STABILITY OF PALM KERNEL SHELL AND STONE DUST POWDER AS A LOCAL MATERIAL FOR ROAD CONSTRUCTION

[1]Joseph Oluwatosin Funke[a] *, Joseph Deborah Tolani[b], and Ayoola Johnson Oluwaseyi[c]

[a]Department of Civil Engineering Kogi State Polytechnic, Itakpe Campus, Nigeria..

[b]Department of Hospital Sisters Health System (HSHS), Springfield Illinois, USA.

[c]Department of Civil and Mining Engineering Confluence University of Science and Technology, Osara, Nigeria..

Abstract

This project is aimed to determine the impact of Palm kernel shell (PKS) and stone dust waste (SDP) as a local material in improving poor soil, in order to reduce the cost of expensive materials in road construction and to help to provide good strength for the sub grade and sub base material. Sieve Analysis, Atterberg Limit, Moisture Content, Specific Gravity, Compaction and California Bearing Ratio (CBR) were conducted on natural and stabilized soil mixture. The natural soil (A-7-6) was blended with stone dust waste (SDP) and palm kernel shell (PKS) at varying proportion of 2%, 4%, 6%, 8%, and 10% by dry weight of soil respectively. Inclusion of additives increase the Maximum Dry Density (MDD) at 6 and 8% while it predominantly decreases the Optimum Moisture Content (OMC) values of the stabilized soil mixture. The plasticity index of samples decreased from 2 % to 8 % which indicates that the additives of SDP and PKS improves the engineering characteristics of deficient soil and reduces its plasticity index at 8 %. The trend of variation of CBR with an increase in percentage of SDP and PKS showed a decrease in CBR from 0 to 2 %, after which the values increased at 4 to 8% and reduced at 10 % of SDP and PKS. Soil blended with 8% SDP and PKS offered the best result with increase in MDD (1.920 g/cm^3) and CBR (34 %). The potential of these additives improves soil properties and reduces construction cost of road as a cheap stabilizing agent for lateritic soil for sub-grade purposes.

Keywords: *Stabilization, Lateritic soil, Stone dust powder and Palm kernel shell*

1 Introduction

The rate of development in civil engineering construction in developing nations like Nigeria is highly discouraging due to the daily geometrical increase in the cost of materials needed in road construction. Road construction projects are inherently unpredictable and complex due to the dynamic nature of site operations and uncertainties related to weather, soil characteristic and site conditions [1].

The necessity of borrowing materials (lateritic soil) for use in areas where the prevalent soil is not favorable for construction has over the years caused a continuous increase in the cost of borrowing and transporting these materials. Sometimes there is need to stabilize the prevalent soil on site and the cost of stabilization is determined to a large extent from the optimal quantity of stabilizing agent required for effective stabilization [2]. Most available laterite are not suitable for use in road construction, the importation of suitable materials from other locations may result to additional costs, a factor responsible for high cost of road construction [3].

Stone dust powder is a waste material obtained from crusher plant. Stone powder produced from stone crushing zones appears as a problem for effective disposal. Palm kernel shell (PKS) is a by-product of the oil palm fruits. The oil palm plant (Elaeis guineensin) comes from West Africa, where it grows in the wild and has developed into an agricultural crop, the palm kernel shell, which is the crushed shell housing the palm kernel seed, is an economically valuable tree that is widespread throughout the tropics [4].

The palm kernel shell can be regarded as a natural pellet and a high grade solid renewable fuel for burning. It can be combined with steam coal or burned at biomass power plants; it is usually blended with other grades of biomass. The palm kernel shell contains silicates that form a scale in boilers if too much shell is fed into a furnace. The residual shell is disposed of as gravel for the maintenance of plantation roads. They are yet to be utilized to a great extent as a construction material, but blended palm kernel shells have been used to modify lateritic soil because of their good interlocking characteristics, low specific gravity, and high porosity. Research has been conducted to see whether they can make suitable stabilizing agents for the improvement of soils for civil engineering construction [5]. According to Adeyemi and Joseph [6], palm kernel shells have very low ash and Sulphur content.

2 Methodology

The materials used for the research work is laterite soil, which was obtained from Osara- Itakpe road by disturbed sampling method in accordance to BS 1377 (2016) standard procedure for sample collection, Kogi State. Palm kernel shell was obtained at Ikare, Ondo State, and the stone dust waste was obtained in Lokoja.

This research work was carried out using standard laboratory methods in collecting and testing samples. The laboratory tests performed on the natural soil to determine its engineering properties were in accordance with BS 1377 (2016) while BS 1924 (2018) was used for the stabilized soil. The laboratory tests carried out are; Natural moisture content, Sieve analysis, Specific gravity, Atterberg's limit (liquid limit, plastic limit and plasticity index tests), Compaction and California Bearing Ratio (CBR). The stabilized laterite was mixed with the addition of SDP and PKS ranging from 2-10 % of additives.

3 Results and Discussion

A. Index Properties

The soil index properties result is shown on Table1. The natural soil was classified as A-7-6 soil according to American Association of State Highway and Transportation Officials (AASHTO) standard, and Clay of Low Plasticity (CL) according to Unified Soil Classification System (USCS). Sieve analysis graph for natural soil is presented on Fig.1 This soil, according to Nigeria General Specification for Roads and Bridge Works [7] cannot be used as sub-grade and sub-base courses for road pavement structures and will require stabilization to improve its strength and durability.

TABLE 1: Physical Properties of Natural Soil

Properties	Values
Moisture Content (%)	16.82
Maximum Dry Density (g/cm^3)	1.89
Percentage passing BS 0.075mm (%)	46.00
Liquid limit (%)	43.20
Plastic limit (%)	23.33
Plasticity Index (%)	19.87
Specific Gravity of Natural Soil	2.17
Specific Gravity of Stone Dust Waste	2.85
Specific Gravity of Palm Kernel Shell	4.05
California Bearing Ratio (CBR) %	10 %
AASHTO Classification	A-7-6
USCS Classification	CL

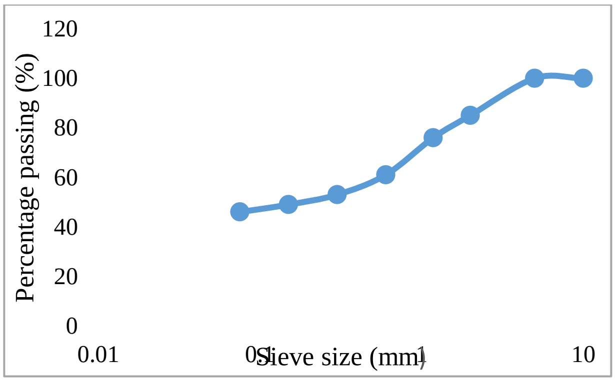

Fig.1: Sieve Analysis Graph

TABLE 2: Summary of Stabilized Laterite Soil Containing 2-10 % of SDP and PKS

Composition	AASHTO	S. G	LL (%)	PL (%)	PI	MDD (g/cm^3)	OMC (%)	CBR (%)
0 (%)	A-7-6	2.17	43.20	23.33	19.87	1.896	30.20	10
2 %	A-7-6	1.92	43.50	25.00	19.50	1.707	23.73	7
4 %	A-7-6	1.81	46.40	38.88	17.52	1.889	13.00	12
6 %	A-2-7	1.68	49.00	34.44	14.56	1.917	20.06	23
8 %	A-2-5	1.74	50.50	43.33	7.17	1.920	17.50	34
10 %	A-7-6	1.60	61.00	23.33	37.67	1.870	32.50	10

B. Specific Gravity Results

The specific gravities of natural soil, SDP and PKS were 2.17, 2.85 and 4.05 respectively, while the addition of SDP and PKS resulted in the reduction of its specific gravity as presented in Fig. 2. The increase in SDP and PKS is responsible for the progressive decrease in the specific gravity of the soil-SDP/PKS mixture. This could be considered as an enhancement for the soil property for different geotechnical practices.

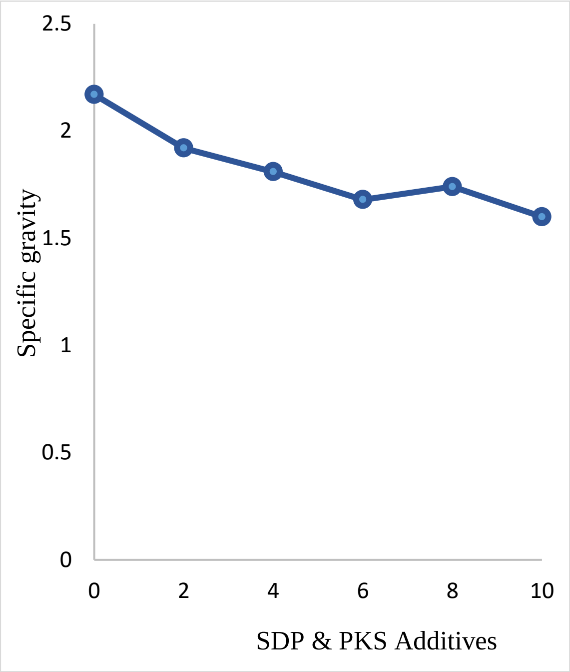

Fig. 2: Specific gravity result with 0 to 10% additives of SDP and PKS.

C. Atterberg Limit Results

Fig. 3 shows an increase in plastic limit and liquid limit, while the plasticity index of the soil decreased with increasing percentage of SDP and PKS from 2 to 8% which indicates that it makes the soil more workable [6]. But consistency limits results do not meet the requirements for subgrade material from 2 to 10%, which is specified as; PI < 12% [8].

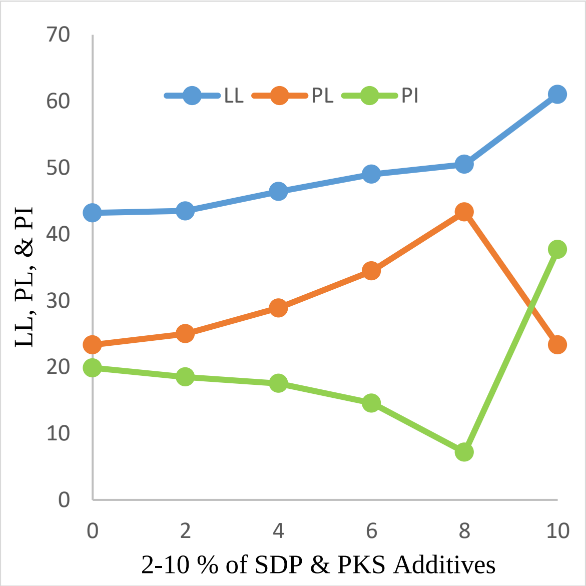

Fig. 3: Atterberg's limit graph.

D. Compaction result

Compaction was carried out on the soil mixed with 2-10 % of SDP and PKS by weight of dry soil. Variations of MDD with a change in SDP and PKS composition are presented on Fig. 4. The trend of variation of OMC with an increase in percentage SDP and PKS in Fig.5 shows a decrease in OMC from 2 to 8 %, after which the values increased at 10 %. This trend is attributed to reduction in OMC due to a reduction in the lateritic soil containing a substantial number of fines.

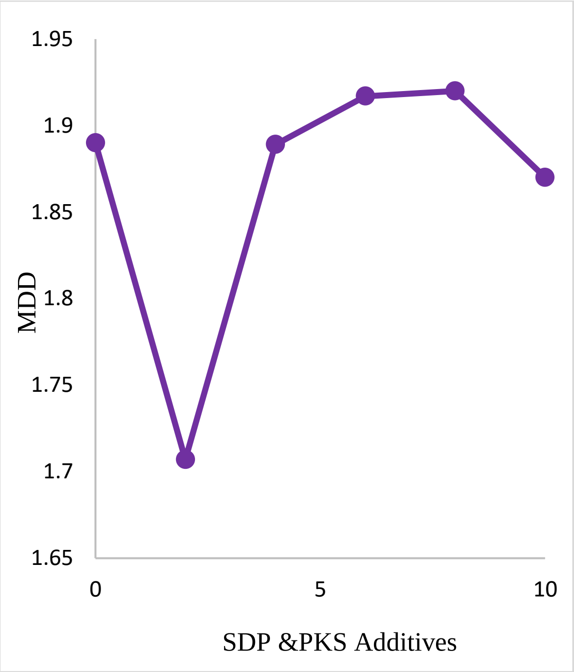

Fig. 4: MDD Graph

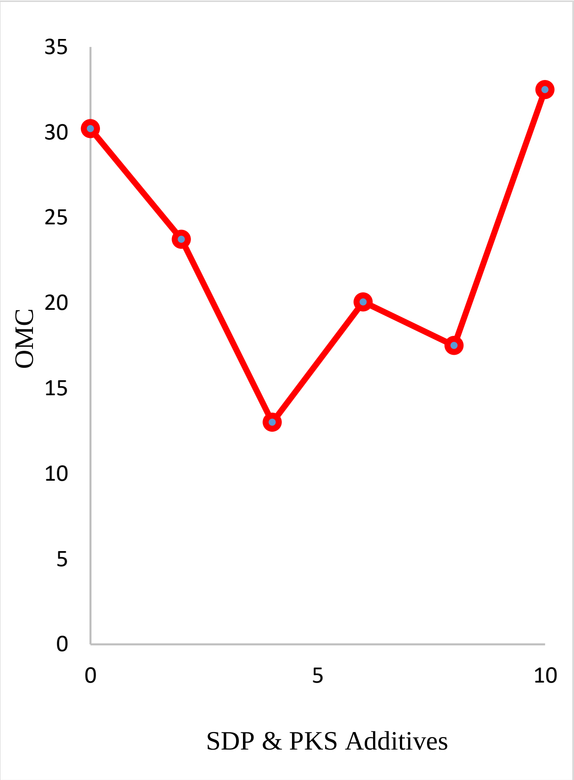

Fig.5: OMC Graph

E. CBR Results

The effect of the application of SDP and PKS on the CBR of the soil is graphically presented in Fig. 6. The stabilized lateritic soil shows an increase at 6 and 8% additives of SDP and PKS. The highest values for the stabilized soil are 34 % at 8% of SDP and PKS. Therefore, the optimum percentage of stabilized soil sample is 8 % based on the highest CBR value. The addition of SDP and PKS to the soil increased its CBR, meaning that the capacity of the soil to bear load is subject to it increased.

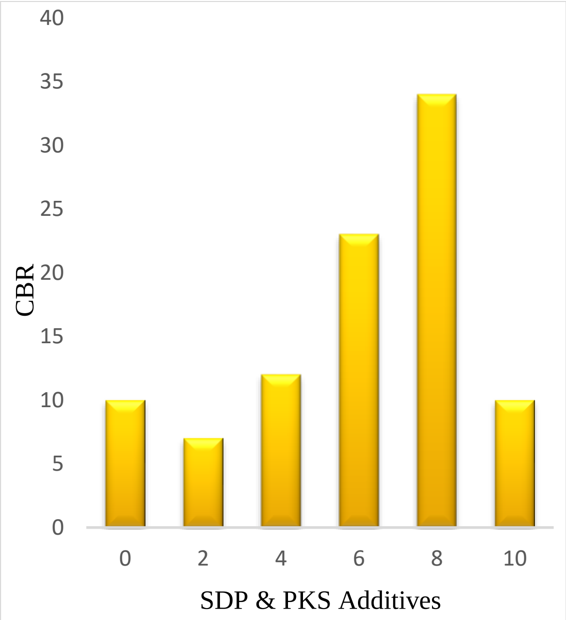

Fig. 6: CBR Graph Result

4 Conclusion

Base on result obtained from various experiment carried out on borrow pit sample. The following conclusions are drawn from the study.

i. The soil sample was classified according to AASHTO soil classification system to be (A-7-4) sub group.

ii. The addition of SDP and PKS increases the plasticity index of the soil.

iii. SDP and PKS decreases the OMC from 2% to 8% but increases the MDD of the soil. This confirms that the activity of the mixture increased with the addition SDP and PKS at 8% improves the strength of the soil efficiently at which the CBR is increased.

Conclusively, it is recommended that the 8% of SDP and PKS should be used as a stabilizing agent for sub-grade construction. More effort should be made in identifying other possible sources of waste as soil stabilizing material that will be environmentally friendly and cost effective.

References

[1]. K. Mohamad, C. Rajiv, D. Nashwan and B. Claudio, "Road construction project: An integrated and interactive visual tool for planning earth work operations". *Proceedings of the 13th International Conference on Construction Application of Virtual Reality, London U.K.* Pp. 584-592, Uploaded 2019.

[2]. A.A..Firoozi., C.G Olgun., A.A Firoozi and M.S Baghini. "Fundamentals of Soil Stabilization". *International Journal of Geo-Engineering.* Vol. 8(26). https:doi.org/10.1186/s40703-017-0064-9. 2017

[3]. O.F. Joseph, M.M Alhaji, and M. Alhassan. "Laboratory and Field Evaluation of Lateritic Soil Stabilized with Cement and Terrazzo Waste Sludge". *2nd International Civil Engineering Conference (ICEC) 2020.* Department of Civil Engineering Federal University of Technology, Minna, Nigeria.

[4]. N. Segun, M.O Olumide and E.O Opeyemi. "Effects of Palm Kernel Shell Ash on Lime-Stabilized Lateritic Soil". *Slovak Journal of Civil Engineering.* Vol. 25 (3), Pp. 1 – 7, 2017

[5]. N.E Ekeocha and F.N Agwuncha. "Evaluation of Palm Kernel Shells for use as Stabilizing Agents of Lateritic Soils". Asian Transactions on Basic and Applied Sciences (ATBAS ISSN: 2221 – 4291) vol. 04 Nọ 02. 2014.

[6]. E.A. Adeyemi and O.A Joseph. "Comparative Analysis of Ekiti State Soil Stabilized with Different Additives". *Asian Journal of Science and Technology.* Vol. 06, Nọ 12, pp. 2054-2058. 2015

[7]. Nigeria General Specifications of Road and Bridge Work, Federal Ministry of Works, Lagos, Nigeria. https://www.scribd.com 1997.

[8]. A.I. Adekemi, A.O Adebisi and M.A Kareem. "Use of Sludge Ash in Stabilizing Two Tropical Laterite". International Journal of Scientific and Engineering Research. 7(8), 104-108. 2016.