample C

According to the AASHTO classification, Sample A as shown above ranges between fine sand and fine gravel, it is therefore an A-2-7 soil (Silty or clayey gravel sand), while Sample B ranges between the sand and gravel sizes. The material is gravelly sand with 1.84% clay fractions, it is classified as A-2-4. Sample Cwhich ranges from clay to fine sands is A-6 soil (Clayey soil)

4.1 ATTERBERG LIMIT TEST

The Atterberg Limit test was performed on the soil samples. The result for each soil samples are shown in appendix II. The results show that Sample A has a liquid limit 35.5%, plastic limit 17.9% and plasticity index 17.6%, Sample B has a liquid limit of 38.7%, and plastic limit of 23.4% with plasticity index 15.3% and Sample C has a liquid limit 60.22%, plastic limit 25.9% and plasticity index 34.32%. The graphs of the liquid limit for the respective soil samples are plotted in appendix II.

When liquid limit falls between this category below:

L.L < 35 = (L) Low Plasticity
L.L = (35-40) = (I) Intermediate Plasticity
L.L = (50-70) = (H) High Plasticity

This implies that Sample A has intermediate plasticity, Sample B has low plasticity and Sample C has high plasticity.

4.2 SPECIFIC GRAVITY TEST

The specific gravity of a soil is the ratio of a certain volume of the material the weight of an equal volume of water. This is not suitable for soil containing more than 10% stones retained in the 37.5mm BS test sieve and such should be broken down to less than this size.

The result of the specific gravity test performed on the three samples A, B and C were found to be 2.82, 1.79 and 2.56 respectively.

Table 4.1: Showing SG values of the soil samples

Soil Samples	Sample A	Sample B	Sample C
Weight of empty glass + Lid W1 (g)	267.1	267.1	267.1
Weight of empty glass + Lid+ water (g)W4	591.8	591.8	591.8
Weight of empty glass + Lid+ 50g Soil sample (g) W2	317.1	317.1	317.1
Weight of empty glass + Lid+ water + 50g Soil sample (after 24hrs) (g) W3	624.06	613.9	622.27
Specific Gravity $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$	2.82	1.79	2.56

Table 4.2: Showing natural moisture content of soil samples

Samples	Sample A	Sample B	Sample C
M_1 = mass of empty clean can (g)	29.7	30	29.3
M_2 = mass of can and moist soil (g)	95.1	94.3	90.1
M_3 = mass of can and dry soil (g)	74.3	82.7	75.02
W = moisture content	0.28	0.22	0.201
W_0 = aggregate moisture content (%)	28	22	20.1

4.4. CALIFORNIA BEARING RATIO

This test was performed on the samples to readily know the true behaviour of the soil and the soil resistance to shear. The results are shown in appendix III with graphs showing the relationship between the dry densities and moisture content. The low CBRvalues exhibited by the samples A & B indicates that the sub-grade had a weak bearing strength and is susceptible to erosion on exposure to precipitation or surface runoff, thereby encouraging and exacerbating rutting and deformation of pavement.

SAMPLES	2.5 mm CBR Penetration Values		5.0 mm CBR Penetration Values	
	TOP	BOTTOM	TOP	BOTTOM
SAMPLE A	7.6%	4.2%	8.5%	4.6%
SAMPLE B	6.04%	4.5%	6%	5.26%
SAMPLE C	13.62%	15.095%	15.12%	16.29%

4.5. COMPACTION TEST

This test was performed on the natural soil samples to specify suitable moisture content forfield compaction. The laboratory results are shown in appendix III with the graphs showing the relationship between dry density and moisture content for the soil samples. Sample A has a maximum dry density (MDD) of 1680mg/m^{3}and optimum moisture content (OMC) of 23%, Sample B has MDD of 1525 mg/m^3 and OMC of 32.7% and Sample C has MDD 1452 mg/m^3 and OMC of 31.3%.

4.6. PAVEMENT MODEL TEST

After allowing the model to properly compact, each model was tested by leaving them in the open and letting normal weather conditions such as sunshine and rainfall act on them and then the moisture content of the sub-grade were taken. Below are the average moisture content for sample

Plate 6 – Side view of the pavement models, the 1st on the left without geotextile and the rest with geotextile incorporated

Samples	Weight of can	Weight of can + wet sample(g)	Weight of can + dry sample(g)	Weight of wet sample(g)	Weight of dry soil(g)	Wt of moisture(g)	Moisture content %
Sample A + Geotextile layer	29.3	56.2	50.7	24.9	21.4	3.5	25.7
Sample B + Geotextile	29.7	68.7	62.1	39	32.4	6.6	20.4
Sample C + Geotextile	29.4	46.7	44	17.3	14.6	2.7	18.5
Sample A without Geotextile	30	47.5	43.4	17.5	13.4	4.1	30.6

V. CONCLUSION

From the above analysis taken on both soil sample and material it is of economic benefit to introduce the use of geotextiles in road construction as it reduces the act of "borrowing to fill" when the in-situ soil can easily be enhanced by use of geosynthetics.

Geotextiles are effective tools in the hands of the civil engineer that have proved to solve amyriad of geotechnical problems. With the availability of variety of products with differing characteristics, the design engineer needs to be aware of not only the application possibilities butalso more specifically the reason why he is using the geotextile and the governing geotextile functional properties to satisfy these functions.

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