Effect of Compactive Effort on Compaction Characteristics of Lateritic Soil Stabilized With Terrasil

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***Abstract*—A laboratory study on the influence of compactive effort on the compaction characteristics of laterite soil treated with 2, 4, 6, 8 and 10% terrasil by dry weight of the soil and compacted using the energies of the British standard light (BSL), West African Standard (WAS) and British standard heavy (BSH) were undertaken. The laterite soil was classified as A-6 with respect to the American Association of States Highway and transportation Officials (AASHTO) classification system and CL according to Unified Soil Classification System (USCS). The Liquid limit, plastic limit, plasticity index and shrinkage limit generally decreases with increasing terrasil content. The MDD values recorded for the natural soil for BSL, WAS and BSH compactive effort are 1.84, 1.88 and 1.90Mg/m^3 respectively while peak values of 1.90, 2.01 and 2.02 Mg/m^3 was recorded at 4%, 6% and 6% terrasil treatment respectively. The OMC values recorded for the natural soil for BSL, WAS, and BSH compactive effort are 17.30%, 16.50% and 15.09% respectively. For the WAS and BSH compactive effort, the OMC decreases with increasing terrasil content up to 6% after which it increases while for the BSL compactive effort, the least value of OMC was recorded at 8% terrasil content. For the terrasil stabilize lateritic soil an average increase in MDD with increasing energy level was observed and BSH compactive effort at an optimal blend of 6% terrasil is recormended for use as sub grade material**

Keywords—Optimum moisture content(OMC), Maximum dry density (MDD), British Standard Light (BSL), West African Standard (WAS), British standard Heavy (BSH),Compaction.

INTRODUCTION

Lateritic soils are generally used for road construction in Nigeria. According to Alhassan (2008), Lateritic soil in its natural state generally have low bearing capacity and low strength due to high content of clay. When lateritic soil contains a large amount of clay materials its stability and strength cannot be guaranteed under load in presence of moisture. The improvement in strength and durability of lateritic soil then become imperative, this has geared researchers towards using stabilizing materials that can be sourced locally at a very low cost (Bello, *et al*., 2015). Also where in most cases sourcing for alternative soil may prove economically unwise, stabilizing the available soil to meet the desired objective becomes a viable option (Osinubi K. , 1999).

Soil stabilization is a process by which the geotechnical characteristics of the virgin soil get improved through mechanical or chemical process by use of additives. Current trend for enhancement of engineering properties of soil is stabilization through deployment of different additives, especially industrial wastes which in turn create scope for best utilization of abundantly available industrial waste at a substantially low cost. Further, stabilization not only increases the strength and durability of soil but also plays major role in prevention of soil erosion in the controlled media. Stabilization can be achieved by use of thermal, electrical, mechanical or chemical methods. The first two methods are rarely used. However, mechanical and chemical stabilization have gained popularity because, these are easy to handle as well as to manage in any construction environment.

With technological advancement, new materials are emerging for soil stabilization. Such material include nano-chemicals such as terrasil which is use as admixture in the present study. Terrasil is a nanotechnology based 100 percent organosilane, water soluble, ultraviolet and heat stable, reactive soil modifier use to waterproof soil subgrade. It reacts with water loving silanol groups of sand, silt, clay and aggregates to convert it to highly stable water repellent alkyl siloxane bonds and forms a breathable in-situ membrane. It resolves the critical sub-surface issues (Rintu and Kodi, 2015). It is water soluble, chemically reactive and non-leachable and works well with all silicate containing materials. It can be applied to almost all types of soil. Terrasil being a Nano modification keeps the pores open to allow vapours to escape while preventing water to come in. Nanochemicals can be identified as environmental friendly since they conserve limiting resources like aggregates and bitumen. They also allow the use of in-situ soils minimizing use of fuel for transporting good soils over long distances (Ajay, 2014).

When soils are stabilized, they are usually compacted before any construction can be carried out on them. This is to achieve the desired densification and strength improvement as a loosely packed soil cannot attain the desired objective without densification (Joel and Joseph, 2015). The compaction of soil plays an important role in construction of structures, highways and airports. Proctor in 1933 developed a laboratory compaction test to determine the maximum dry density of compacted soils, which can be used for specifications of field compaction (Ogunsanwo, 1990). The different compaction effort is one of the other important factors that affect the compaction of a soil. Besides that, the compaction of soils also influenced by the soil type, the moisture content and other factors. The laboratory compaction characteristics of the soil influence the selection of criteria to evaluate the field compaction. These criteria are often characterized by setting a minimum deviation interval for the field dry density and moisture content compared with the laboratory obtained standard compaction curve, especially the two key parameters: maximum dry density and optimum moisture content (Indraratna, *et al*., 2012). The need for adequate and reliable geotechnical characterization of soils in different compaction energy level is very important in controlling the soil properties of earth constructions. However, only very limited studies have investigated the effect of compaction energy on certain geotechnical properties of lateritic soil stabilized with terrasil. This study evaluates the influence of different compactive effort on compaction characteristics of lateritic soil stabilized with terrasil. The results obtained are assessed with a view to determining the percentage of terrasil mixed with laterites that yield optimum compaction when compacted at the different energy.

MATERIALS AND METHODS

A. Soil

The soil used for this study was collected by method of disturbed sampling at average depths of 1 – 1.2m around Obanla area of Federal University of Technology Akure (FUTA). The samples were collected in large bags while a sizeable amount was collected in an airtight polythene bag in order to obtain the natural moisture content upon returning to the laboratory. All soil samples were transported to the Geotechnical laboratory of the Federal University of Technology Akure (FUTA) for subsequent tests.

B. Terrasil

Technical specifications are shown in Table 1. A simplified diagram of the reaction mechanism of Terrasil with soil is shown in figure 1. Soil when treated with Terrasil forms Si-O-Si bonded nano-siliconize surfaces and converting water loving Silanol groups to water repellent Alkyl Siloxane groups in soil

Table 1: Technical specifications of Terrasil

Property	Description
Appearance	Pale Yellow Liquid
Solid Content	68±2%
Viscosity at 25^{0}C	20-100cps
Specific gravity	1.01
Solubility	Forms water clear solution
Flash Point	Flammable 12ºC
Terrasil : Water	1: 200ml
Dosage	2% to 10% at 2% interval by weight of dry soil

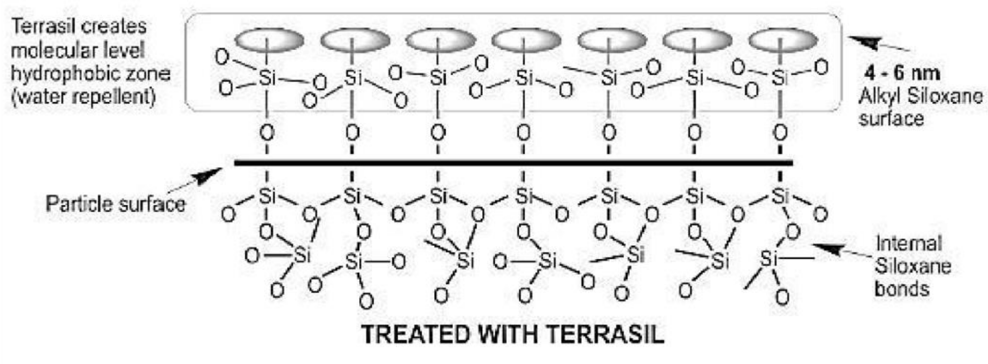

Figure 1 Reaction mechanism of soil treated with Terrasil

METHODS

A. Properties Test

Index properties tests on the natural were carried out in accordance with BS 1377 (1990) and BS 1924 (1990).

B. Atterberg Limits

The Atterberg limits consisting of liquid limit, plastic limit, shrinkage limit and plasticity index were determined in accordance with the British Standards BS 1377 (1990) and BS 1924 (1990) for the natural and treated soil respectively.

C. Compaction

All the compactions involving moisture-density relationships were carried out using energies derived from the British Standard Light (BSL), West African Standard (WAS) and British standard Heavy (BSH) energies. The BSL compactions was carried out using energy derived from a rammer of 2.5kg mass falling through a height of 30cm in a 1000cm^3 mould. The WAS compaction, was carried out using energy derived from a rammer of 4.5kg mass falling through a height of 45cm in a 1000cm^3 mould. The soil was compacted in five layers, each layer receiving 10 blows. Finally, the BSH compaction moisture density relationships were determined using energy derived from a hammer of 4.5kg mass falling through a height of 45cm in a 1000cm^3 mould. The soil was compacted in 5 layers, each receiving 27 blows.

RESULTS AND DISCUSSION

A. Index Properties

Results of tests carried out on the natural soil are summarized in Table 2. The soil is classified as A–6 in the AASHTO classification system and CL in the Unified Soil Classification System, USCS. The soil is reddish brown in colour with liquid limit of 38.00 % plastic limit of 22.18 % and plasticity index of 15.82 %.

Table 2: Index Properties Results of Natural Lateritic Soil

Property	**Value/Description**
Percentage passing BS sieve No. 200	44.56 %
Liquid Limit %	38.00
Plastic Limit %	22.18
Plasticity Index %	15.82
AASHTO Classification	A-6
USCS classification	CL
Specific Gravity	2.20
Colour	Reddish Brown

B. Atterberg Limits

Figure 2 shows the relationship between atterberg limit and terrasil content. With the addition of terrasil, the Liquid limit decreases from 38.00% for the natural soil to 30.60% at 10% terrasil. The plastic limit and shrinkage limit generally decrease from 22.18% and 12.1% for the natural soil to 17.8 and 7.1 respectively at 10% terrasil while the plasticity index decrease from 15.80% for the natural soil to 12.20% at 8% terrasil content.

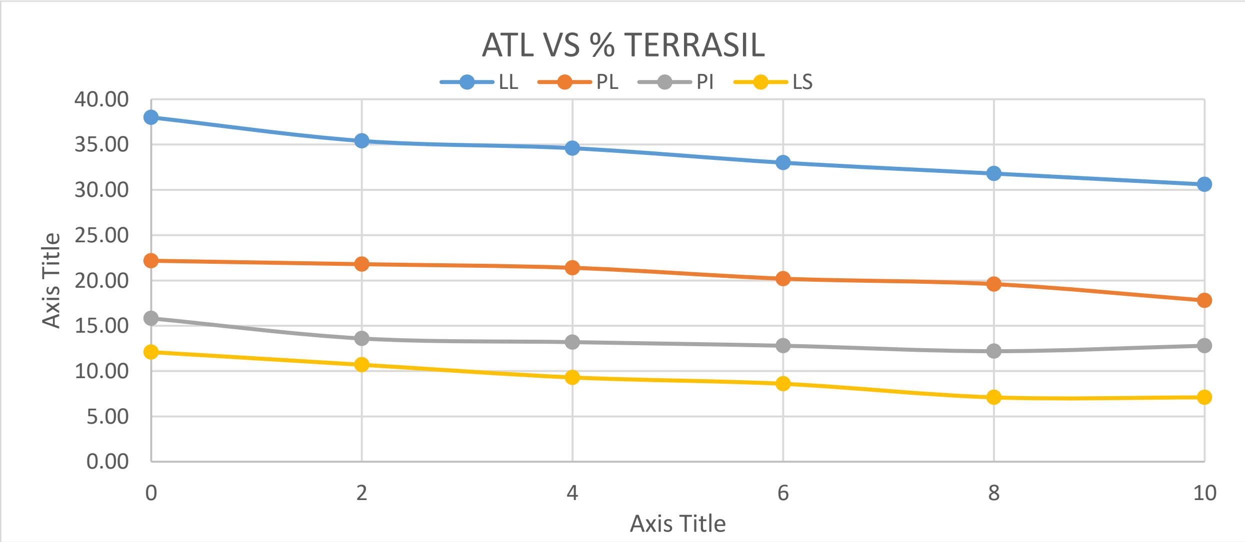

Figure 1: Variation of Atterberg limit with Terrasil content

C. Compaction Characteristics

Maximum Dry Density

Figure 3 show the variation of maximum dry density with terrasil content for BSL, WAS and BSH compaction. The result shows that the MDD value for the BSL compaction initially increase from 1.84Mg/$m^3$for the natural soil to 1.90Mg/m^3 at 4% Terrasil after which it decrease with increasing terrasil content having a value of 1.80 Mg/m^3 at 10% terrasil content. For the WAS and BSH compaction the MDD value initially increase from 1.88Mg/m^3 and 1.93Mg/m^3 for the natural soil to 2.01Mg/m^3 and 2.02 Mg/m^3 respectively at 6% terrasil after which it decreases with increasing terrasil with values of 1.83 Mg/m^3 and 1.94 Mg/m^3 recorded at 10% terrasil content. The compaction results also show that there is an average increase in MDD with increasing energy level.

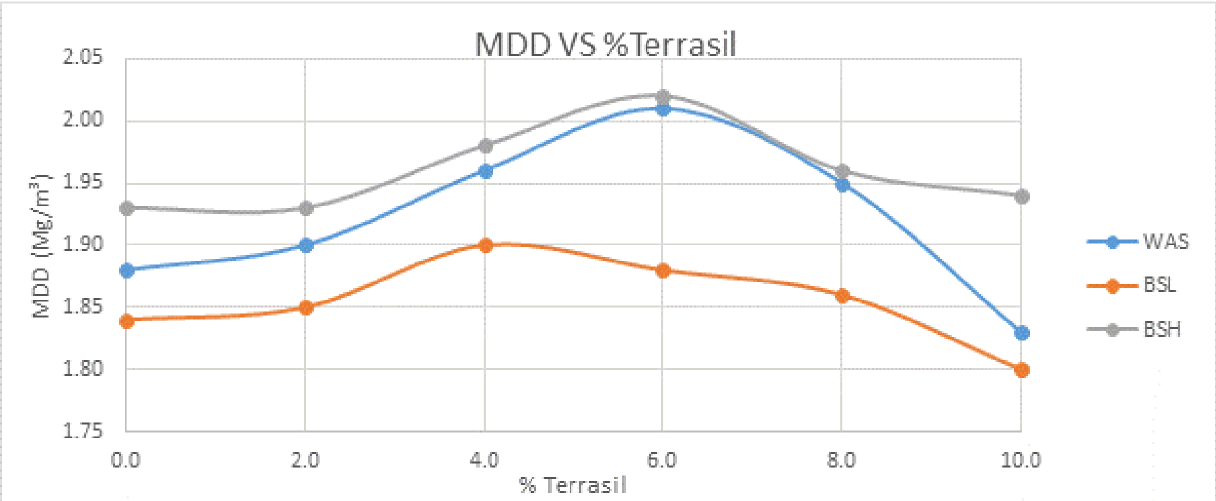

Figure 3: Variation of MDD with Terrasil content for BSL, WAS and BSH compactive effort

Optimum Moisture Content

The variation of optimum moisture content (OMC) of terrasil stabilized lateritic soil for BSL, WAS and BSH compactive efforts is shown in Figure 4 The result shows that with the addition of terrasil for the WAS and BSH compaction, the OMC initially decrease from 16.50% and 15.09% for the natural soil to least values of 15.20% and 14.12% at 6% terrasil then increase to 18.15% and 16.94% at 10% terrasil respectively. For the BSL compaction, the OMC decrease from 17.30% to 13.69% at 4% terrasil then increase to 17.00% at 6% terrasil after which it reduces to 13.00% at 0.8% terrasil

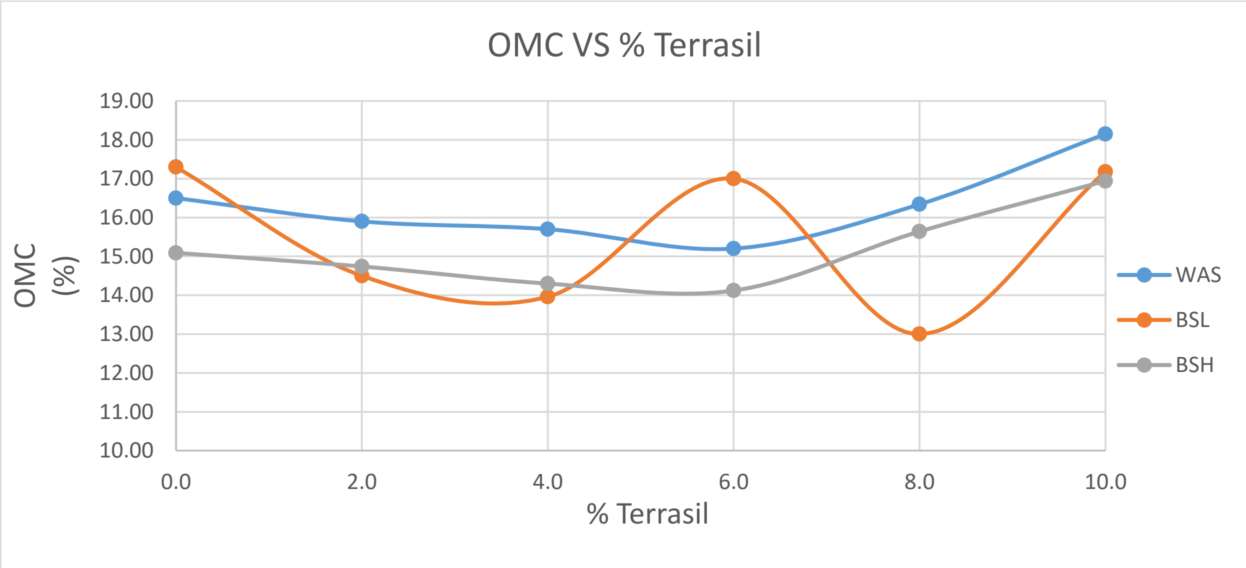

Figure 4: Variation of OMC with Terrasil content for BSL, WAS and BSH compactive effort

CONCLUSIONS

The following conclusions can be drawn from the study,

I. The soil is classified as A-6 in the AASHTO rating and CL in the Unified Classification System

II. Liquid limit, plastic limit, shrinkage limit and plasticity index decrease with increasing terrasil content.

III. The maximum dry density (MDD) for the BSL energy level initially increase to a maximum value of 1.90Mg/m^3 at 4% terrasil after which it decrease with increasing terrasil content while the optimum moisture content (OMC) initially decreases to 13.96% at 4% terrasil and then increases to 17.00% at 6% terrasil after which it decreases again to 13.00% at 8% terrasil content and have a value of 17.18 at 10% terrasil

IV. The maximum dry density (MDD) for the WAS energy level increase initially to peak value of 2.01Mg/m^3 at 6% terrasil after which it decrease with increasing terrasil content while the optimum moisture content (OMC) initially decreases to a least value of 15.20% at 6% terrasil and then increases with increasing terrasil content.

V. The maximum dry density (MDD) for the BSH energy level initially increase to a peak value of 2.02Mg/m^3 at 6% terrasil after which it decrease with increasing terrasil content while the optimum moisture content (OMC) initially decreases to a least value of 14.12% at 6% terrasil after which it increases with increasing terrasil content.

VI. The MDD shows an average increase with increasing compactive effort.

REFERENCES

AASHTO (1986): “Standard Specifications for Transportation, Material and Method of Sampling and Testing” 14 Edition, American Association of State Highway and Transportation Official Washington D.C.

Ajay, I. R. (2014). Sustainability through Innovation. In *Smart Construction* (pp. 25-27).

Alhassan, M. (2008). Potential of rice husk ash for soil stabilization. *AUJT*, *71*(4), 247-250.

Bello, A. A., Ige, J. A., & Hammed, A. (2015). Stabilization of Lateritic Soil with Cassava Peels Ash. *British Journal of Applied Science and Technology* , *7*(6), 642-650.

BS 1377. (1990). "Methods of testing soils for civil engineering purposes". British Standard Institute, London.

BS 1924. (1990). "Methods of tests for stabilized soils". British Standard Institute, London.

Indraratna, B., Heitor, A., & Rujikiatkamjorn, C. (2012). *Effect of compaction energy on shear wave velocity of dynamically compacted silty sand soil.* .

Joel, M., & Joseph, E. E. (2015). Comparative Analysis of Cement and Lime Modification of Ikpayongo Laterites for Effective and Economic Stabilization. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)* , *6*(1), 49-56.

Ogunsanwo, O. (1990). Geotechnical properties of undisturbed and compacted amphibolite derived laterite soil. *Bulletin of the International Association of Engineering Geology*, *42*(1), 67-70.

Osinubi, K. (1999). Evaluation of Admixture Stabilization of Nigeria Black Cotton Soil. *Nigerian Society of Engineers Technical Transaction, 34*(3), 88-96.

Osinubi, K. J. (1997). Soil stabilization using phosphatic waste. *In Proc. of 4th Regional Conference on Geotechnical Engineering, GEOTROPIKA 1997*, (pp. 225 -244). Johor Bahru, Malaysia.