International Journal of Academy of Engineering Research and Theory (IJAERT), ISSN: 2545-5931
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Open Access Manuscript Accepted: 22nd Sept., 2018 Volume 1, Issue 1, Nov., 2018, Pp 1-4

Permeability Potentials and Characteristics of Plastic Pellet Stabilized Sedimentary Formation

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Abstract: *Engineering constructions require large quantities of lateritic soils where drainage is very important. Therefore construction of these infrastructures by using the available soils especially the laterite is more beneficial in relation to their characteristics as construction material that would allow the passage of water when saturated. In other to mitigate the harmful effect of plastic waste in the environment, it is necessary to determine the various ways by which it could be used in construction and geotechnical industries. In this study, the lateritic soil used was taken on the Ibeshe-Ewekoro-Ilaro Formation at Ajegunle, along Papalanto-Ilaro road, Ogun State, Nigeria and the solid plastic wastes were taken from plastic recycling plant at Papalanto, Ogun State, Nigeria. The plastic wastes were cut into pellets passing through 5mm sieve and then substituted for lateritic soil from 0% to 50% at 5% interval for the tests while 0% served as control experiment. The test conducted in line with BS 1377 (1990) on plastic pellet stabilized lateritic soil is falling head permeability. From the results, it was observed that permeability parameters increases as the percentage of plastic pellet substitution increases with interesting increase at above 30% plastic pellet substitution. The use of plastic for in construction industry would reduce the quantities of plastic waste generated, and therefore, environmental risks and hazards caused by plastic wastes would be greatly reduced if not completely eliminated.*

Keywords: *Potential, Permeability, Plastic, Stabilized, Lateritic, Waste, Environment.*

Introduction

Soil permeability is essential due to the fact that underground seepage study is an important aspect of most of the civil engineering works. Once sub-structure is constructed, the soil mass holding foundation should not leak water. In addition, permeability aids in the determination of geostatic stresses and the effect of water pressure on earth structures. It also gives an idea about settlement of a foundation and volumetric changes in soil layers when subjected to fluids or water. Hence, before embarking on construction of structures, it is always helpful to know the amount of water that can be discharged through a soil mass, and estimating permeability is the best way to know the discharged quantity of water. The various factors affecting the permeability of a soil to water are chemical components of interacting fluid and its temperature, porosity of soil, soil compaction, particle size of soil grain size, particle shape, degree of packing of soil mass constituents, particle size, impurities in the water, void ratio, degree of saturation, adsorbed water, entrapped air and organic material (Brian, 1980; Ola, 1983; Chen, 1995; Teferra and Leikun, 1999; Knappett and Craig, 2012; Olarewaju, 2018).

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Background Study

Laterites are formed from the leaching of parent sedimentary rocks such as sandstones, clays, and limestones; metamorphic rocks such as schists, gneisses and migmatites; igneous rocks such as granites, basalts, gabbros, peridotites; and mineralised proto ores; which leaves the more insoluble ions, predominantly iron and aluminium (Brian, 1980; Ola, 1983; Chen, 1995; Knappett and Craig, 2012; Olarewaju, 2018). Lateritic soil in the sedimentary basin of south-western Nigeria consists primarily of Abeokuta, Ewekoro and Ilaro Formations that extends towards the Republic of Benin where Cement Factories are located and the areas under consideration includes (but not limited to) Ajegunle, Abalabi, Ilaro, Ifo, Ibeshe, Ewekoro, Oja-Odan, Papalanto, etc. There are roads, factories, rural and urban infrastructural development in these areas. Part of the backfill materials used during the dualization of Lagos-Abeokuta express way were taken from the borrow pit located at Ajegunle and other places in the aforementioned areas. The sedimentary rocks of two sheets are deposited in a coastal basin which extended from Nigeria westwards across Benin Republic and Togo to the Volta River in Ghana (Olarewaju, 2018). Researchers (Jones and Hockey, 1964) have divided the sediments into a group of red sandstones with subordinate variegated clays and a group of well-stratified shales and sandstones, often false-bedded. These include the rock phosphates and Jones and Hockey (1964) estimated the total thickness of the sedimentary succession overlying the basement in the Ifo area to be about 92 m. The Ilaro Formation has some of the very few natural exposures. The borehole drilled for water in the Ilaro Formation (Jones and Hockey, 1964), provides a section of the lower and middle parts of the formation and there is a transition from the arenaceous lower members of the formation into the underlying Ewekoro shales. According to the same source, the bored section, totaling about 50.0 m comprises of sand, red and mottled, clayey ill-sorted of about 15.0 m; sand, brown fine-grained of about 7.0 m; clay, variegated, sandy of 1.0 m; sand, variegated, medium- and coarse- grained of about 5.5 m; clay and shale, variegated about 8.5 m as well as sand, brown, very fine-grained of around 5.2 m. Shale, dark grey of about 3.0 m and sand, variegated, medium-grained of about 1.0 m. Shale, dark grey of about 3.0 m and sand, grey, very fine-grained of about 1.5 m (Jones and Hockey, 1964). In Ewekoro Formation, the new formations according to Jones and Hockey (1964) are erected on the basis of units distinguishable in the field and, where there are no outcrops or boreholes, geological boundaries have been mapped on evidence from the topography, soil types and shallow pits. This is particularly true of the boundary between the Ewekoro and llaro Formations where at the outcrop, the arenaceous lower members of the Ilaro Formation, make a well-defined escarpment above the low-lying Ewekoro shales (Jones and Hockey, 1964). A lot of work has done on lateritic soil stabilized with plastic pellets by Olarewaju, 2016a, 2016b, 2016c, Olarewaju, 2017a

2017b, 2017c, 2017d and Olarewaju, 2018 but little work has been done on the permeability potentials of plastic pellet stabilized lateritic soil with a view to determining the behavior of the composite materials under the influence of water movement within the pores (Brian, 1980; Ola, 1983; Chen, 1995; Teferra and Leikun, 1999; Knappett and Craig, 2012; Olarewaju, 2018).

Methodology

The sedimentary soil (lateritic soil) used in this study (Figure 1) was taken on the sedimentary formation located at Ajegunle, along Papalanto-Ilaro road, Ogun State, Nigeria and the solid plastic wastes were taken from plastic recycling plant at Papalanto, Ogun State, Nigeria. The plastics were cut into pellets passing through 5mm sieve and then substituted for lateritic soil from 0% to 50% at 5% interval for the tests while 0% served as control experiment. The test conducted in line with BS 1377 (1990) on plastic pellet stabilized lateritic soil is falling head permeability (Jones and Hockey, 1964; Brian, 1980; Bowles, 1981; Olarewaju, 2018).

Figure 1: Sedimentary Formation at Abalabi, Ajegunle, Papalanto-Ilaro Road, Ogun State, Nigeria (Ibeshe-Ewekoro-Ilaro Formation)

Results and Discussion

The results of permeability potential for various plastic pellet substitutions in stabilized sedimentary formation (lateritic soil) are presented in Table 1.

Plastic Pellet Substitution	0% Plastic Pellet	5% Plastic Pellet	10% Plastic Pellet	15% Plastic Pellet	20% Plastic Pellet	25% Plastic Pellet	30% Plastic Pellet	35% Plastic Pellet	40% Plastic Pellet	45% Plastic Pellet	50% Plastic Pellet
Dosage of Plastic Pellet Substitution	Control	Low Dosage			Medium Dosage			High Dosage			
Permeability Coefficient, K ($x10^{-7}$ cm^3/sec)	2.09	8.40	9.68	11.39	15.25	17.85	21.34	25.74	34.23	215.28	503.62
Head Difference (cm)	0.50	2.00	2.30	2.70	3.60	4.20	5.00	6.00	7.90	40.40	70.20
Quantity (Volume) of Water Discharged, Q (cm^3)	1.57	6.28	7.23	8.48	11.31	13.19	15.71	18.85	24.82	126.92	220.53

Table 1: Permeability potential results for various plastic pellet substitutions in stabilized sedimentary formation (lateritic soil)

Plastic pellet substitutions in the range of 5% to 15% are classified as low dosage while 20% to 30% are classified as medium dosage, above which are classified as high dosage with 0% serving as control experiment (Olarewaju 2016a, 2016b, 2016c and 2016d; Olarewaju 2017a, 2017b and 2017c). Plastic pellet substitutions in the range of 5% to 10% show similar behavior, 15% to 20% also exhibit similar characteristics and 25% to 30% also shows similar behavior in terms of hydraulic conductivity, vis a vis coefficients of permeability, head difference and quantity (volume) of water discharged. The results of permeability coefficients, head difference and quantity (volume) of water discharged increases as the percentage of plastic pellet substitution increases with interesting increase at above 30% plastic pellet substitution. The test results of the hydraulic conductivity are used to estimate ground water flow, calculate seepage through dams, find out the rate of consolidation and settlement of structures, to plan the method of lowering the ground water table, to calculate the uplift pressure and piping, to design the grouting and also for soil freezing tests for the design of pits for recharging and details of these has been presented in Olarewaju (2018). The permeability potentials and characteristics of sedimentary soils, whether formed under arctic, temperate or tropical conditions, is determined by certain physical characteristics designated as engineering properties. Since determination of these engineering properties is usually expensive, index properties, which are simpler and cheaper to evaluate but indicative of the engineering characteristics, are investigated. Engineering construction and underground structures requiring rapid drainage are retaining wall backfill, underground storage tanks, etc. that will increase overburden load on the underground structures if the retained soil material is saturated (Brian, 1980; Ola, 1983; Chen, 1995; Teferra and Leikun, 1999; Knappett and Craig, 2012; Olarewaju, 2018).

Conclusion

In this study, permeability potentials and characteristics, vis a vis coefficients, head difference and quantity of water discharged (hydraulic conductivity) were determined for composite material of plastic pellet stabilized lateritic soil mixed with varying degrees of plastic pellets ranging from 0% to 50% at 5% intervals. The results showed that coefficient of permeability, volume/quantity of water discharged and head difference increases as the percentage of plastic pellet substitution increases with interesting increase at above 30% plastic pellet substitution. The use of the composite material as backfill materials in engineering constructions most especially where rapid drainage is essential would require the use of lateritic soil mixed with certain dosage of plastic pellets. This would reduce the quantities of plastic waste generated, and therefore, environmental risks and hazards caused by plastic wastes would be greatly reduced if not completely eliminated (Ola, 1983; Chen, 1995; Olarewaju, 2018).

Acknowledgement

The author acknowledges the contributions of Adeyemo K. N., Ajibade Q.A. and Adeleye R. A. in the data collection as well as Aro M. O. for technical assistance in the Geotechnical and Material Laboratory.

References

Bowles, J. E. (1981). *Engineering Properties of Soils and their Measurement* (2nd edition), McGraw Hill Intl., London, pp 79-92.

Brian Vickers, (1980). *Soil Mechanics*: Laboratory Work in Civil Engineering, Granada Publishing, London, pp 11-38.

BS 1377, (1990). Methods of Test for Soils for Civil Engineering Purposes, British Institution, London.

Chen, W. F. (1995). *The Civil Engineering Handbook,* CRC Press, London. 1386.

Craig, R. F. (1994). *Soil Mechanics* (5th edition), Chapman and Hall, Great Britain, pp 248-292, pp 403-420.

Jones, H. A. and Hockey, R. D. (1964). The Geology of Part of South-Western Nigeria, (Explanation of 1 : 250,000 Sheets Nos. 59 and 68), Geological Survey of Nigeria Bulletin No. 31, Ministry of Mines and Power, Published by the authority of the Federal Government of Nigeria.

Knappett, J. A. and Craig, R. F., (2012). Craig's Soil Mechanics, Eight Edition, Spon Press, An Imprint of Taylor and Francis, London and New York.

Olarewaju, A. J., (2018). Chapter 1: *Hydraulic Conductivity of Compacted Lateritic Soil Mixed with Plastic Pellets,* Book Title: "Advances in Civil Engineering (Volume - 1)", AkiNik Publications, https://www.akinik.com, New Delhi, India, (in press).

Olarewaju, A. J., (2017a). CBR Strength Characteristics of a Laterite Stabilized with 2% to 10% (Low Dosage) Thermoplastic, *International Journal of Advanced Geotechnic and Impact Engineering, IJAGIE,* ISSN (Online): 2545-5559, Vol. 1, Issue 1, Dec., pp 1 – 11.

Olarewaju, A. J., (2017b). CBR Strength Characteristics of a Laterite Stabilized with 12% to 20% (Medium Dosage) Thermoplastic, *International Journal of Academic Research and Innovation, IJARI,* ISSN (Online): 2545–5214, Vol. 1, Issue 1, Dec., pp 1 – 9.

Olarewaju, A. J., (2017c). CBR Strength Characteristics of a Laterite Stabilized with 25% to 50% (High Dosage) Thermoplastic, *International Journal of Advances in Engineering Materials and Processes, IJAEMP*, ISSN (Online): 2550-7230, Vol. 1, Issue 1, Dec., pp 1 – 10.

Olarewaju, A. J., (2016a). Characteristics of Densified Plastic Pellets Stabilized Lateritic Soil to Reduce the Impact of Blast Loads on Underground Structures, *International Journal of Academic Research and Innovation, IJARI, ISSN* (Online)*: 2545 – 5214*, Volume 1, Issue 1, Nov., pp 1-7.

Olarewaju, A. J., (2016b). Geotechnical Properties of Plastic Stabilized Lateritic Soil, *American Journal of Engineering Research (AJER), e-ISSN: 2320-0847 | p-ISSN: 2320-0936,* Volume-5, Issue-9, Sept., pp-150-156.

Olarewaju, A. J., (2016c). Engineering Properties of Concrete Mixed with Varying Degrees of Fly Ash, *American Journal of Engineering Research (AJER), e-ISSN: 2320-0847 | p- ISSN: 2320-0936,* Volume-5, Issue-9, Sept., pp-146-149.

Olarewaju, A. J., (2016d). Densification characteristics of lateritic soil stabilized with plastic pellets, *International Journal of Applied Research*, ISSN (Print): 2394-7500 | ISSN (Online): 2394-5869, Volume-2, Issue-9, Sept., pp 300 - 305.

Ola, S. A. (1983). *Tropical Soils of Nigeria in Engineering: Geotechnical Properties of Some Nigeria Lateritic Soils,* Practice A. A., Balkema/Rotterdam, Netherland, pp 71-82.

Teferra, A., and Leikun, M. (1999). Soil Mechanics. Addis Ababa University, South Africa.