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CBR Strength Characteristics of a Laterite Stabilized with 25% to 50% (High Dosage) Thermoplastic

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Abstract: *This study is aimed at investigating the possibility of using thermoplastic as an alternative for construction materials with a view to turning waste to job opportunities rather than problem or nuisance. The laterite used in this study was taken at Ajegunle, Abalabi* (6^0 53' 13.758"N, 3^0 7' 59.994"E) *along Papa-Ilaro road, Ogun State, Nigeria and the solid thermoplastic wastes were taken from a plastic recycling plant at Papalanto* (6^0 53' 26.406"N, $3^0$10' 21.788"E), *Ogun State, Nigeria. The thermoplastic waste were grounded into pellets passing through 5mm sieve and then substituted for lateritic soil from 25% to 50% (at 5% interval) for soaked and unsoaked California Bearing Ratio (CBR) test in line with BS 1377 (1990) while 0% served as control experiment. The tests conducted are soaked and unsoaked CBR. From the results, it was observed that plastic pellet stabilized soil exhibit the same CBR characteristics as lateritic soil while CBR value increases as percentage of plastic pellet increases for both soaked and unsoaked from 25% to 50% substitution. Based on the results of this study, plastic pellet could be used as a substitute as well as stabilizing agent in lateritic soil for road construction materials. Therefore, environmental risk and hazard caused by plastic waste could be greatly reduced if not completely eliminated.*

Keywords: *Thermoplastic, Environment, Laterite, CBR, Soaked, Unsoaked, Waste*

Introduction

Thermoplastic is a material that possesses the properties of fusing when heated and hardening when cooled and they have effect on the environment through all stages of their existence. Their existence ranges from manufacture to utilization and final disposal. Lateritic soil on the other hand is a rich brick-colored soil that contains mainly iron and aluminum but poor in silica and is well known to be an earthwork material as well as a sub grade material but most importantly, it is not in abundant in some part of the world. Lateritic soil that could not meet the required strength needs addition of other materials to improving the strength and stability. Stabilization is the combination of soils and/or additives to change its properties and remain in its stable compacted state without undergoing any change under effect of exposure. Plastic waste is very common in most countries of the world today. This waste could be seen as an opportunity rather than problem or nuisance and therefore recycling plastic waste into construction materials is very essential (Sophie, 2009)

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Background Study

The roads constructed using waste plastic, popularly known as Plastic Roads, are found to perform better compared to those constructed with conventional. The performance studies carried out on the roads constructed using plastic indicated satisfactory performance with good skid resistance, good texture value, stronger and less amount of progressive unevenness over a period of time (Chakole, 2015). Soil stabilization involves the use of binding materials in weak soils to improve its geotechnical properties such as compressibility, permeability and durability among others. Traditionally and widely accepted types of soil stabilization techniques use products such as bitumen emulsions which can be used as a binding agents for producing a road base. However, bitumen is not environmentally friendly and becomes brittle when it dries out. Portland cement has been used as an alternative to soil stabilization. However, this can often be expensive and is not a very good "green" alternative. Cement fly ash, lime fly ash (separately, or with cement or lime), bitumen, tar, cement kiln dust (CKD), tree resin and ionic stabilizers are all commonly used stabilizing agents. The proper proportion in soil helps in controlling the compaction factor and also proportion makes it very useful. In this process some technique or process is undergone and those can be coined as basic principle of this stabilization process in which firstly the sample of any soil is to be considered. If the bearing capacity of the soil is not good enough then the further properties of the soil need to be concluded which helps to determine various properties of soil. Then the construction procedure is considered by compaction of the stabilized layer in a profound manner (Pragyan et al, 2013). This study is aimed at investigating the possibilities of using plastic waste as substitute or stabilizing agent in road construction and other constructions requiring stabilized lateritic soil (Hans et al., 1951; Sophie, 2009; Verma, 2008; Jean-Piera, 2004; Olarewaju, 2016a; 2016b; 2016c and 2016d).

Methodology

The lateritic soil used in this study was taken at Ajegunle (Figure 1), Abalabi (6^0 53' 13.758"N,3^0 7' 59.994"E) along Papa-Ilaro road, Ogun State, Nigeria and the solid thermoplastic wastes were taken from plastic recycling plant (Figure 2) at Papalanto (6^0 53' 26.406"N, $3^0$10' 21.788"E), Ogun state, Nigeria. The thermoplastic were grounded into pellets passing through 5mm sieve and then substituted for lateritic soil from 25% to 50% at 5% interval for California bearing ration (CBR) test while 0% served as control experiment. The tests conducted in line with BS 1377 (1990) are compaction, soaked and unsoaked CBR (Brian, 1980; Bowles, 1981).

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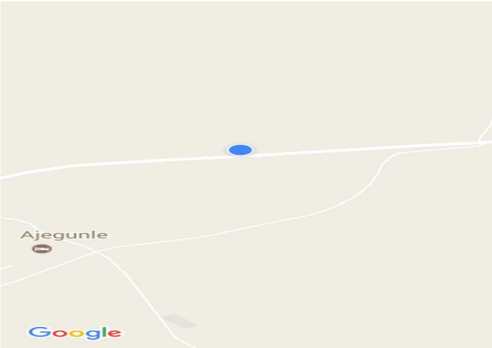

Figure 1: Location of lateritic soil sample *(6⁰ 53' 13.758"N, 3⁰ 7' 59.994"E)*

Figure 2: Location of plastic waste *(6⁰ 53' 26.406"N, 3⁰10' 21.788"E)*

Results and Discussion

The results of load against penetration for soaked control and 25% plastic pellet substitution are presented in Figure 3 while the results of load against penetration for soaked control and 30% plastic pellet substitution are presented in Figure 4. In addition to this, the results of load against penetration for soaked control and 35% plastic pellet substitution are presented in Figure 5 while the results of load against penetration for soaked control and 40% plastic pellet substitution are presented in Figure. Furthermore, the results of load against penetration for soaked control and 45% plastic pellet substitution are presented in Figure 6 while the results of load against penetration for soaked control and 50% plastic pellet substitution are presented in Figure 7. The results of penetration and load of soaked control and 25% plastic pellet substituted for lateritic soil are presented in Figure 8 while the results of load against penetration for unsoaked control and 30% plastic pellet substitution are presented in Figure 9. In addition, the results of load against penetration for unsoaked control and 35% plastic pellets substitution are presented in Figure 10 while the results of load against penetration for unsoaked control and 40% plastic pellet substitution are presented in Figure 11. The results of load against penetration for unsoaked control and 45% plastic pellet substitution are presented in Figure 12 while the results of load against penetration for unsoaked control and 50% plastic pellet substitution are presented in Figure 13. Finally the results of load against penetration for unsoaked control and 50% plastic pellet substitution are presented in Figure 14.

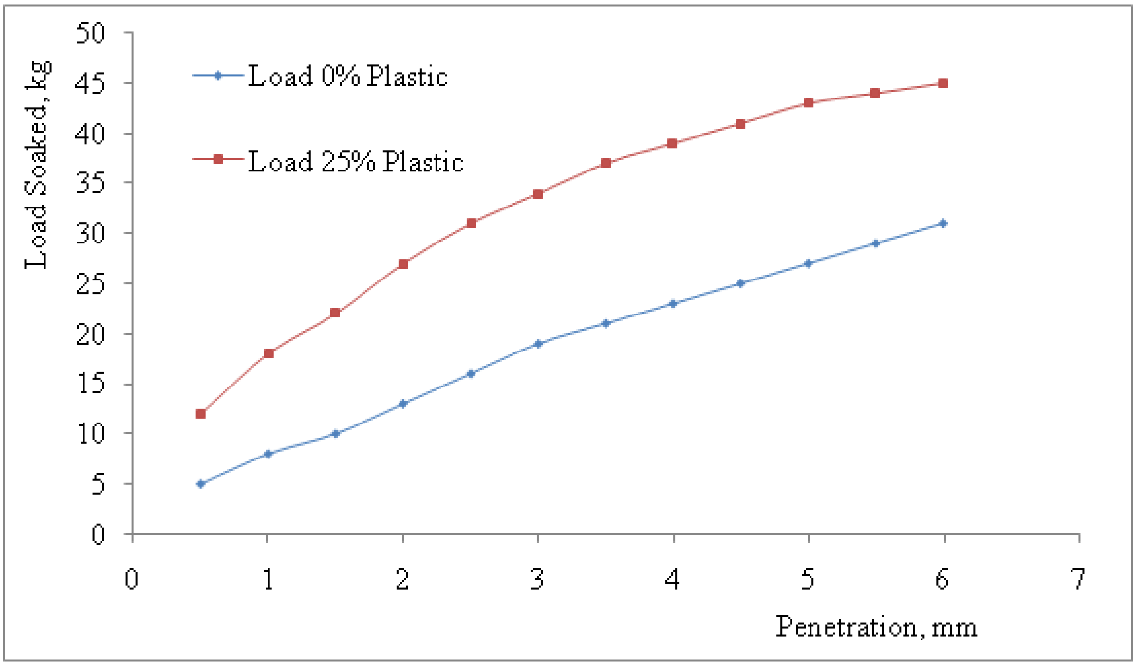

Figure 3: Results of load against penetration for soaked control and 25% plastic pellet substitution

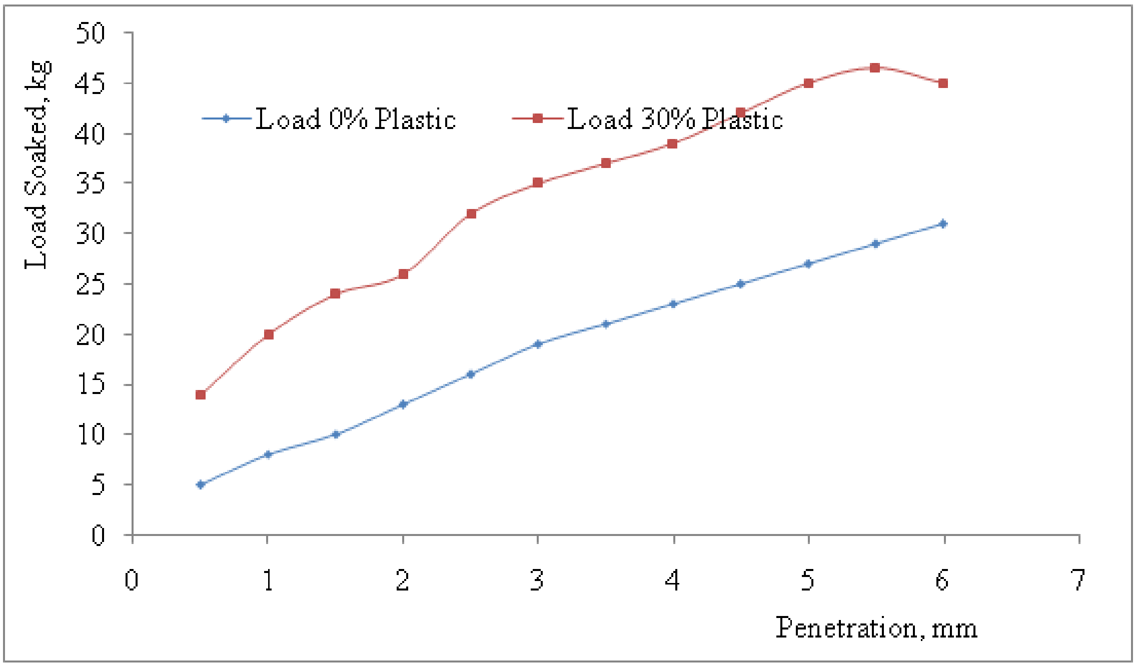

Figure 4: Results of load against penetration for soaked control and 30% plastic pellet substitution

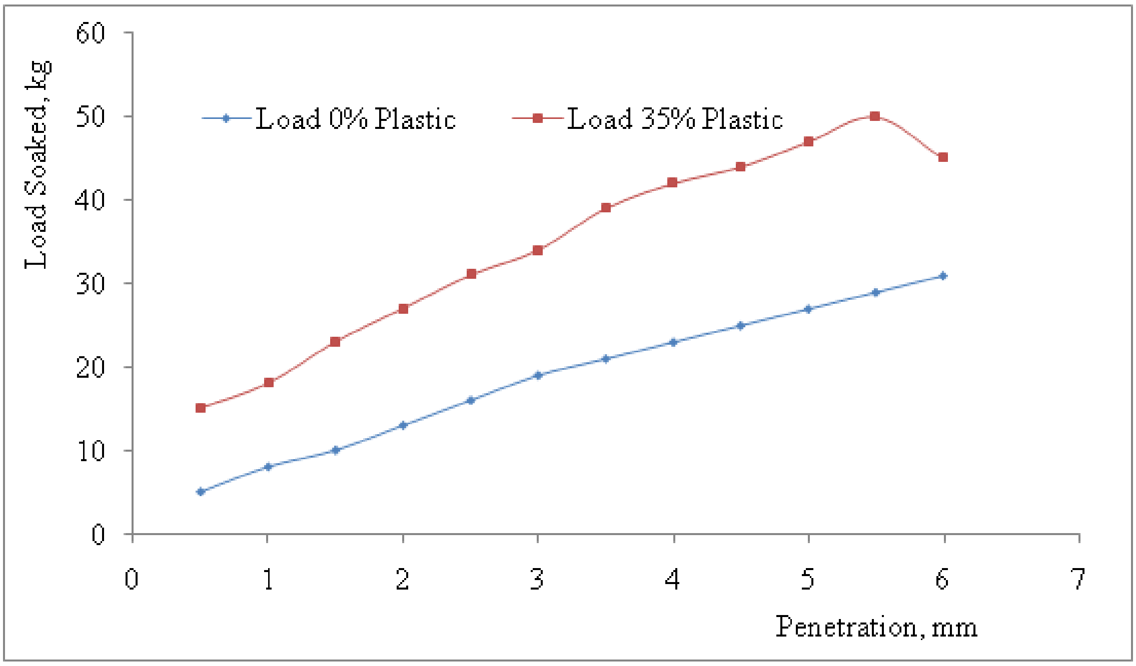

Figure 5: Results of load against penetration for soaked control and 35% plastic pellet substitution

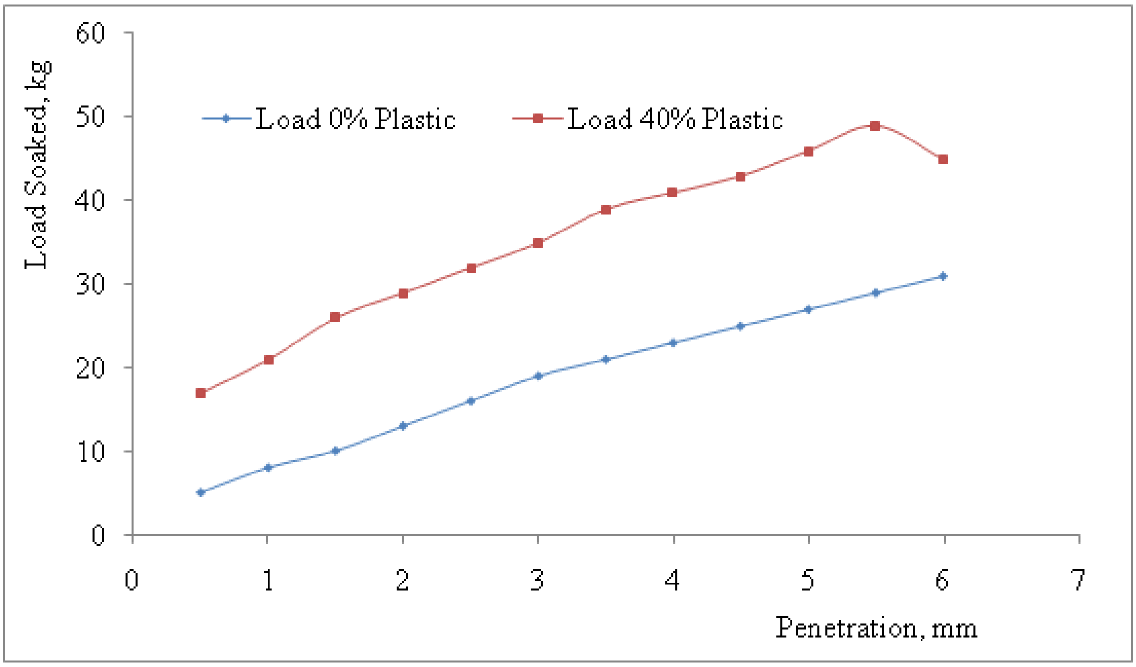

Figure 6: Results of load against penetration for soaked control and 40% plastic pellet substitution

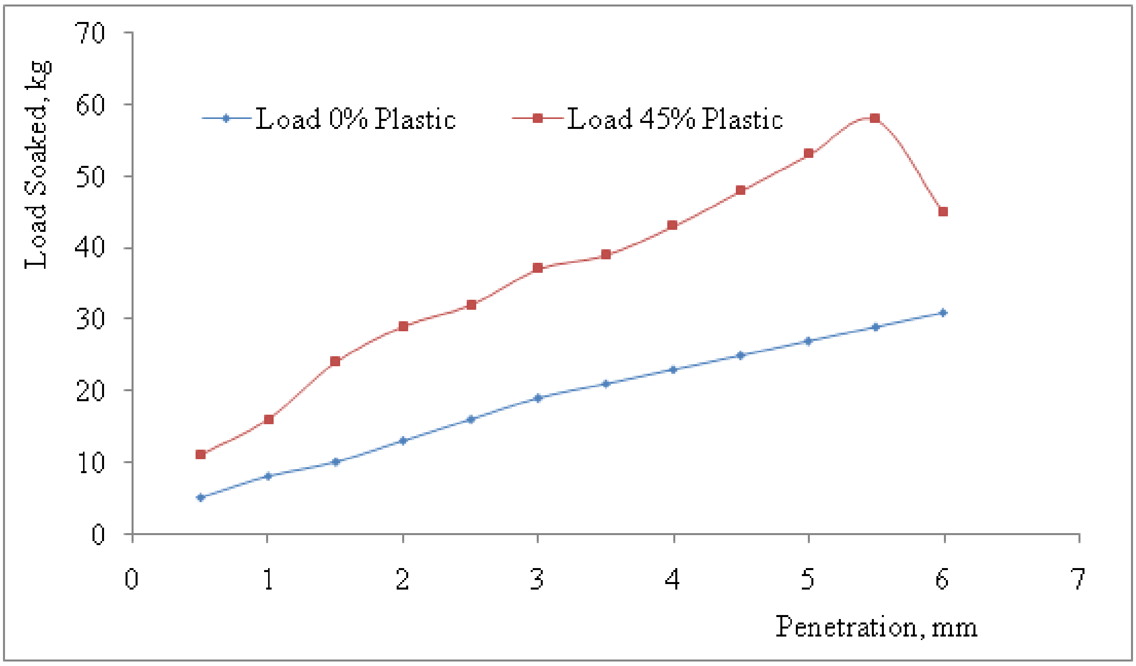

Figure 7: Results of load against penetration for soaked control and 45% plastic pellet substitution

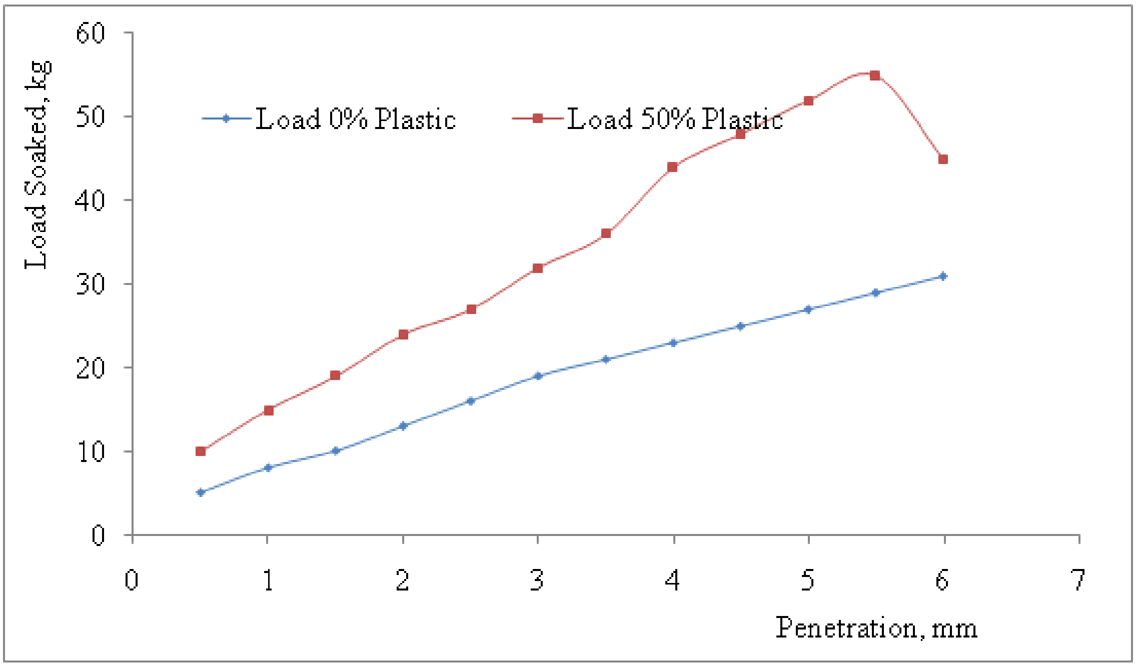

Figure 8: Results of load against penetration for soaked control and 50% plastic pellet substitution

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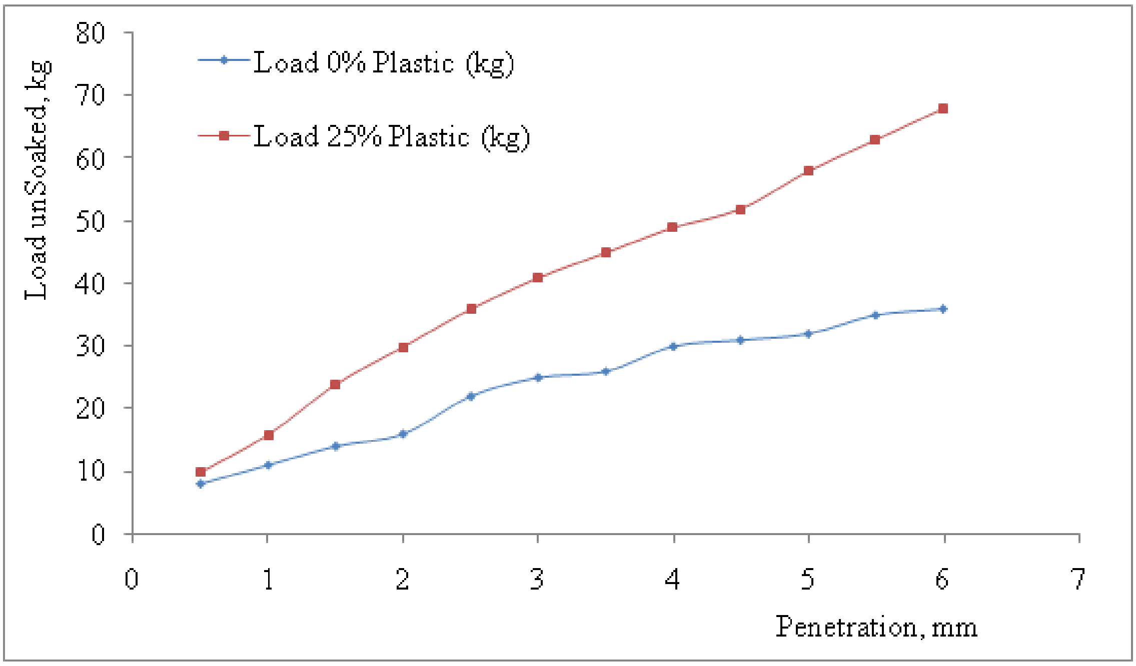

Figure 9: Results of load against penetration for unsoaked control and 25% plastic pellet substitution

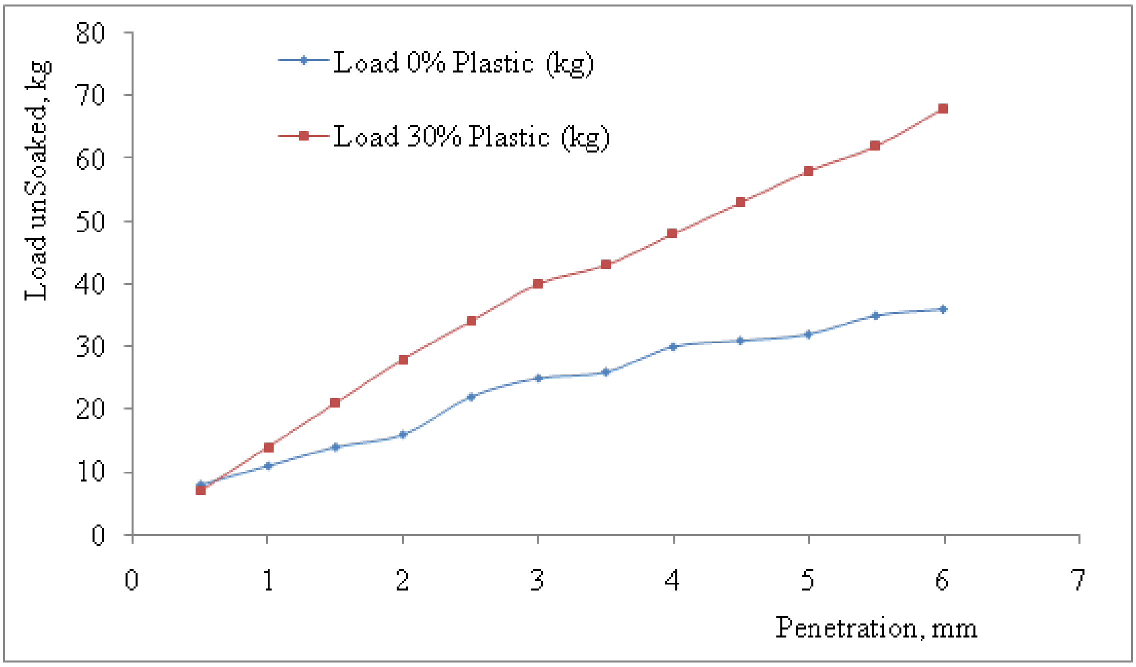

Figure 10: Results of load against penetration for unsoaked control and 30% plastic pellet substitution

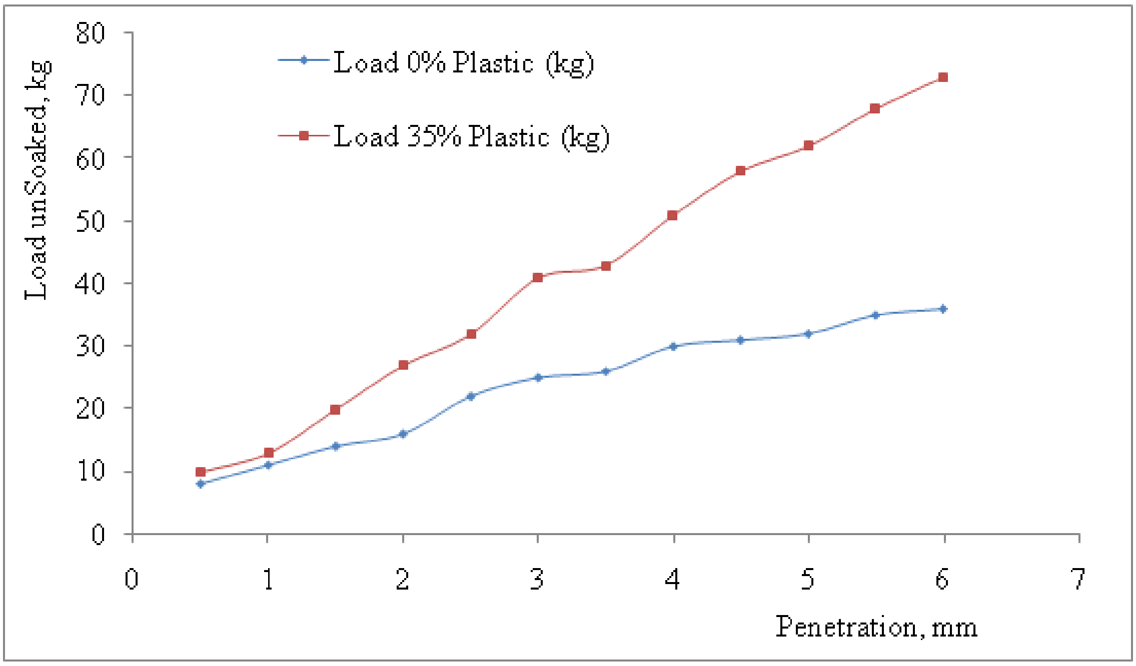

Figure 11: Results of load against penetration for unsoaked control and 35% plastic pellet substitution

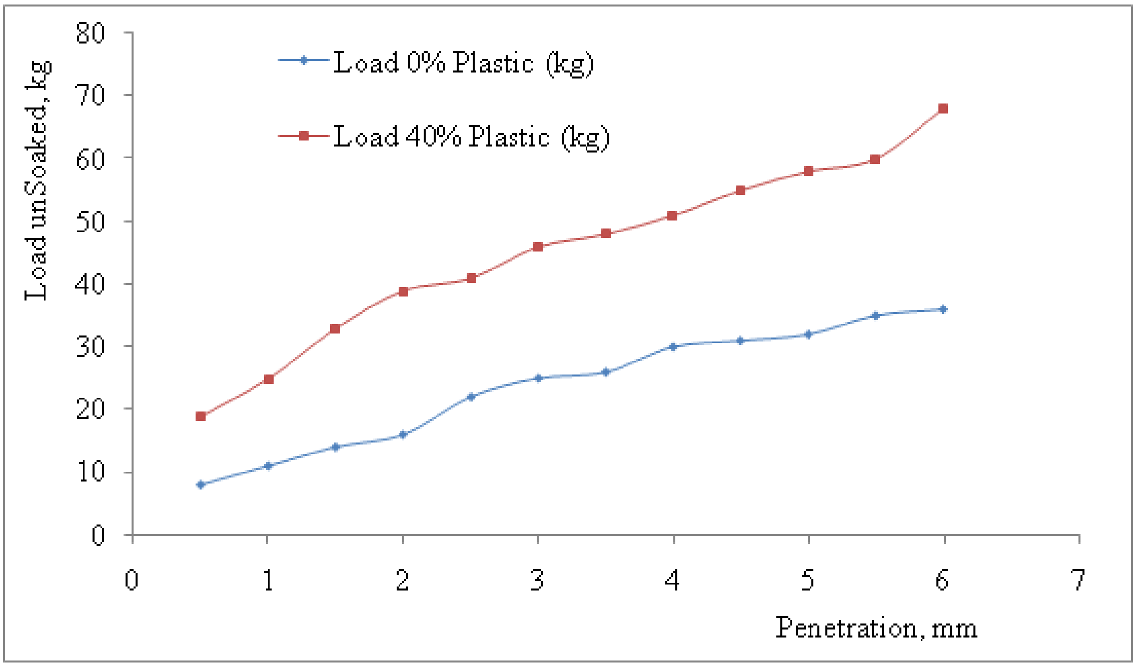

Figure 12: Results of load against penetration for unsoaked control and 40% plastic pellet substitution

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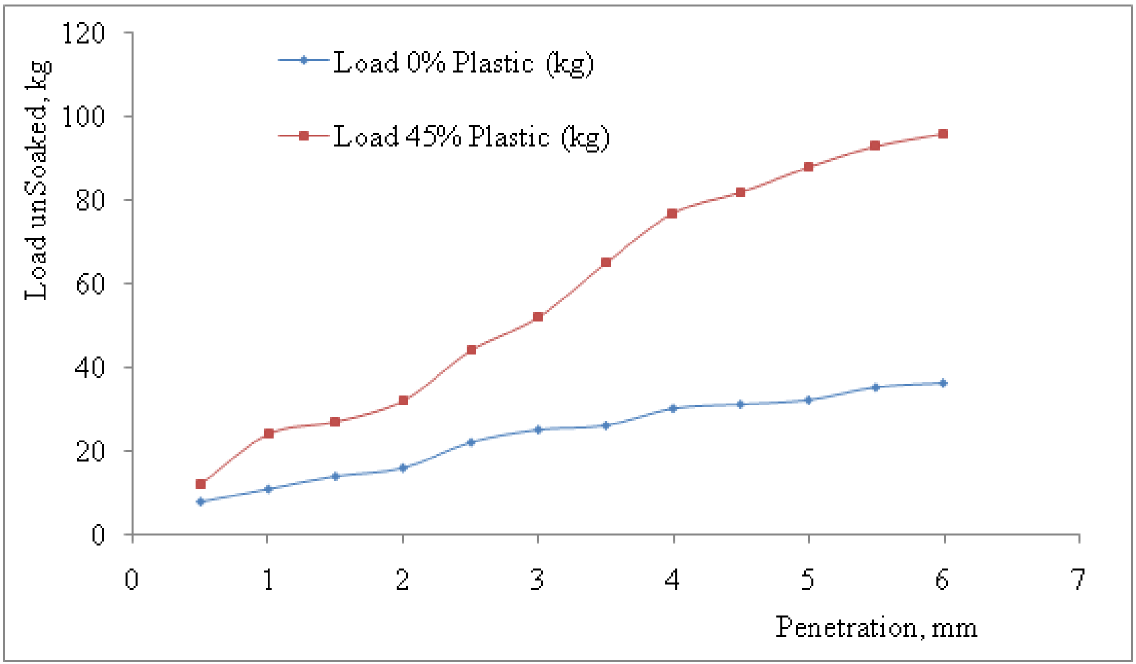

Figure 13: Results of load against penetration for unsoaked control and 45% plastic pellet substitution

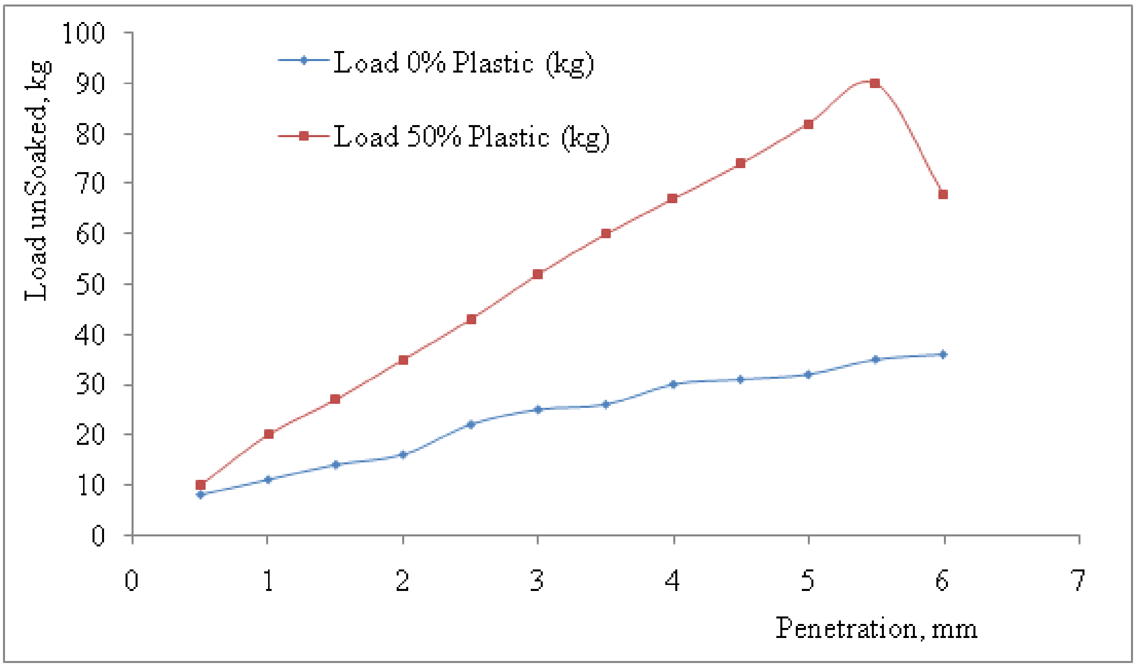

Figure 14: Results of load against penetration for unsoaked control and 50% plastic pellet substitution

The load values of high dosage (25% to 50%) plastic pellets (at interval of 5) substitution for high dosage is greater than that of control experiment. The values for percentage substitutions keep on increasing till a slight decrease in CBR value between 45% and 50%. From the results, with 0% serving as control experiment for soaked and unsoaked (Figures 3 and 14), it was observed that the plastic substituted for lateritic soil behaves just like control experiment but there is increase in load values of the experiment with CBR value of 3.37% for control experiment and 5.85% for 25% plastic pellets substitution. The CBR value of plastic pellets substituted for lateritic soil at high dosage is greater than CBR value of control experiment (0%) for soaked and unsoaked. Lateritic soil in its natural state contains air content which when in contact with water can take moisture but plastic pellets in its natural state cannot absorb such quantity of water. The water absorbed by lateritic soil surrounded on its outer surface and normally act as lubricant between the soil particles whereas plastic pellets cannot retain such quantity of water. The more the outer surface the more water the soil particles absorbed. After the absorption of water, there will be rearrangement of soil particles which will eventually account for the reduction in the values of strengths parameters in its natural state compared to lateritic soil mixed with plastic pellets. The more the percentage of substituted plastic pellets, the more the strengths characteristics. Reduction of strength parameters at high dosage of plastic substitution is inevitable. There is bound to be reduction in the strength values around 40% to 50% and above. This is because at such percentages (high dosage), there is more void (due to increase in the plastic pellets) and the surface to absorb water has reduced due reduction in the quantity of lateritic soil present in the sample and also the water quantity used in the test is constant (Olarewaju, 2016a, 2016b, 2016c, and 2016d).

This CBR value is related to the CBR value for sub-grade materials that is used to design other component of highway pavement (Road Note 29, 1970). If the CBR value results of the soaked experiment falls between 0% and 2% within a water logged area (i. e. depth of water-table below the formation level is less than 600mm) is regarded as heavy clay. This can be used to design sub-base of 350mm to 400mm thickness depending on the expected traffic wheel load, provided there is permanent and adequate drainage (Road Note 29, 1970). This sub base thickness is therefore used to design other components of the highway. The average CBR value of 6.606 was recorded for the soaked high dosage while 8.25 was recorded for unsoaked high dosage. According to Road Note 29 (1970), lateritic soils with CBR value above 6% and in water logged area is regarded as soaked CBR. This category of soil may be regarded as sand and the expected traffic load must be determined before other components of a highway pavement can be designed. To estimate the expected traffic load for highway pavement design, life span of the pavement must be known as well as a constant growth. Once the expected axle load is determined, then Road Note 29 (1970) can be used to determine the thickness of the sub-base layer. For instance the soaked CBR value of high dosage is 6.606 and if the expected traffic load is 0.01×10^6 cumulative number of standard axle, therefore, the sub-base thickness will be 90mm with rolled asphalt road base of 60mm and surfacing (i. e., base course + wearing course) of 50mm while ensuring adequate and permanent drainage is provided.

Lateritic soil with CBR value above 7% and elevated surface is regarded as unsoaked CBR. This category of soil may be regarded as sand and the expected traffic load must be determined before other components of a highway pavement can be designed. To estimate the expected traffic load for highway pavement design, life span of the pavement must equally be known as well as a constant growth. Once the expected axle load is determined, then Road Note 29 (1970) can be used to determine the thickness of the sub base layer. For instance the unsoaked CBR value high dosage is 8.25 and if expected traffic load is 0.01×10^6 cumulative number of standard axle, therefore, the-sub base thickness will be 90mm with rolled asphalt road base of 60mm and surfacing (base course + wearing course) of 50mm while ensuring adequate and permanent drainage is provided (Sophie, 2009, Verma, 2008, Jean-Piera, 2004, Olarewaju, 2016a, 2016b, 2016c, and 2016d).

Conclusion

High dosage substitutions ranges from 25% to 50% (at interval of 5) plastic pellet substitutions for the soaked and unsoaked load and it behave like control experiment (0% plastic pellet substitution)**.** There is increase in value from 25% up to 35% plastic pellet replacement of lateritic soil but there is significant decrease in value at 40% to 50% replacement. Recycling plastic waste for construction purpose will help reduce capital invested on plastic waste treatment plants and will also save the environment from problem of toxic smoke from incinerators.

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