*International Journal of Advances in Civil and Infrastructure Engineering (IJACIE)*, ISSN: 2550-7192
Akinola Johnson OLAREWAJU
Open Access Manuscript Accepted: 22nd Sept., 2018 Volume 1, Issue 1, Nov., 2018

# Settlement Potentials and Characteristics of Plastic Pellet Stabilized Sedimentary Formation

Akinola Johnson OLAREWAJU
Civil Engineering Department, Federal Polytechnic Ilaro, Ogun State, Nigeria
E-mail: akinolajolarewaju@gmail.com

**Abstract:** *Structure built over a layer of saturated clay will result to consolidation settlement if the water table is lower permanently in a stratum overlaying a clay layer. The time taken for settlement is a factor that can influence the design and construction of civil engineering infrastructures. The coefficient of compressibility is the most suitable of all the consolidation parameters for direct estimation of settlement. In the world today, plastic waste has constituted environmental nuisance most especially in developing nations. Due to non-biodegradable nature of plastic waste, there is need to find alternative use, most especially in construction industry. In this study, the lateritic soil used was taken on the Ibeshe-Ewekoro-Ilaro Formation at Abalabi, 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 while 0% plastic pellet substitution served as control experiment. For settlement potentials, 90% consolidation tests conducted on the composite materials of plastic pellet stabilized lateritic soil in line with BS 1377 (1990). From the results, coefficient of volume compressibility (Mv) and oedometer settlement (Soed) increases at certain dosage of plastic pellet increases in the lateritic soil. The use of plastic as lateritic soil stabilizers will reduce the quantity of waste and therefore, environmental risks and hazards caused by plastic waste would be greatly reduced if not completely eliminated*

**Keywords:** *Settlement, Potentials, Stabilized, Lateritic, Plastic, Soil, Waste, Environment.*

## Introduction

The mechanism of leaching involves acid dissolving the host mineral lattice, followed by hydrolysis and precipitation of insoluble oxides and sulfates of iron, aluminium and silica under the high temperature conditions of a humid subtropical monsoon climate. An essential feature for the formation of laterite is the repetition of wet and dry seasons. It is during wet season movement of water occurs and this movement of water leads to run-off if the soil is not permeable (Jones and Hockey, 1964; Ola, 1983). Plastic waste has constituted a menace in the environment most especially in the developing countries like Nigeria, Tanzania, Ghana, etc. Plastics are made up of long chain molecules called polymers. Various types of polymers can be made from hydrocarbons derived from coal, natural gas, oil and organic oils which are transformed into materials with desirable properties. Plastics that can be readily recycled are thermoplastics which means they will soften when heated. Thermosetting plastics harden when heated which are often used in electrical applications and are not suitable for recycling (Knappett and Craig, 2012; Chen, 1995)

.

## Background Study

Lateritic soil is a product of sedimentary formation and according to Jones and Hockey (1964), around the Ewekoro and Ilaro Formations there is Ilaro-Ibeshe where several water supply borings have been put down at Ilaro. This provides a good section of the greater part of the formation. The borehole, according to Jones and Hockey (1964), intersected the top of the Ewekoro Formation at 137 m in the limestone member and the section which is part of Ilaro Formation comprises of the followings: Shale, brown and grey of around 4.3 m and clay and shale, grey, slightly carcareous locally of around 27.0 m as well as limestone, impure, with fragments and casts of Dentalium of about 2.5 m. Also present is shale, grey, calcareous locally of around 13.4 m and shale, grey, with oyster shell fragments of 2.0 m and shales and paper shales, calcareous locally of around 16.2 m. According to the same source, mudstone, dark grey, with abundant worm tracks of 0.3 m and shale and mudstone, calcareous of 12.5 m. Shale, with numerous grains of glauconite of 3.0 m and mudstone, glauconitic, with worm tracks of 0.6 m. Shale and mudstone, calcareous of 15.0 m, glauconite rock of 1.22 m, limestone, glauconitic of 1.0 m, limestone, white, shelly and crystalline of 8.0 m, marl, dark grey, shelly locally of 4.6 m and finally limestone, white, shelly with subordinate grey marl of about 8.2 m (Jones and Hockey, 1964).

Plastics are light, durable, moldable, hygienic and economic, making them suitable for a wide variety of applications including food and product packaging, car manufacturing, agriculture and housing products. Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, however, an array of variants are made from renewable materials such as polylactic acid from corn or cellulosic from cotton linters. Due to their low cost, ease of manufacture, versatility, and imperviousness to water, plastics is used in a multitude of products of different scale, including paper clips, spacecraft, etc. When found not useful, disposal of plastic wastes is not properly done, even when properly done, due to non-biodegradable nature, it remains as waste for a long period and this constitutes a menace in the society. This study is aimed at determining the settlement capabilities as well as various characteristics of plastic stabilized lateritic soil. This is with a view to establishing its usage in the construction industries so that the menace of plastic waste could be greatly reduced if not completely eliminated in the society. 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 settlement potentials of plastic pellet stabilized lateritic soil with a view to determining the settlement potentials and characteristics of the composite materials under the impact of pressure loads..

## Methodology

The lateritic soil used in this study was taken on the sedimentary formation located at Abalabi (Figure 1), 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 and substituted for lateritic soil from 0% to 50% at 5% interval while 0% plastic pellet substitution served as control experiment. For settlement potentials, in line with BS 1377 (1990), pressure loads were applied on the composite materials of plastic pellet stabilized lateritic soil and 90% consolidation tests conducted (Jones and Hockey, 1964; Brian, 1980; Bowles, 1981)..

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

## Results and Discussion

The detail results of consolidation parameters obtained from the 90% consolidation test on composite materials of plastic pellet stabilized lateritic soil ranging from 0% to 50% are Cc, Mv, Cv, K, Soed, e, pressure load variation, etc. Settlement potentials and characteristics were determined from these consolidation parameters. Details of the above parameters are presented in Olarewaju (2018). The results of settlement potentials and characteristics of plastic pellets stabilized lateritic soil are presented in Table 1. The coefficient of volume compressibility (Mv) refers to decrease in volume per unit volume of soil per unit increase in effective stress. It can be expressed in terms of void ratio of specimen thickness. This is an important parameter in estimating the primary consolidation settlement of a soil (Craig, 1994; Knappett and Craig, 2012; Chen, 1995). The results of coefficient of volume compressibility, Mv (obtained from Equation 1) are presented in Table 1.

$$M_v = \frac{1}{H_1} \cdot \frac{H_1 - H_2}{P_2 - P_1} \quad or \quad \frac{1}{1+e} \cdot \frac{e_1 - e_2}{P_2 - P_1} \qquad Equation\ 1$$

where Mv is the coefficient of volume compressibility, $H_1$ and $H_2$ are heights of soil samples under pressure $P_1$ and $P_2$ respectively ((Craig, 1994; Knappett and Craig, 2012; Chen, 1995; Olarewaju 2016a, 2016b and 2016d; Olarewaju, 2017a, 2017b and 2017c; Olarewaju, 2018).

From the results presented in Table 1, at low dosage (5% to 15%) of plastic pellet substitution in the lateritic soil, the coefficient of volume compressibility (Mv) and oedometer settlement (Soed) reduces as the plastic pellet substitution increases. But in the case of medium dosage (20% to 30%), the coefficient of volume compressibility (Mv) and oedometer settlement (Soed) increases as the plastic pellet substitution increases while both are lower than the control experiment (0%). Further increase in the percentage of pellets in the lateritic soil from 35% to 50% (high dosage) revealed that the coefficient of volume compressibility (Mv) and oedometer settlement (Soed) increases as the percentage of plastic pellet substitution in the lateritic soil increases but both observed parameters are higher than control experiment (0%). For low and high dosage, the coefficient of volume compressibility (Mv) and oedometer settlement (Soed) are higher than the control experiment (0%) while at medium dosage the observed parameters are lower than the control experiment (0%). The results showed that the values of coefficient of volume compressibility (Mv) and oedometer settlement (Soed) increases as the percentage of plastic pellet substitution increases. In another development, the increase in oedometer settlement (Soed) is as a result of having higher moisture content before loading. This is due to the composite material getting saturated very faster and an initial expansion (heaving) of the sample before loading. When loads are applied, the material compresses at higher rate than when it is ordinary soil sample. The settlement takes place in lesser time, hence, help to reduce the consolidation (gradual settlement). Moreover the mixture of plastic with lateritic soil tends to make the soil to reduce some of its index properties, and the soil behaves like sand such that the settlement becomes immediate (Craig, 1994; Knappett and Craig, 2012; Chen, 1995; Olarewaju 2016a, 2016b and 2016d; Olarewaju, 2017a, 2017b and 2017c; Olarewaju, 2018).

| 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 | | | |
| Coefficient of Volume Compressibility, Mv ($M^2$/MN) | 0.0136 | 0.0228 | 0.0197 | 0.0164 | 0.0.192 | 0.0181 | 0.0210 | 0.0214 | 0.0259 | 0.0277 | 0.0257 |
| Oedometer Settlement, Soed (mm) | 0.551 | 0.693 | 0.599 | 0.334 | 0.423 | 0.426 | 0.635 | 0.651 | 0.787 | 0.842 | 0.842 |

Table 1: Results of settlement potentials and characteristics of plastic pellet stabilized sedimentary formation (lateritic soil)

## Conclusion

This study has presented the range of coefficient of volume compressibility (Mv) and Oedometer settlement (Soed) for lateritic soil stabilized with varying degrees of plastic pellets from 0% to 50% with 0% serving as control experiment. It is shows the increase and reduction of Mv and Soed as the plastic pellet increases in the lateritic soil compared with control experiment (0%). The use of plastic as soil stabilizers as well as substitute in lateritic soil for construction materials will reduce the quantity of plastic waste in the society and therefore, environmental risks and hazards caused by plastic wastes would be greatly reduced if not completely eliminated (Craig, 1994; Knappett and Craig, 2012; Chen, 1995; Olarewaju, 2018).

## Acknowledgement

The author acknowledges the contributions of Obadimu, T. A., Salaudeen, A. A. and Adeleye O. I. 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.

Bowles, Joseph E. (1997). *Foundation Analysis and Design*, 5th edition, International Edition, McGraw Hill Company Inc., Singapore, 151.

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 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 2: *Consolidation Parameters of Compacted Lateritic Soil Mixed with Plastic Pellets*, Book Title: "Advances in Civil Engineering (Volume - 1)", AkiNik Publications, New Delhi, India, https://www.akinik.com, (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., pp146-149.

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.