EXPERIMENTAL INVESTIGATION OF FUNCTIONS OF GEOTEXTILES IN ROAD CONSTRUCTION

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ABSTRACT

The economical development of a country is closely related to its road transport infrastructure facilities available. The periodic maintenance of the road is limited due to cost consideration which will disrupt the service and affect the function of the road. To overcome these constraints, Geotextiles shall be used in pavements to extend the service life of the pavement which requires less repair and maintenance and also reduces the total thickness of the pavement system. In this paper, an attempt is made to enhance the performance of the flexible pavement using woven geotextiles and non-woven geotextiles between the layers of soft subgrade and base course and also effective utilization of fly ash in subgrade for stabilization. Fly ash stabilization along with inclusion of geotextiles increases the California Bearing Ratio (CBR) value in unsoaked and soaked condition. The performance of geotextiles is better when compared to woven geotextiles because of its better puncture resistance when subjected to impact loading and also good drainage properties than woven geotextiles.

Key words: Geotextile, Geosynthetics, Geomembranes, Fly ash and California Bearing Ratio.

1. INTRODUCTION

Geosynthetics 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. They include geotextiles, geogrids, geonets, geomembrane, geosynthetic clay liners, geofoam, geocells and geocomposite. The most popular geosynthetics used are the geotextiles and geomembrane. The 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. Geomembrane is an essentially impermeable membrane in the form of manufactured sheet used widely as cut-offs and liners. A geocomposite is an assembled polymeric material in the form of manufactured sheet or strips, consisting of at least, one geosynthetic among the components, used in geotechnical environmental and transportational engineering applications.

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.
(4) To analyse the results and make appropriate recommendations for optimal use.

1.2 NEED OF THE STUDY

The high rate of erosion and poor drainage system in different parts of the country has led to speedy road degradation and extra costs incurred on road rehabilitation; hence the use of geosynthetics is aimed at controlling this phenomenon. The benefits of a geosynthetic material in any application are defined by six discrete functions: separation, filtration, drainage, reinforcement, sealing and protection. The geotextile acts as a filter through which water passes while it restricts fine-grained soil from entering into coarse-grained soil (sand or gravel) and thus prevent their being washed away and forestall failure of the road.

1.3 SCOPE OF THE STUDY

This work shall be limited to the use of geosynthetics as a soil stabilizer in road construction. It would involve the collection of soil materials and determination of their geotechnical properties both soaked and unsoaked after which the geotextile would be incorporated into the soil sample and their geotechnical properties also determined in both the soaked and unsoaked conditions. The result would be analysed and the effect of the geotextile on the tested soil sample would be evaluated and the appropriate recommendations would be made for their best use.

In developing countries, the use of geosynthetics is relatively new but gaining widespread popularity in construction. Geosynthetics are becoming rapidly popular in construction because of their ability to perform certain necessary functions while offering practical advantages such as:

i. A wide availability of products from the market place
ii. The relative ease of shipping and field handling (flexibility)
iii. Rapid installation techniques, i.e fast speed of construction, without the need for heavy equipment such as earth-moving machines.
iv. Lightweight in comparison with other construction materials, therefore imposing less stress upon the foundation
v. Durability and long life when properly selected
vi. General environment safety, since they will not degrade. (However, there is possibility of degradation if exposed to sunlight and certain highly corrosive chemicals) (Okunade, 2010)

2. TYPES OF GEOSYNTHETICS

Geosynthetics are usually produced either in sheets or in fabric filaments (fibres) with the major variations in their composition, thickness and strength. These are then further worked upon in the production process to produce the construction geosynthetics group. The different types of this geosynthetics group products are geotextiles (geofabrics), geogrids, geonets, geomembranes, geosynthetic clay liners (GCL), geopipes or geotubes, geocells, geofoams, drainage/infiltration cells and geocomposites.

3. METHODOLOGY

The designed methodology is based on previous years of research and experiencein 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 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 procedureBS 1377-2.

3.2.2 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.

4. PAVEMENT MODELING

In modeling forth pavement, four (4) wooden moulds were 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 rammer, 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. The side of the mould with the lower slope was removed. The moisture content of the sub-grade was determined to check the effectiveness of the geotextile placed between the soil layers

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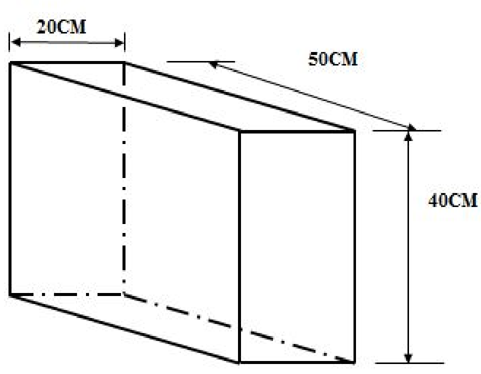


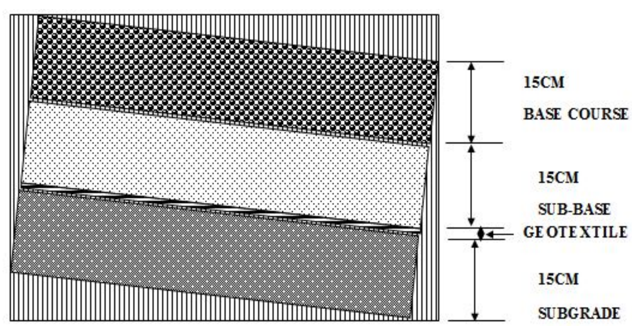
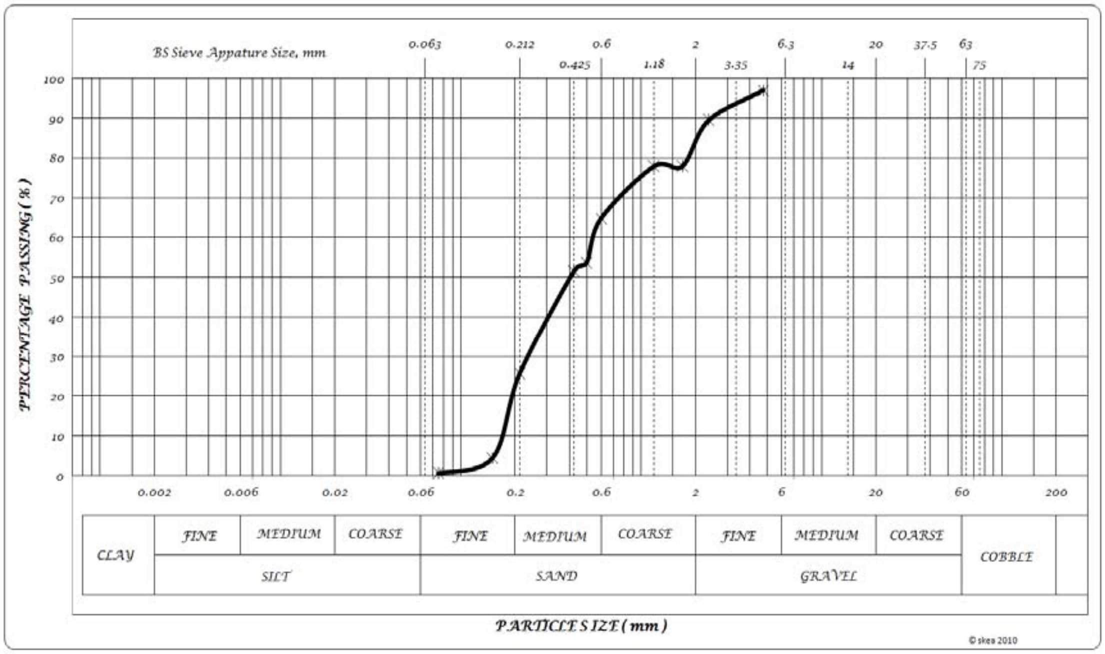


Fig 1: **Mould showing dimensions of the various cross sections**

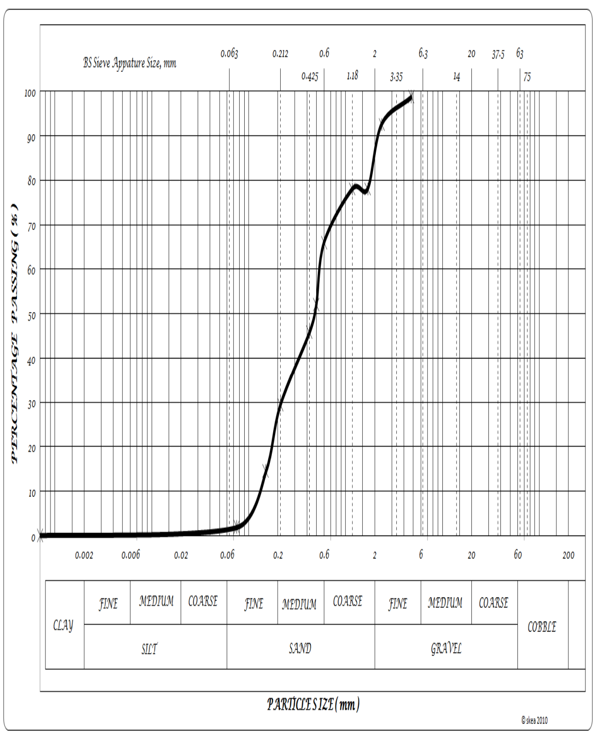
5. RESULTS AND DISCUSSION

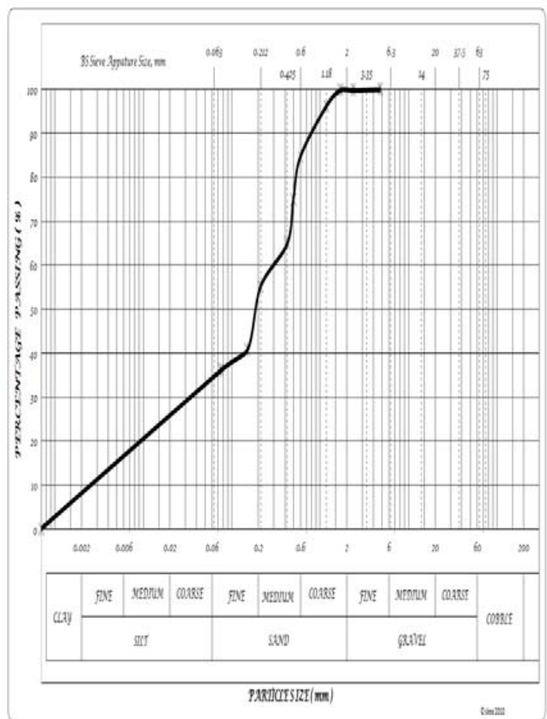
5.1 PARTICLE-SIZE DISTRIBUTION

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.



Graph 1: Particle size distribution graph for Sample A





Graph 2&3: Particle Size distribution graph for Sample B&C

5.2 CALIFORNIA BEARING RATIO

This test was performed on the samples to readily know the true behavior 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

Table 1: CBR result

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%

The low CBR values 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.

5.3 PAVEMENT MODEL TEST

5.4 DRAINAGE 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 samples.

Fig 2: Side view of the pavement models, the 1st on the left without geotextile and the rest with geotextile incorporated

This test was performed by taking the moisture content of the varying sample sub-grades. It was observed that the soil without the geotextile had the higher moisture content after exposure to natural weather conditions

Table 2: Showing the moisture content of the soil sample used as sub-grades with and without geotextile.

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

5.5 SEPARATION TEST:

This test to shows that the geotextile material ensures proper separation of layers in the road section as shown in the plates below

Fig 3: Proper Separation of sub-grade from the sub-base

This helps to prevent the poor subgrade from pumping up into the aggregate base course and it also prevents the aggregate base course from sinking into or mixing with the weaker subgrade material. Plate 8 on the other hand shows an improper separation between the subgrade and the sub-base. From the plate, it is evident that the sub-base has sunk into the subgrade

Fig 4: Merging - Improper Separation of sub-grade from the sub-base

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 differingcharacteristics, the design engineer needs to be aware of not only the application possibilitiesbutalso more specifically the reason why he is using the geotextile and the governing geotextilefunctional properties to satisfy these functions. Design and selection of geotextiles based onsound engineering principles will serve the long-term interest of both the user and the industry.

This project has been able to show the beneficial functions of geotextiles in road construction as sampled on the various soil types. From results gotten it is quite economical to introduce the use of geosynthetics as a whole into the Engineering industry. The material should be used also in effective separation of subgrade and sub-base courses in road construction and other engineering constructions.

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