Utilization Of Geotextile for Soil Stabilization A-Review

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ABSTRACT

The process of enhancing the subgrade soil's load bearing capability and technical qualities to sustain pavements and structures is known as soil stabilization. This study investigated the use of geotextile as reinforcement to stabilize two soil samples (lateritic and clay). Particle size analysis, the Atterberg Limit test, the specific gravity test, the compaction test, and the California Bearing Ratio test were all conducted as part of geotechnical testing. The American Association of State and Highway Transportation Officials (AASHTO) classifies the two soil samples as A-7-6 and A-7-5, which are deemed to be "poor" subgrade materials. To assess the strength of the soil samples, CBR tests were carried out both with and without non-woven geotextiles, with the non-woven geotextiles being positioned in a single layer at a depth of H/4 from the top and base surfaces of the soil. The results revealed that adding non-woven geotextile to the soil increased its strength since it had higher CBR values (15.1% and 19.6%) when placed at depth H/4 from the base surface as opposed to depth H/4 (14.1% and 18.2%) from the top surface. The trial outcomes clearly show that the presence of geotextiles raises the soil's CBR value; as a result, geotextiles should be used as a modernized method of enhancing road construction on subpar soils and to thin out pavement layers.

KEYWORDS: Geotechnical test, stability, reinforcement, and geotextile for pavement.

INTRODUCTION

The strength of the fill material and the subgrade beneath it determines how the road surface will behave. Roads should be built on solid native soil deposits. When removing and replacing those soils is not economically feasible, stabilizing the soil may be required to create a working surface that will allow for the proper construction of the base course gravel layer and the reduction of overall rutting [1].

The most widespread use of stabilization in engineering is in the construction of road and airport pavements, where the main goals are to increase the stability or strength of the soil and to lower the cost of construction [2]. In order to ensure adequate strength to handle the imposed traffic load regardless of unfavorable situations like severe rainfall and flooding, subgrade soil must have a suitable value of CBR. Subgrade soil supports the pavement and acts as the foundation to carry load. However, some subgrade soils have significantly
low and, as a result, incorrect CBR values, making them unable to meet this criterion. In many places across the world, natural soil has a finite strength. As moisture content rises below or up to the point of saturation, the amount of contact and interlock between the aggregate's decreases, lowering the shear strength of the subgrade soil [3].

Geotextiles, geogrids, geomembranes, erosion control blankets and materials, geosynthetic clay liners, geocomposite drainage materials, and geonets are examples of geosynthetics that are frequently utilised in the transportation sector. In terms of transportation engineering, geosynthetic materials primarily serve the purposes of separation, strengthening, filtration, drainage, and functioning as a liquid barrier [4]. Since many years, the primary usage of geotextiles has been as a separator during the construction of roadworks and in the area of stabilization [5]. Geotextiles are planar polymeric materials that are widely employed in roadways for separation and reinforcement in flexible pavement systems. It helps to improve subsurface drainage by providing filtration and drainage and enables the quick dissipation of excess subgrade pore pressures brought on by traffic loading [6]. Over the course of the pavement's intended life, the geosynthetic must, nevertheless, minimize the risk of drainage layer erosion and resist filter clogging. According to the performance requirements, geotextiles are broadly categorized into woven, nonwoven, and knitted constructions. In terms of reinforcement, the woven structure has the advantage that stress can be absorbed by the warp and weft yarns and subsequently by the fibers with little mechanical elongation. Nonwoven fabrics that have been needle-punched are constructed from mixed webs of continuous or staple filaments that have been run through banks of many revolving barbed needles. The tangle of fibers created by the barbs on the reciprocating needles gives the fabrics their mechanical coherence; as a result, they resemble wool felts. Knitted geotextiles are robust yet typically very extensible, whereas needle-punched geotextiles are relatively open and porous structures with high permeability, high elongation, and conformability [7]. Through a fractional interaction between the soil and the geotextile material, a technique for enhancing soil with geotextile increases its stiffness and load carrying capacity. Therefore, if the soil supporting the road crust is weaker, the road's crust thickness will increase, increasing construction costs and increasing the likelihood that the road pavement will fail soon. However, by

using geotextile, this cost can be reduced because the original earth materials found on the construction site are used for the road pavement rather than having to be brought in from a borrow pit [8].
In order to determine the usefulness of the soils in road construction, the results from the assessment of the geotechnical properties of the unreinforced and reinforced soil samples will be compared to the Federal Government of Nigeria specification for road construction [9], as this will direct engineers on the selection of suitable subgrade soils in order to deliver sustainable and cost-effective projects.

METHOD AND MATERIALS

The non-woven geotextile shown in Plate 1 below was purchased from Maccaferri Nigeria Limited, Port-Harcourt. The soil types lateritic and clay were collected from Ogbondoroko borrow pit in Asa Local Government Area (LGA) located on latitudes 8o00 and 9o10 North of the equator and longitudes 2o45 and 4o15 East of the Greenwich Meridian [10] in Ilorin, Kwara State. To stop moisture from evaporating into the atmosphere, soil samples were collected in polythene.

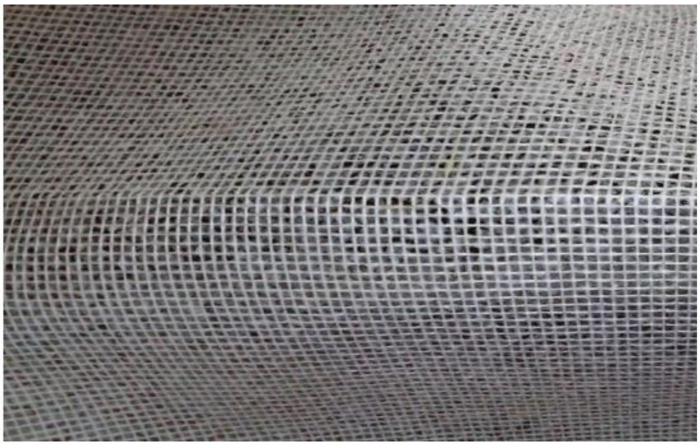

Plate 1: Sample of the non-woven geotextile material used

For the objective of evaluating the appropriateness of the soil for engineering applications, conventional tests were conducted. Following laboratory procedures, several of the necessary geotechnical analyses were completed. These include the California Bearing Ratio (CBR) test, the standard compaction test, the liquid limit, the plastic limit, the plasticity index, and the particle size analysis. This testing was done in accordance with [11] and [12]. A robust metal mould with an interior diameter of 150 mm and a height of 175 mm was used for the compaction testing. Three layers of the soil samples were compacted, with each layer requiring 25 blows from a 2.5 kg rammer dropped from a height of 310 mm. The reinforced non-woven geotextile, as indicated in Figure 1, was put at depths H/4 from the top and base surfaces of the soil in the CBR mould during the CBR tests, which were conducted on compacted soils in a single layer under dry conditions. The loads for penetrations of 0.25 mm, 0.5 mm, 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm, 3.0 mm, 4.0 mm, 5.0 mm, 6.0 mm, 7.5 mm, and 8.00 mm were recorded.

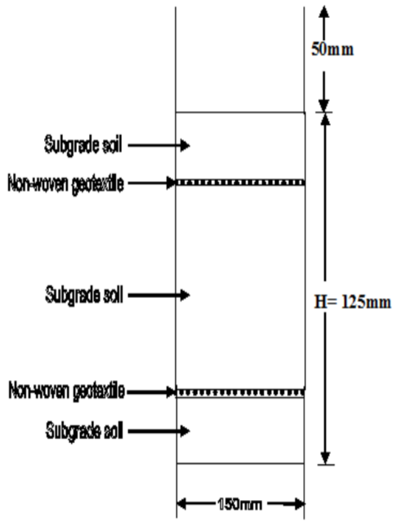

Figure 1: Cross-sectional diagram showing the subgrade soil and non-woven geotextile layers

GEOSYNTHETIC SUBSTANCE

In the CBR mould, soil was interfaced between a non-woven geotextile made of synthetic fibers such polypropylene, polyester, and polyamide at depths of H/4 from the top and bottom surfaces.

Particulars	Non-woven geotextile
Mass per unit area (g/m^2)	203
Grab Tensile strength (N)	710
Puncture Resistance (N)	1820

Table 1: Properties of non-woven geotextile

CONCLUSION AND RESULTS

The results of the analysis of geotechnical parameters of the soil samples are presented and subsequently discussed and for ease of discussion, the results are presented as graphical plots and tables.

SOIL CLASSIFICATION AND SUBGRADE RATING

The virgin soil samples A and B are classified using [11] and are considered as A – 7 – 6 and A – 7 – 5 soils with Group Index Value (G.I) of 7 and 8 respectively. Figure 2 shows the particle size distribution for the virgin soils and AASHTO subgrade rating for this type of soil is 'poor'

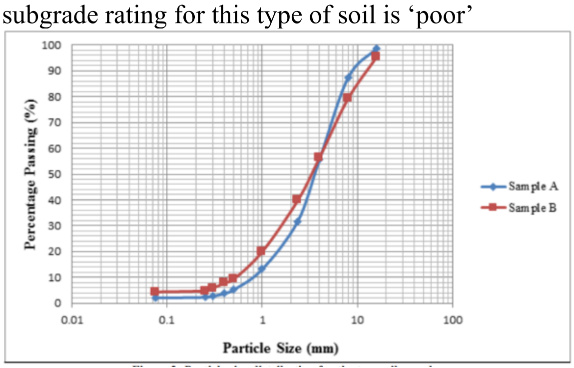

Figure 2: Particle size distribution for the two soil samples

ATTERBERGS LIMIT TEST

According to the findings in Table 2, the liquid limits for soil samples A and B are 35.5% and 43.5%, respectively, while the plastic limits are 20% and 29%. According to [14], a liquid limit of less than 35% denotes low plasticity, between

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35% and 50%, intermediate plasticity, between 50% and 70%, strong plasticity, between 70% and 90%, very high plasticity, and greater than 90%, extremely high plasticity. This shows that the two samples have intermediate plasticity, and that the regulatory standards for construction materials are regarded to be met for plastic limits that do not exceed 33%. In contrast, the two soil samples with plasticity indices of 15.3% and 14.1% are typically higher than the 12% specified by the Nigerian Government Standard Specification of subgrade soils for roads and bridges, which is considered to be a poor standard.

MOISTURE CONTENT, SECTION

The soil samples A and B had moisture contents of 17.9% and 19.3%, respectively (Table 2), and based on the results observed, it can be assumed that the moisture content is high. The implication of a high moisture content is that the soil might exhibit a reduced strength [15].

Particulars	Sample A	Sample B
Liquid limit (%)	35.50	43.50
Plastic limit (%)	20.20	29.40
Plasticity index (%)	15.30	14.10
Moisture content (%)	17.90	19.30
Specific gravity (g)	2.70	2.63
Optimum Moisture Content (O.M.C) (%)	14.50	12.00
Maximum Dry Density (M.D.D) (g/cm^3)	1.35	1.39

Table 2: Summary of some geotechnical properties

SPECIFIC GRAVITY

Samples A and B have specific gravities of 2.70 and 2.63, respectively (Table 2), indicating that these values are within the ranges for lateritic soil (2.50 - 2.75) and clay soil (2.60 - 2.90) [16]. Since soils used for building must have a specific gravity of at least 2.25, this is regarded as being acceptable high, and the mineral makeup of the crystalline rock may have contributed to the comparatively high specific gravity readings.

TEST COMPACTION

This test was conducted to determine the link between the soils' Maximum Dry Density (M.D.D.) and Optimum Moisture Content (O.M.C.) for a given compactify effort and the maximum quantity of water required to increase the strength or load-carrying capability of the soil. These numbers are shown in Table 2, and Figure 3 shows the dry density vs. moisture content connection curves for virgin soil.

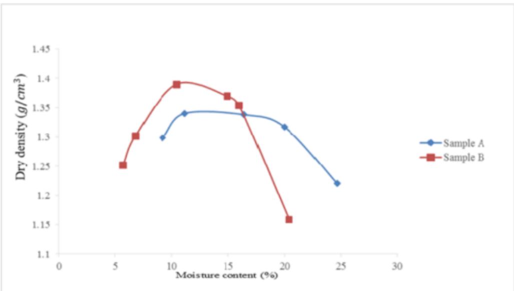

Figure 3: Dry density – Moisture content relationship of the soil samples

CALIFORNIA BEARING RATIO (CBR) TEST

The CBR is a semi-empirical test that is frequently used to estimate the subgrade soils' bearing capacity for pavement design [17]. It quantifies the resistance a mass of soil presents to a plunger's penetration at a certain density and moisture level. The CBR rating increases as soil penetration becomes more challenging. Table 3, Figures 4 and 5, and unsoaked CBR data with and without reinforcement are shown. The CBR values increased significantly after the non-woven geotextiles were added compared to the CBR values before the non-woven geotextiles were added. Figure 5 makes it abundantly evident that, regardless of the placement depth, the CBR values rise as a result of the use of non-woven geotextile. Additionally, it was found that even though the CBR values increased in all cases, the percentage increase was much higher when the non-woven geotextile was placed at depth H/4 in the top and base regions for Sample B. However, this sample performs best when non-woven geotextile is placed at depth H/4 from the base region. This could be explained by the fact that the diameter of the plunger determines the depth through which the effective pressure bulb travels. If the non-woven geotextile is introduced at depths below the depth of the pressure bulb, a significant improvement can be seen. In accordance with the Nigerian Government's standard specification for subgrade soils for roads and bridges [9], Table 4 compares the geotechnical characteristics of soil samples with and without non-woven geotextile. The strength requirements for subgrade soils are met by soil samples A and B when reinforced with non-woven geotextile, according to [9], which advises that soil used in road construction must have at least a 10% CBR value.

Soil samples	Without non-woven geotextile		CBR value (%)	With non-woven geotextile		CBR value (%)
	2.5mm	5.0mm		2.5mm	5.0mm	
Sample A	3.6	4.0	4.0	14.3	14.9	15.0
Sample B	6.0	6.6	7.0	20.5	17.4	21.0

Table 3: Summary of the CBR values (Unsoaked condition)

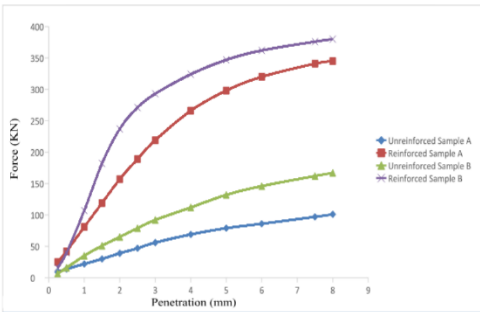

Figure 4: CBR values for reinforced and unreinforced soil sample

FLEXIBLE PAVEMENT DESIGN

The combined action of the pavement's several layers, where the load is delivered immediately to the wearing course and then spread with depth through the base, subbase, and subgrade layers until finally reaching the ground, results in the structural capacity of flexible pavements. The quality of top and upper layer materials is superior since the tension caused by traffic load is greatest at the top, and the subgrade layer is in charge of transferring the weight from the top layers to the ground. Flexible pavements are built so that the load communicated to the subgrade won't be greater than what it can support. As a result, the CBR of the soil influences the thickness of the layers (subbase and base course), which in turn impacts the price of the pavement. For instance, using curve A from Figure 6 with the lowest traffic volume, it can be seen that sample B has pavement thicknesses of 9 cm and 17.5 cm when reinforced with non-woven geotextile and 7% when unreinforced with non-woven geotextile. This shows that an increase in CBR values causes the pavement layer thicknesses to decrease, lowering the cost of road construction.

CONCLUSION

The study looked into the use of non-woven geotextile as a kind of reinforcement in subgrade materials for roads. The geotechnical qualities of the two soil samples were assessed to see whether they were suitable for use as a subgrade. The results indicated that the virgin soil samples A and B, which are classified as subgrade materials A-7-5 and A-7-6 by the American Association of State and Highway Transportation Officials (AASHTO), are substandard. The California Bearing Ratio (CBR) Test revealed that the two soil samples reinforced with non-woven geotextile had higher CBR values in an unsoaked condition (15% and 21%) than they had without reinforcement (4% and 7%), indicating that the soil samples are suitable for subgrade in accordance with the Federal Ministry of Works General Specification (1997) criteria for subgrade.

Additionally, regardless of the depth at which the non-woven geotextile is positioned within the thickness of the subgrade, the application of non-woven geotextile at various depths generally increases the strength of the subgrade soil as evaluated by the California Bearing Ratio (CBR). The non-woven geotextile performs best at a depth of H/4 from the base surface because this results in the greatest increase in the strength of the soil samples, which will help to lower the cost of the pavement thicknesses. However, the depth at which the non-woven geotextile is placed determines its effectiveness as reinforcement.

Because geotextile reinforced soils are durable, non-biodegradable, and improve the ultimate service life of the pavement, they perform better than traditional soil under dynamic loadings. Therefore, it should be applied to improve a subgrade material's performance in a pavement system.

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