EFFECT OF PLASTIC WASTE ON THE STRENGTH CHARACTERISTIC OF NIGERIAN LATERITIC SOIL USED AS SUB BASE MATERIAL IN ROAD CONSTRUCTION: A SYSTEMATIC REVIEW APPROACH

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ABSTRACT

There is increasing need for transportation facilities due to population growth and the maintenance of existing infrastructure. However, the soil properties are improved using soil stabilization techniques using geogrids, fibre, or waste plastic to improve subgrade strength. The paper aims to review the history, benefits, applications, and potential issues of using plastic waste for soil reinforcement. The addition of plastic waste has increase the dry density of lateritic soil and reduces its water absorption capacity. Plastic waste also enhances the load-bearing capacity of the soil, as indicated by the CBR value. The review suggests that 5% plastic waste content is the optimum dosage for improving the CBR value. Stabilization with plastic waste and other agents can enhance the strength of the sub-base material for road construction. However, it also indicates the potential leaching of chemical components from the plastic waste into the environment, which negatively impact ecosystems, water quality, and human health.

KEY WORDS: *Plastic waste, Lateritic soil, Sub-base, Highway*

1.0 Introduction

Road networks are very important infrastructure to every country's economy as it enables persons, goods and services to be moved from one destination to another. As a result, the Nigerian Government has shown great interest in improving the road infrastructures in Nigeria, due to their economic importance(Douglas 2020).

The need for adequate provision of transportation facilities is enormously increasing with increase in population and also the need for maintenance of the existing ones(Zamad et al. 2022). Highway engineers are faced with the problems of providing very suitable materials for the highway construction. Predicated on this fact, continuous researches are being carried out by individuals, firms and institutions on ways to improve the engineering properties of soils(Ojuri 2017).

In most developing countries like Nigeria, rapid increase in human population and urban settlements have increased the demand for good access highways and roads to guarantee connectivity among the different urban settlements(Science 2021). This, in addition to scarcity of quality aggregates, has compelled government and road authorities to make use of naturally occurring geomaterials or construction materials in constructing roads (Science 2021).

Design of the various pavement layers is very much dependent on the strength of the subgrade soil over which they are going to be laid. Subgrade strength is mostly expressed in terms of CBR (California Bearing Ratio)(Praveen A., Bajinder S., n.d.). Weaker subgrade essentially requires thicker layers whereas stronger subgrade goes well with thinner pavement layers. The pavement and the subgrade mutually must sustain the traffic volume(Chimoye 2019).

The subgrade is always subjected to change in its moisture content due to rainfall, capillary action, overflow or rise of water table. For an engineer, it is important to understand the change of subgrade strength due to variation of moisture content(Menon 2018).

Lateritic soils are in high abundance in Nigeria and are mostly used as sub-base materials in road construction due to their various physical and engineering properties which makes them suitable for the purpose(Sani, Yohanna, and Chukwujama 2020). However, there are instances where lateritic soil may contain substantial amount of clay minerals such that its strength and stability cannot be guaranteed under load, especially in the presence of moisture(Chimoye 2019). In most cases, sourcing for alternative soil may prove economically unwise; rather, improving the available soil to meet the desired objective can be a more economical approach(Etim 2016).

Getting rid of plastic waste by burning of plastic wastes releases smoke which contaminates the air. The released smoke contains small particulates, hazardous substances and greenhouse gases which eventually cause health hazard(Ilaro and State 2017). However, the disposal of plastic products also contributes significantly to the environmental impact(“No Title” 2020). Most plastics are not biodegradable and can persist in the environment for many years. Indiscriminate of plastics waste into rivers, streams, drainage, etc. can cause blockage of drainage and sewage systems resulting in water logging, flooding and spread of water borne diseases(Olutaiwo, A. O., Ezegbunem 2017). This has been reported in many countries. With increasing plastic products in the market particularly packaging, being disposed off soon after their purchase and consumption, the landfill space required by plastics waste disposal is a growing concern(Ilaro and State 2017). The best way to dispose plastic wastes and any other non-biodegradable wastes is through recycling. There are quite a number of benefits to be derived from recycling. This includes contributing to energy savings and the reduction of greenhouse gas emissions. In addition, it also saves non-renewable sources like oil and gas. Recycling provides livelihood for teaming populace as well as families in developed and developing nations, either in the form of direct employment or informal economic activities(Sophie, n.d.),(Ilaro and State 2017).

According to(Stabilization, Bitumen, and Combination 2018), ‘’Stabilization is a process of improving subsoil engineering properties prior to construction. This can be accomplished in several ways such as preloading of the grounds application of high energy impacts, use of sand drains and sand filters, prefabricated wick drains, and chemical additives’’.

It has been ascertained through several studies that the qualification of plastic waste in regards to its use as a soil stabilizer. Studies include:[10,14–17] through a research conducted, proved the potential possibilities of HDPE (high density polyethylene) to act as a soil reinforce by enhancing the properties of sub grade soil. Various percentage of HDPE strips length and proportions were obtained from plastic waste and mixed with the soil, on which a series of CBR tests were conducted on the reinforced soil(Gupta et al. 2019). The CBR test conducted shows that the addition of HDPE strips in soil to reinforce it is beneficial in highway application. Nsaif (2013) through a research to study the manner in which soil strengthened is by plastic waste materials concluded that by mixing pieces of plastic waste with both clayey and sandy soil at varying mixing ratios (0, 2, 4, 6, 8)% respectively by weight, there was a relevant increment in the cohesion for both soil types. It was also concluded that was a reduction in MDD and OMC of the soil as a result of the low specific gravities of the plastic pieces[7,10,18]. In 2014, Chebet et al conducted experiments in the laboratory to ascertain the shear strength increase and yielding capacity of found sand locally brought about by the random infusion of HDPE strips obtained from plastic shopping bags. Through visual inspection of the plastic material after the conduction of the tests and analysis, implication was the increased strength for the reinforced soil is as a result of tensile stresses mobilized in the reinforcements. Plastic properties (concentration, length and width of the strips) and soil properties (gradation, shape, particle size) were some of the factors indicated to have an effect on the proficiency of the reinforcement material. In 2015, a research was conducted a research to calculate the technical properties of soil by bringing it together with plastic waste(Dhatrak, A., Konmare, n.d.). The result detected showing that the use of plastic 23 waste bottle chips is an alternative method to enhance the sub grade soil when considering the construction of flexible pavements. Plastic waste was mixed with various proportions (0.5%, 1%, 1.5%, 2% and 2.5%) containing dry soil to calculate value of CBR. It was concluded that the mixture of plastic strip waste with the soil will enhance its strength and also, provide an economical and eco – friendly method to dispose of the plastic waste[11,19,21]. Hansaraj Dikkar (2017) conducted a research to improve the properties of soil by adding plastic shopping bags with different measurements as 10mm and 15mm lengths and 20mm,40mm and 60mm widths. The percentages of plastic content used was 0.15%,0.30%,0.45% and 0.60%.It was concluded from the research that 0.30% of plastic content is optimum percentage to be used as a stabilizing agent for sizes 10mm x 40mm and 15mm x 40mm("No Title" 2020).

However, waste Plastic reinforced soil, according to[10,15,17,18,21] Choudhary et al (2010) studies, the result shows that the potential of reclaimed high density polyethylene strips (HDPE) as soil reinforcement for improving engineering performance of subgrade soil. A series of California Bearing Ratio (CBR) tests were carried out on randomly reinforced soil by varying percentage of HDPE strips (i.e 0.25%, 0.50%, 1%, 2%, 4%) with different lengths and proportions as shown in Figure 2.14-2.17. It increases the CBR value and Secant Modulus which is maximum when strip content is 4% and aspect ratio 3. The maximum CBR value of reinforced system is 3 times that of a unreinforced system. Base course thickness can be significantly reduced if HDPE strip reinforced sand is used as sub-grade material(Jalal and Hassan 2021).

Also Dixit, (2017), used waste medical capsule plastic packing as a reinforcing material and its effect on dry density, California Bearing Ratio and Permeability of three soil type's viz., sand, moorum and expansive soil with different percentage of randomly distributed reinforcing elements in the form of waste medical packing polythene strips. Different percentages of reinforcement considered are 1, 2, 4 and 7 and the sizes of strips being 7x7mm, 20x7mm and 35x7mm[2,17,21]. CBR values to an extent of 7 times, in case of sandy soils reinforced with medical waste strips compared to the improvements with similar mixes with moorum and expansive soil. Medical waste reinforced sandy soils exhibited no improvement in permeability while those with moorum and expansive soil samples showed slight improvement. The 7 mm by 7 mm and 20 mm by 7 mm sizes were effective in improving CBR values as compared to 35 mm by 7 mm size(Dixit 2017).

2.0 Material and Method

2.1 A systematic review

2.2 The main research question of the work

RQ1. How does the addition of plastic waste affect the compaction characteristics (e.g., maximum dry density, optimum moisture content) of Nigerian lateritic soil used as a sub-base material in road construction?

RQ2. How does the presence of plastic waste influence the load-bearing capacity (e.g., California Bearing Ratio, resilient modulus) of Nigerian lateritic soil when used as a sub-base material in road construction?

RQ3. What is the C.B.R, UCS value of unreinforced soil and the stabilized after the inclusion of plastic waste on the deformation and settlement characteristics of Nigerian lateritic soil used as a sub-base material in road construction?

RQ4. What are the optimal proportions and mix design considerations for incorporating plastic waste into Nigerian lateritic soil to achieve improved strength characteristics as a sub-base material?

RQ5. How do different soil improvement techniques, such as stabilization or reinforcement, interact with the addition of plastic waste in Nigerian lateritic soil used as a sub-base material, and what are the resulting strength characteristics?

RQ6. What are the environmental implications of using plastic waste in the sub-base material of roads constructed with Nigerian lateritic soil, particularly regarding leaching and potential contamination?

RQ7. What are the long-term durability effects of incorporating plastic waste on the Nigerian lateritic soil sub-base material, considering factors such as aging, weathering, and degradation?

2.3 composition and subtraction

This review specifically focuses on scientific and gray literature on the Plastic Waste, Sub Base Material, and Road Construction. Much of the data and information is drawn from studies and reports. For that purpose, five criteria were developed to identify, screen and select relevant scientific studies and gray literature for inclusion and exclusion from the review

• **Subject relevance:** studies that primarily dealt with environmental impacts of plastic waste, soil stabilization, sub base lateritic soil, road pavement were largely eligible for inclusion.

• **Geographic scope:** studies conducted in Africa mainly in Nigeria, were eligible for inclusion. However, few studies in other developing regions were also included when such studies have unique and relevant evidence related to the context in Africa (Nigeria).

• **Intervention scale:** Studies that primarily focused on soil stabilization using plastic waste as additive. For all purposes were eligible for inclusion.

• **Type of data:** Both quantitative and qualitative studies were considered for inclusion; studies with sound empirical analysis were particularly preferred.

2.4. Search strategy and data sources

Searching for relevant studies and gray literature was conducted by using databases of scientific journal publishers, internet search engines, and websites of different academic and development organizations. For it is imperative that the search is sufficiently broad yet specific enough to cater all the high-quality relevant studies and literature, a comprehensive and structured search strategy combining key terms and phrases was used as summarized hereunder.

2.4.1. Journal articles

Published scientific papers were searched and accessed. The main e-journal publishers and links accessed were Science Direct, Springer, Elsevier, and Research Gate. The keywords of the topic (Plastic waste, Lateritic soil, Sub-base, Highway) and other related word and phrase.

2.5. Identification and selection of studies

Following the comprehensive literature search, 264 potentially eligible records were identified and retrieved. First stage screening for duplication and unrelated at title led to the exclusion of 44 records. In the second stage, the abstracts and executive summaries of the remaining 220 records were read and evaluated based on the inclusion and exclusion criteria. As a result, 118 of the 220 records were excluded after reading the abstracts mainly because they did not meet the inclusion criteria. Subsequently, full-text evaluation was conducted for the remaining 102 records, of which 61 more were excluded on the grounds of limited relevance, poor quality and unreliability of data. Finally, 41 studies for quantitative and qualitative were selected for the systematic review.

2.6. Research quality assessment and data extraction

Both objective and subjective evaluation criteria were used to assess and determine the quality of the studies and reports to be eligible for inclusion. The evaluation criteria included; the theoretical basis and relevance of the research; research methodology and design; reliability of data sources; and quality of the analysis. Both quantitative and qualitative information related to the research questions were systematically extracted.

3. Results and discussion

3.1 The addition of plastic waste affects the compaction characteristics (MDD, OMC) of Nigerian lateritic soil used as a sub-base material in road construction?

The addition of plastic waste to Nigerian lateritic soil used as a sub-base material in road construction has both positive and negative effects on its compaction characteristics. The addition of plastic waste can increase the maximum dry density of lateritic soil. Plastic particles act as fillers and increase the soil's overall mass, leading to higher compaction densities. This effect is particularly noticeable when the plastic waste content is relatively low to moderate(Olutaiwo, A. O., Ezegbunem 2017).The presence of plastic waste has influence the optimum moisture content of lateritic soil. Plastic particles can act as barriers, reducing the soil's water absorption capacity. As a result, the soil may require less water content to achieve maximum compaction. However, if the plastic waste content becomes excessive, it can hinder compaction and lead to inadequate densification(Mahdi et al. 2012).The waste all over the country for the stabilization of soil which will help to the most extent to decrease the requirement of valuable land for their disposal and also reduce the hazardous environmental impacts[17,22].

3.2 The influence of plastic waste ON the load-bearing capacity (e.g., California Bearing Ratio, resilient modulus) of Nigerian lateritic soil when used as a sub-base material in road construction

The presence of plastic waste has implications for the load-bearing capacity of Nigerian lateritic soil when used as a sub-base material in road construction.

The addition of plastic waste to lateritic soil impact the CBR value, which is a measure of the soil's load-bearing capacity(Ilaro and State 2017). Plastic particles can enhance the interlocking and stabilization of soil particles, leading to an increase in the CBR value. The improved interlocking mechanism provided by the plastic waste can contribute to enhanced load-bearing capacity and resistance to deformation under applied loads.(Olutaiwo, A. O., Ezegbunem 2017). The resilient modulus is a measure of the soil's ability to withstand repeated loads without permanent deformation. The presence of plastic waste in lateritic soil has affect its resilient modulus(Vitalis and Biotech 2016). Plastic particles can improve the stiffness and load-bearing capacity of the soil, resulting in an increase in the resilient modulus. This increase indicates that the soil is better able to resist deformation under repeated loading conditions, which is advantageous for sub-base materials in road construction(Muttaqa and Zango, n.d.). The feasibility of reinforcing soil with different waste plastic content (i.e. HDPE, LDPE, and PP) was investigated in this study. Granular size materials were randomly mixed with locally available soil and tested to determine CBR values. Design of flexible pavement with different material and cost analysis of road was done(Dixit 2017),16]. Based on the results, the following conclusions can be drawn:

1) Addition of HDPE, LDPE, PP waste plastic, to local soil increases the CBR value.

2) The CBR value of the unreinforced soil was 7.9 % which were increased to26.9% for 5% HDPE waste plastic content, 20.38 % for 5% LDPE and 23.2% for 5% PP.

3) The maximum improvement in CBR value was obtained when waste plastic content was 5%. Bearing Ratio Index (BRI) value was found approximately 3.40 for HDPE waste plastic whereas for LDPE and PP, BRI was 2.57 and 2.930m.

4) It was observed that there is large decrease in pavement crust thickness with the addition of HDPE, LDPE & PP in the lateritic soil. With 5% HDPE waste plastic content.

3.3 What is the C.B.R, UCS value of unreinforced soil and the stabilized after the inclusion of plastic waste on the deformation and settlement characteristics of Nigerian lateritic soil used as a sub-base material in road construction?

The inclusion of plastic waste in Nigerian lateritic soil used as a sub-base material in road construction can influence its deformation and settlement characteristics.

The presence of plastic waste can have both positive and negative effects on the deformation characteristics of lateritic soil. Plastic particles can improve the interlocking and stabilization of soil particles, leading to increased stiffness and reduced deformation under applied loads. This can enhance the soil's resistance to deformation and improve its overall performance as a sub-base material.(Mahdi et al. 2012).

The impact of plastic waste on settlement characteristics of lateritic soil can vary depending on various factors, including the type, size, and content of the plastic waste(Cden, n.d.). Plastic particles can help reduce settlement by improving the load-bearing capacity and stability of the soil. The additional interlocking provided by the plastic waste can minimize the potential for settlement under applied loads(Pet and Waste 2016).

However, it is important to note that the settlement behavior of lateritic soil can be influenced by other factors such as moisture content, compaction method, and loading conditions.

Based on the review of the various research papers we can conclude that plastic strips in optimum amount with suitable dimension is feasible for improving the engineering properties of soil. Plastic can be utilized as one of the materials that can be used as soil stabilizing agent in proper proportion, which helps in increasing the CBR of the soil. Thus, using plastic as a soil stabilizer is economical and gainful use in construction as there is lack of good quality soil for various construction(Kassa et al. 2020).

Reviewing the researches conducted, it was observed that, the C.B.R value of unreinforced soil was 7.9% which were increased to 26.9% for 5% HDPE waste plastic content, 20.38% for 5% LDPE and 23.2% for 5% PP(Pet and Waste 2016) as in figure 1.

Also, the experimental study has provided a good insight of the unconfined strength (UCS) characteristics of glass fibre reinforced lateritic soil[18,26]. The following conclusions have been made based on the results:

- The UCS value of fibre-reinforced soil has significantly improved and the optimum fibre content depends on the fibre length.
- For 10 mm fibre, the strength of soil is improved for all the fibre contents used.
- For 20 mm fibre, the optimum content is found to be 1%, whereas in case of 30 mm fibre it is found to be 0.75%.
- The optimum fibre length is 20 mm for fibre contents up to 1%, whereas it is 10 mm at 1.25% content.
- The strain corresponding to peak UCS increases considerably with fibre reinforcement and it further increases with fibre content and length.
- The stiffness modulus at 2% axial strain increases with fibre content up to 0.5%, remains almost the same up to 1% fibre content and then decreases at 1.25% content.

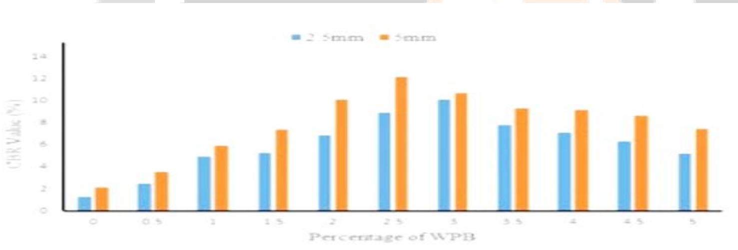

Figure 1. CBR Value

3.4 The optimal proportions and mix design considerations for incorporating plastic waste into Nigerian lateritic soil to achieve improved strength characteristics as a sub-base material?

Determining the optimal proportions and mix design considerations for incorporating plastic waste into Nigerian lateritic soil to achieve improved strength characteristics as a sub-base material requires site-specific testing and analysis(Marçal et al. 2021), many refuse from plastic company and market having taking to incinerator for burning as in Figure 2.

The content typically ranges from 1% to 10% by weight of the soil, although specific projects may have different requirements. It is important to strike a balance between achieving strength enhancement and maintaining the desired engineering properties(Pet and Waste 2016).

The size and shape of plastic waste particles can influence their effectiveness in enhancing strength characteristics. Ideally, the plastic waste should be properly shredded as in Figure 3 or ground to achieve a consistent particle size distribution. Smaller particle sizes tend to provide better interlocking and dispersion within the soil matrix, leading to improved strength properties(Ojuri 2017). Different types of plastic waste may have varying effects on the strength characteristics of lateritic soil. Common plastic types used in sub-base materials include high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polypropylene (PP)(Mohajerani et al., n.d.).

Figure 2: heap of waste plastic Figure 3: plastic waste cut into desired size

Based on the review of the various research papers we can conclude that, the maximum or optimum dosage of the plastic waste used in stabilization of lateritic soil use as sub base material in Road construction is 5%, as it marks the maximum improvement in CBR value, and it was observed that there is large decrease in pavement crust thickness with the addition of 5% HDPE, LDPE and PP waste plastic content in lateritic soil[2,3,14].

3.5 The interaction of different soil improvement techniques, such as stabilization or reinforcement, with the addition of plastic waste in Nigerian lateritic soil used as a sub-base material

The interaction between different soil improvement techniques, such as stabilization or reinforcement, and the addition of plastic waste in Nigerian lateritic soil used as a sub-base material can have varying effects on the resulting strength characteristics.

Stabilization involves the addition of certain materials or chemicals to enhance the strength and durability of the soil. Common stabilization methods include cement stabilization, lime stabilization, and chemical stabilization(Marathe and Kumar 2015). When plastic waste is added to the lateritic soil along with these stabilization agents, the combined effects can be beneficial in improving the strength characteristics of the sub-base material.

However, the addition of plastic waste in conjunction with cement stabilization can enhance the interlocking and binding mechanisms within the soil matrix(Yadav and Patel 2020). The plastic waste particles act as fillers, improving the overall packing density and contributing to increased strength properties(Olutaiwo, A. O., Ezegbunem 2017).

Lime stabilization, when combined with plastic waste, can promote Pozzolanic reactions between the lime and the plastic particles(“No Title” 2020). This can result in improved strength, reduced plasticity, and enhanced long-term durability(Ilaro and State 2017).

Chemical additives, such as polymers or soil modifiers, can be used in conjunction with plastic waste to enhance the strength characteristics of the lateritic soil(Information 2019). The plastic waste can act as a reinforcement element, assisting in better dispersion and bonding of the chemical additives within the soil matrix(Menon 2018).

Reinforcement involves introducing materials to increase the tensile strength and load-bearing capacity of the soil. Common reinforcement techniques include the use of geosynthetics, such as geogrids or geotextiles, or the inclusion of natural or synthetic fibers. When combined with plastic waste, these reinforcement techniques can further enhance the strength characteristics of Nigerian lateritic soil as a sub-base material(Imtiaz and Philosophy 2021).

The specific effects of reinforcement techniques combined with plastic waste will depend on factors such as the type and content of the plastic waste, the type and configuration of the reinforcement material, and the soil conditions.

3.6 The environmental implications of using plastic waste in the sub-base material of roads constructed with Nigerian lateritic soil.

Plastic pollution is referred to as the amassing of plastic materials in the environment which have a negative effect on the surroundings and also the living organisms(Geyer, R., Jambeck, J.R. and Law, n.d.). Plastic pollution majorly impacts land and aquatic habitats alike. The fact that they are cheap and long – lasting has led to the increase in pollution. Plastic pollution can be grouped into macro-plastics which refer to large plastics which can be seen clearly that do not have a direct impact on the food chain in their current form, microplastics which are generally macro – plastics that have been degraded through various processes breaking it down into smaller particles("No Title" 2020). Despite the multiple benefits that the material offers, plastics are associated with high levels of waste and leakage to the environment. This is the result of single-use plastics applications, inadequate end of-life treatment, low recyclability and re-usability rates and high potential of disintegration into microplastics(Geyer, R., Jambeck, J.R. and Law, n.d.).

Although more research is critically needed in the subject, it is evident that very little percentage of disposed plastic is actually recycled or converted to energy through incineration(Prakhash et al., n.d.). Study also shows that microplastic pollution is much higher on land than in marine or freshwater. Though the long – term effects of microplastic pollution are yet to be fully determined, some of the effects include the fact that most plastics are non-biodegradable and majority end up in the sewers("No Title" 2020). Sewage sludge is commonly used as fertilizers for the soil, thereby transferring the microplastics to the soil and this has adverse effects on living organisms which we depend on like earthworms(Science 2021). Also chlorinated plastics (PVC) which is very commonly used contains toxic chemicals which is then released into the soil, this not only affects the soil stability and its organisms but also flows into nearby water sources thereby leading to contamination(Pet and Waste 2016).

Improper plastic waste disposal is becoming a pressing environmental issue in most African countries. They are currently covering landfills and water bodies, clogging sewerage systems, disrupting the ecological cycle and creating an aesthetically unpleasing environment. This in turn causes serious damage to animal, plant and human lives(Ogundare et al. 2021). Polyethylene Terephthalate (PET) bottles are conventional plastic bottles that currently are highly utilized. They are used to package water, soft drinks, liquid foods, and various other beverages. With their increasing demand, their disposal is becoming difficult. The degradation of waste PET bottles takes a very long time in nature (more than a hundred years). Recycling and using these plastic bottles to stabilize expansive clay soil are moves in the right direction making the construction industry an appropriate candidate with its high consumption ability(Kassa et al. 2020).

It has been ascertained through several studies that the qualification of plastic waste in regards to its use as a soil stabilizer. Studies include: (Choudhary, A.K., Jha, J.N. and Gill, n.d.) in 2010 through a research conducted, proved the potential possibilities of HDPE (high density polyethylene) to act as a soil reinforce by enhancing the properties of sub grade soil. Also, a research to study the manner in which soil strengthened is by plastic waste materials concluded that by mixing pieces of plastic waste with both clayey and sandy soil at varying mixing ratios (0, 2, 4, 6, 8)% respectively by weight, there was a relevant increment in the cohesion for both soil types. It was also concluded that was a reduction in MDD and OMC of the soil as a result of the low specific gravities of the plastic pieces(Nsaif, n.d.). In 2014, Chebet et al conducted experiments in the laboratory to ascertain the shear strength increase and yielding capacity of found sand locally brought about by the random infusion of HDPE strips obtained from plastic shopping bags. Through visual inspection of the plastic material after the conduction of the tests and analysis, implication was the increased strength for the reinforced soil is as a result of tensile stresses mobilized in the reinforcements (Chebet, F. C. and Kalumba, n.d.). Dhatrak et al. (2015) conducted a research to calculate the technical properties of soil by bringing it together with plastic waste. The result detected showing that the use of plastic 23 waste bottle chips is an alternative method to enhance the sub grade soil when considering the construction of flexible pavements[20,37].

When plastic waste is incorporated into the sub-base material, there is a potential for leaching of chemical components from the plastic. Leaching occurs when water percolates through the soil, potentially carrying dissolved substances from the plastic waste into the surrounding environment(Abdulfatah et al. 2013). The leached substances may include additives, residual monomers, or other potentially harmful compounds present in the plastic waste.

The leaching of substances from plastic waste has the potential to contaminate soil, groundwater, and nearby surface water bodies. The contaminants may include organic compounds, heavy metals, or other toxic substances associated with the plastic waste. If not managed properly, this contamination can have adverse effects on the local ecosystem, water quality, and human health.

Over time, plastic waste incorporated into the sub-base material can undergo degradation or weathering, resulting in the generation of microplastics. Microplastics are small plastic particles less than 5mm in size. These particles can be released into the environment through various processes, such as erosion, runoff, or wind dispersion. Microplastics have raised concerns due to their potential negative impacts on ecosystems and organisms.

It is crucial to address these environmental implications through proper waste management practices and engineering solutions. Some potential measures to mitigate these concerns include:

Using plastic waste that has been appropriately processed and treated to minimize potential leaching and contamination risks. Employing adequate geosynthetic barriers or liners to minimize the migration of leachate from the sub-base material into the surrounding environment. Implementing proper drainage and storm water management systems to minimize runoff and potential contamination of nearby water bodies. Conducting regular monitoring and assessment of the sub-base material, including testing for leachate and potential contaminants, to ensure compliance with environmental standards.

3.7 Long-term durability effects of incorporating plastic waste on the Nigerian lateritic soil sub-base material

The long-term durability effects of incorporating plastic waste into Nigerian lateritic soil as a sub-base material can be influenced by factors such as aging, weathering, and degradation(Mohajerani et al., n.d.).

Over time, the plastic waste incorporated into lateritic soil can undergo aging processes, which may affect its mechanical properties and durability(Abdulfatah et al. 2013). Exposure to environmental factors, such as temperature variations and moisture content fluctuations, can lead to changes in the plastic waste's characteristics. These changes can impact the overall performance of the sub-base material(Ramasamy 2015).

Weathering can cause physical and chemical changes in the plastic waste, leading to degradation, loss of mechanical properties, and potential changes in its behaviour within the soil matrix.

Depending on the type of plastic waste incorporated, degradation can occur over time due to factors such as microbial activity, chemical reactions, or mechanical stress(Attah et al. 2021). Plastic degradation can result in changes in the physical and chemical properties of the plastic waste, potentially affecting the performance and durability of the lateritic soil sub-base material(Imtiaz and Philosophy 2021).

It's important to note that the long-term durability effects of incorporating plastic waste into lateritic soil as a sub-base material are influenced by several factors, including the type of plastic waste, its content, and the specific environmental conditions to which the material is exposed.

4. Conclusion

All of the papers listed above have generally shown that strength and stiffness of the composite soil is improved by waste plastic reinforcement.

According, the review it can be concluded that the addition of plastic waste can increase the maximum dry density of lateritic soil. Plastic particles act as fillers and increase the soil's overall mass, leading to higher compaction densities. This effect is particularly noticeable when the plastic waste content is relatively low to moderate. Plastic particles can act as barriers, reducing the soil's water absorption capacity. As a result, the soil may require less water content to achieve maximum compaction hence OMC increases.

Plastic waste also has impact on the CBR value of the soil, which is a measure of the soil's load-bearing capacity. Plastic particles enhance the interlocking and stabilization of soil particles, leading to an increase in the CBR value. The improved interlocking mechanism provided by the plastic waste can contribute to enhanced load-bearing capacity and resistance to deformation under applied loads. This increase indicates that the soil is better able to resist deformation under repeated loading conditions, which is advantageous for sub-base materials in road construction. It was observed that, the C.B.R value of unreinforced soil was 7.9% which were increased to 26.9% for 5% HDPE waste plastic content, 20.38% for 5% LDPE and 23.2% for 5% PP.

The size and shape of plastic waste particles influence their effectiveness in enhancing strength characteristics. Based on the review of the various research papers we can conclude that, the maximum or optimum dosage of the plastic waste used in stabilization of lateritic soil use as sub base material in Road construction is 5%, as it marks the maximum improvement in CBR value, and it was observed that there is large decrease in pavement crust thickness with the addition of 5% HDPE, LDPE and PP waste plastic content in lateritic soil.

The interaction between different soil improvement techniques, such as stabilization or reinforcement, and the addition of plastic waste in Nigerian lateritic soil used as a sub-base material can have varying effects on the resulting strength characteristics.

Stabilization involves the addition of certain materials or chemicals to enhance the strength and durability of the soil. Common stabilization methods include cement stabilization, lime stabilization, and chemical stabilization. When plastic waste is added to the lateritic soil along with these stabilization agents, the combined effects can be beneficial in improving the strength characteristics of the sub-base material.

When plastic waste is incorporated into the sub-base material, there is a potential for leaching of chemical components from the plastic, it occurs when water percolates through the soil, potentially carrying dissolved substances from the plastic waste into the surrounding environment. The leached substances may include additives, residual monomers, or other potentially harmful compounds present in the plastic waste, which lead to contaminate soil, groundwater, and nearby surface water bodies. This contamination can have adverse effects on the local ecosystem, water quality, and human health.

It's important to note that the long-term durability effects of incorporating plastic waste into lateritic soil as a sub-base material are influenced by several factors, including the type of plastic waste, its content, and the specific environmental conditions to which the material is exposed.

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