Compaction Characteristics of Plastic Pellet Stabilized Sedimentary Formation

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Abstract: *Recycling helps to reduce the pollution caused by waste and huge amounts of energy are used when making products from raw materials. Recycling requires much less energy and therefore helps to preserve natural resources in this case, natural (raw) rubber used in the production of plastic products. This study is aimed at providing alternatives use for plastic wastes in the construction industries. The lateritic soil used in this study was taken on the sedimentary formation located at Abalabi (6^0 53' 13.758"N, 3^0 7' 59.994"E), Ajegunle, along Papalanto-Ilaro road, Ogun State, Nigeria and plastic wastes were taken from different locations in Ilaro, Ogun State, Nigeria. The plastic wastes were cut into pieces passing through 5mm sieve and then substituted for lateritic soil in the range of 0% to 50% at 5% intervals while 0% plastic pellet substitution served as control experiment. In line with BS 1377 (1990), compaction tests were carried out on the composite materials to determine the various optimum moisture contents and maximum dry densities at different test water contents for all the substitutions. From the results, it was observed that 0% plastic pellet substitution (i. e. control experiment) has the maximum dry density value. In addition to this, 35% to 40% plastic pellet substitution has the maximum optimum moisture content value while increase in plastic pellet substitution reduces the density of the composite material. The composite material at 10% plastic pallet substitution can be used for road base and sub base and it is therefore a possible alternative solution for safe disposal of the plastic wastes from causing nuisance. Therefore environmental risk and hazard caused by plastic waste would be greatly reduced, if not completely eliminated.*

Keywords: *Compaction, Stabilization, Sedimentary, Formation Composite, Material, Plastic Pellets.*

Introduction

Plastics are versatile materials that are ideal for a wide range of applications while the relatively low density of most plastics gives plastic products the advantages of light weight. They are corrosion resistant to many substances which attack other materials, making them durable and suitable for use in diverse environments. They can easily be moulded into complex shapes, allowing other materials to be integrated into plastic products, and making them ideal for so many functions. Plastic waste poses a threat to the plants and animals including humans. Some marine species, such as sea turtles, have been found to contain large proportions of plastics in their systems. When this occurs, the animal typically starves, because the plastic blocks the animal's digestive system (Nnochiri et al. 2017; Ikumapayi and Akinlabi, 2018; Olutaiwo and Johnson, 2018; Olarewaju, 2018a, b, and c). In developing countries, the scope for recycling of plastic waste is growing as the amount of plastic being consumed increases on daily basis. This is the process of converting waste materials into new materials and objects and it is an alternative to conventional waste disposal that can save material and help lower greenhouse gas emissions. Recycling can prevent the waste of potentially useful materials and reduce the consumption of fresh raw materials, thereby reducing energy usage, air pollution, land pollution as well as water pollution. Recycling is very important as waste has a huge negative impact on the natural environment where harmful chemicals and greenhouse gasses are released from rubbish in landfill sites (Nnochiri et al. 2017; Ikumapayi and Akinlabi, 2018; Olutaiwo and Johnson, 2018; Olarewaju, 2018a, b, and c).

Background Study

Laterization is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils and the initial products of weathering are essentially kaolinized rocks called saprolites. Laterites are formed from the leaching of; (1) parent sedimentary rocks such as sandstones, clays, limestones; (2) metamorphic rocks such as schists, gneisses, migmatites and (3) igneous rocks such as granites, basalts, gabbros, peridotites and mineralised proto-ores which leaves the more insoluble ions, predominantly iron and aluminium. 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 sub-tropical monsoon climate. An essential feature for the formation of laterite is the repetition of wet and dry seasons (Nnochiri et al. 2017; Ikumapayi and Akinlabi, 2018; Olutaiwo and Johnson, 2018; Olarewaju, 2018a, b, and c). Rocks are leached by percolating rain water during the wet season; the resulting solution containing the leached ions is brought to the surface by capillary action during the dry season. These ions form soluble salt compounds which dry on the surface while the salts are washed away during the next wet season. Laterite formation is favoured in low topography reliefs of gentle crests and plateaus which prevents erosion of the surface cover. It vary significantly according to their location, climate and depth while the main host minerals for nickel and cobalt can be either iron oxides, clay minerals or manganese oxides. Iron oxides are derived from mafic igneous rocks and other iron-rich rocks while bauxites are derived from granitic igneous rock and other iron-poor rocks. Nickel laterites occur in zones of the earth which experienced prolonged tropical weathering of ultramafic rocks containing the ferro-magnesian minerals olivine, pyroxene and amphibole. In a loose state, soil consists of solid particles, water and air. Compaction of the soil, usually by mechanical means, reduced the air voids with the aim of controlling subsequent moisture content changes; achieving a state of increased unit weight; increasing the shear strength of the soil; reducing the permeability; making the soil less susceptible to settlement under load, especially repeated loading from, say, traffic (Nnochiri et al. 2017; Ikumapayi and Akinlabi, 2018; Olutaiwo and Johnson, 2018; Olarewaju, 2018a, b, and c). When water is added to a dry soil, each soil particle adsorbs a film of water which surrounds it and as more water is added, the film of water increases in thickness and permits easier sliding of particles relatives to each other. Obviously there is an optimum quantity of water, for a particular soil being compacted in a particular manner, at which there is a maximum mass of solid matter per volume while a minimum quantity of air is maintained. Nnochiri, et al.. (2017) study the effects of palm kernel shell ash on lime-stabilized lateritic soil and Adeboje, et al. (2017) also conducted a research on stabilization of lateritic soil with pulverized palm kernel shell for road construction while Olutaiwo, et al. (2018) investigated the strength characteristics determination of palm kernel shell ash in cement–modified lateritic soil (Nnochiri et al. 2017; Ikumapayi and Akinlabi, 2018; Olutaiwo and Johnson, 2018; Olarewaju, 2018a, b, and c)..

Methodology

The lateritic soil used in this study was taken on the sedimentary formation located at Abalabi (6^0 53' 13.758"N, 3^0 7' 59.994"E), Ajegunle (Figure 1), along Papalanto-Ilaro road, Ogun State, Nigeria and plastic wastes were taken from different locations in Ilaro, Ogun State, Nigeria. The plastic wastes were cut into pieces passing through 5mm sieve and then substituted for lateritic soil in the range of 0% to 50% at 5% intervals for compaction test while 0% plastic pellet substitution served as control experiment. In line with BS 1377 (1990), compaction tests were carried out on the composite materials to determine the various optimum moisture contents and maximum dry densities at different test water contents for all the substitutions (Knappett and Craig, 2012; Craig, 1994; Brian, 1980; Bowles, 1981).

Figure 1: (a) Plastic Waste (b) Plastic Pellets (c) Sedimentary Formation at Abalabi, Ajegunle, Papalanto-Ilaro Road, Ogun State, Nigeria

Results and Discussion

Soil bulk density is defined as the ratio of dry solids to the bulk volume of the soil occupied by those dry solids and it is an important site characterization parameter since it charges for a given soil. It varies with structural condition of the soil particularly that is related to packing. The bulk volume includes the volume of the solids and the pore space. Bulk density is needed for converting water percentage by weight to content by volume, for calculating the weight of a volume of soil too large to weigh conveniently. The dry density is the relationship between the density of sample of soil in a dry state and its moisture content for a given degree of compaction and it is expressed as g/cm^3. In this study, the results of (1) moisture content against test water content for varying degrees of plastic pellet substitution in lateritic soil; (2) bulk density against test water content for varying degrees of plastic pellet substitution in lateritic soil; (3) dry density against test water content for varying degrees of plastic pellet substitution in lateritic soil; (4) maximum dry density against plastic pellet substitutions and lastly (5) optimum moisture content against plastic pellet substitutions are presented in Figs. 2, 3, 4, 5 and 6 respectively. From the results shown in Figures 2, 3 and 4, the moisture content, bulk density and dry density increases as the test water content increases but reduction of bulk and dry densities were observed from 8% test water content and above for all the plastic pellet substitutions. In addition, from the results, as the plastic pellet substitution in lateritic soil increases, maximum dry density reduces while the optimum moisture content increases (Figures 5 and 6). Furthermore, control experiment (0% plastic pellet substitution, i. e. 100% lateritic soil) has the highest value of maximum dry density of 2.2 g/cm^3 and lowest maximum dry density value of 1.33 (approximately 1.5) g/cm^3 was observed at 50% plastic pellet substitution.

The maximum dry density falls within the range of 2 g/cm^3 to 2.3 g/cm^3 at zero percent plastic pellet substitution and started to decrease as the substitution of plastic pellet increase which shows that the increase in plastic pellet leads to reduction in maximum dry density because plastic does not absorb water like that of lateritic soil and is a light-weight material. Plastic does not stick to each other because of its smooth surfaces. The highest optimum moisture content value around 17.5% for 35% and 40% plastic pellet substitutions was observed which shows that since plastic pellet cannot absorb water, at high dosage of plastic pellet the optimum moisture content will increase. The optimum moisture content is low at zero percent plastic pellet substitution because lateritic soil absorbs water unlike plastic pellet.

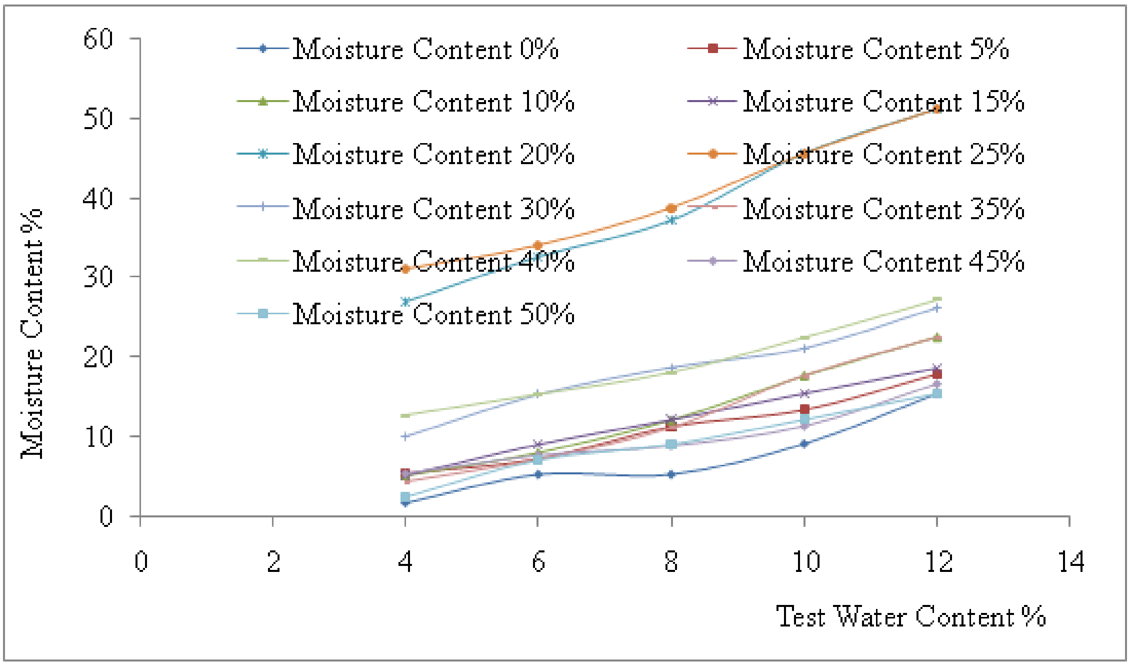

Figure 1: Moisture content against test water content for varying degrees of plastic pellet substitution in lateritic soil

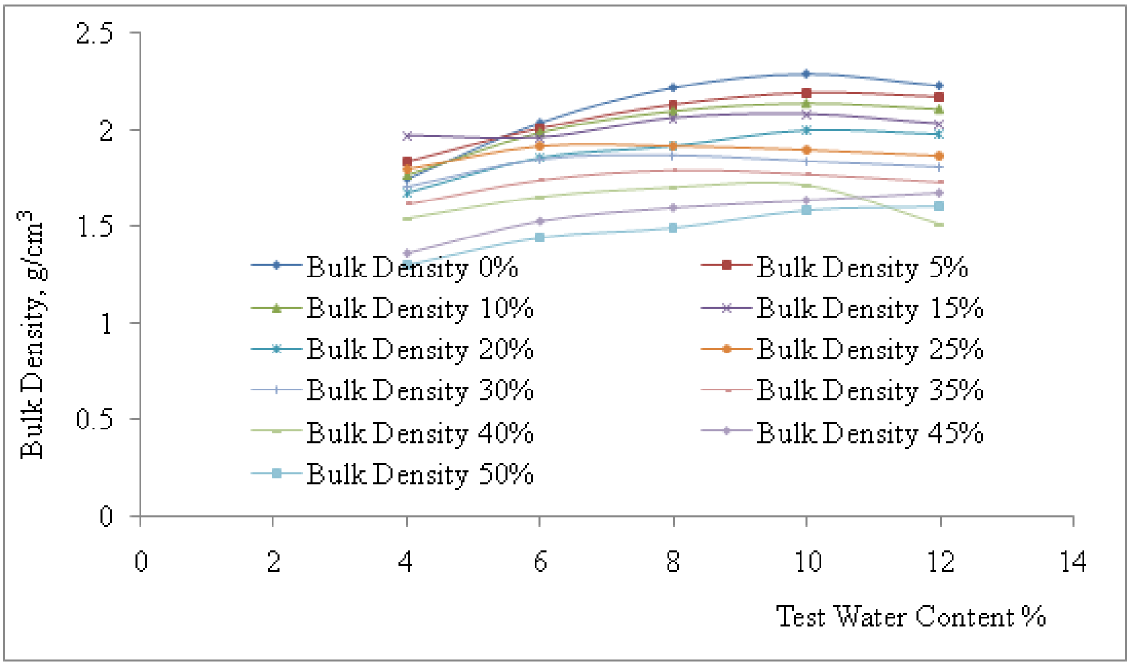

Figure 2: Bulk density against test water content for varying degrees of plastic pellet substitution in lateritic soil

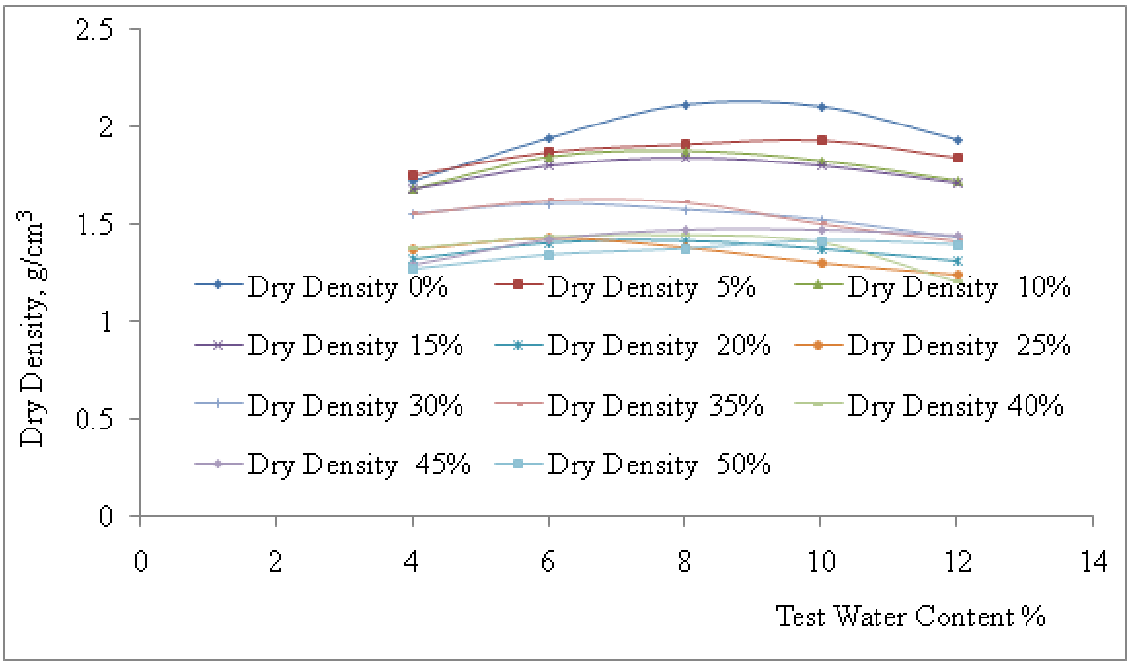

Figure 3: Dry density against test water content for varying degrees of plastic pellet substitution in lateritic soil

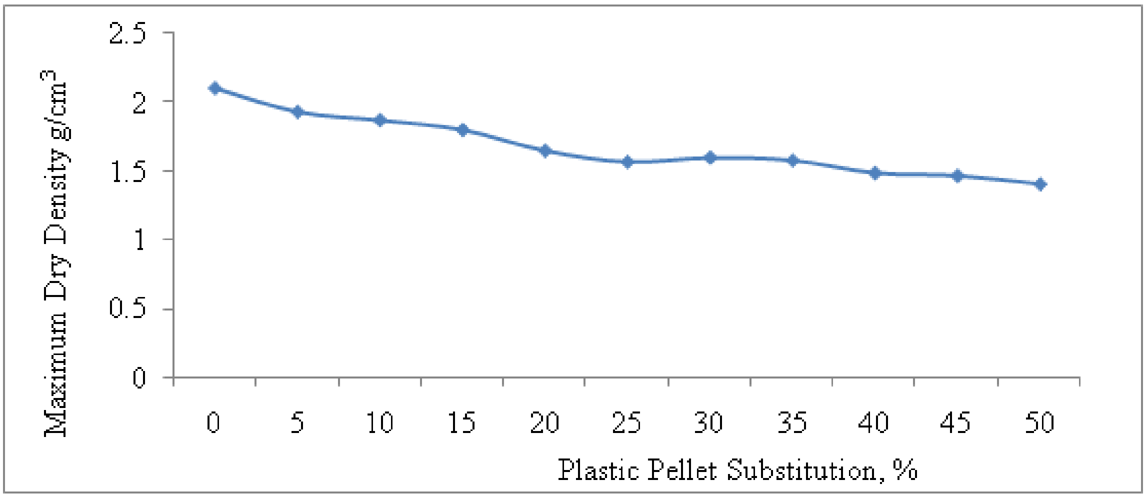

Figure 4: Maximum dry density against plastic pellet substitutions

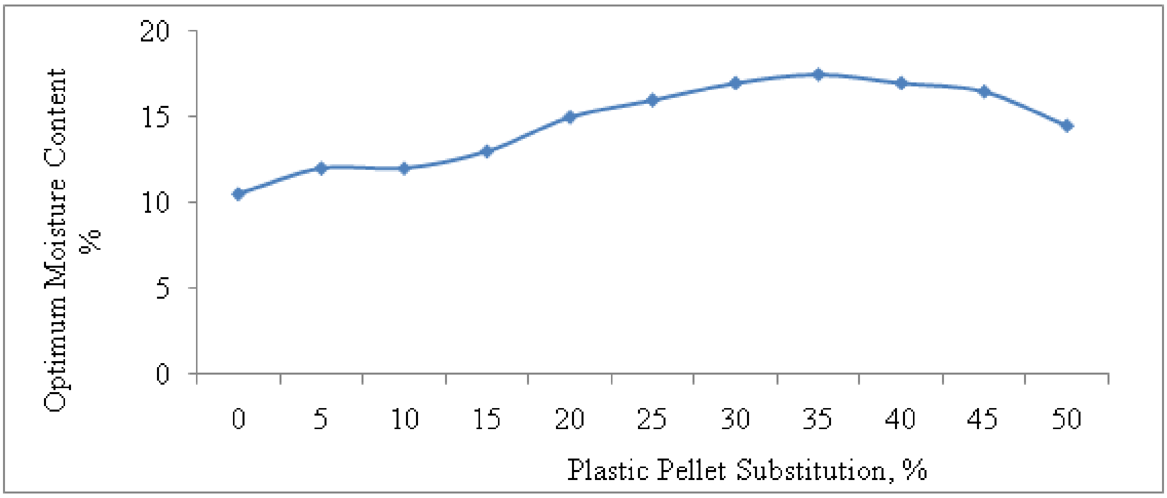

Figure 5: Optimum moisture content against plastic pellet substitutions

Conclusion

Studies on compaction characteristics of plastic pellet stabilized sedimentary formation were carried out for 5% to 50% plastic pellet substitutions in lateritic soil at 5% intervals with 0% serving as control experiment. From the results, it was observed that 0% plastic pellet substitution (i. e. control experiment) has the maximum dry density value. In addition to this, 35% to 40% plastic pellet substitution has the maximum optimum moisture content value while increase in plastic pellet substitution reduces the density of the composite material. The composite material at 10% plastic pallet substitution can be used for road base and sub base and it is therefore a possible alternative solution for safe disposal of the plastic wastes from causing nuisance. Therefore environmental risk and hazard caused by plastic waste would be greatly reduced, if not completely eliminated.

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