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Potentials of Carbide Waste as a Modifer to the Geotechnical Properties of Lateritic Soil.

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ABSTRACT

Lateritic soil collected at Permanent Site, Federal Polytechnic Kaura Namoda, which is opposite Civil Engineering Complex, classified as A-7-6 using AASHTO soil classification was treated up to 16% carbide waste content by dry weight of the soil sample. The effects of carbide waste content (4% to 16%) on the lateritic soil with respect to plasticity characteristics, compacting characteristics, specific gravity and shear strength parameter were evaluated. Results obtained indicate an increase in liquid limit, plastic limit and plasticity index with the increase of carbide waste content. Maximum dry density (MDD) initially increases and later gradually decreases with the addition of carbide waste contents. The optimum moisture content (OMC) decreases with the increment of carbide waste content. Specific gravity continuously increases with the increase of carbide waste contents. Cohesion decreases, while the angle of internal friction increases with the increment of carbide waste contents. Based on the requirement of Nigeria General Specification for sub-base road and general construction materials, an optimal 4% carbide waste content is to be used for the modification of the lateritic soil.

Key words: Lateritic Soil, Atterberg Limit, Compaction, Shear Strength Parameters.

INTRODUCTION

The present economic crunch in Nigeria has escalated the cost of building and constructional materials thereby making it difficult for the common man to purchase them and use for constructional purposes. This situation has given rise to continuous use of local material such as laterite.

Laterites are the traditional materials for building roads and airfield construction in all the tropics and subtropical countries of the world. In Nigeria, residential houses of most rural dwellers have been built and are continuously being built with laterite.

The word laterite was suggested first by Buchanan (1807) [1], to denote building materials used in mountain region of Malabar, India. The definition was to a material of soft consistency that hardens on exposure to air.

Laterites have been given many definitions and because of various views from researchers this generated a lot of controversies that lasted for over a hundred and fifty years, until Alexander and Cady (1962) [2] came up with the definition that was believed to gain a wide acceptance. They defined laterite as highly weathered material rich in secondary oxides of iron, aluminium or both. It is nearly of bases and primary silicates, but it may contain large amount of quartz and kaolinite. It is either hard or capable of hardening on exposure to wetting and drying. Laterite is a highly weathered tropical soil, rich in secondary oxides of any or a combination of iron, aluminium and manganese.

Most tropical laterites are composed predominately of kaolinite clay mineral with some quartz. In some cases they contain swelling clay mineral type (e. g. vermiculite, hydrated halloysite and montmorillonite). When laterite contains swelling clay mineral type, they are known as problematic laterites [3].

Laterites are used as road making material and they form the sub-grade of most tropical roads; they are used as sub-base and base for low costs roads and these carry low to medium traffic. A lot of lateritic gravels and pisoliths are good for gravel roads. There are instances where laterites may contain substantial amount of clay minerals that its strength and stability cannot be guaranteed under load, especially in the presence of moisture. These laterites are also common in many tropical regions including Nigeria where in most cases sourcing for alternative soil may prove economically unwise but rather improve the available soil to meet the desired specification [4].

This type of soil has desirable engineering properties that make it suitable in the construction of road, dam, foundation of structure, etc. However, these properties sometimes fall short of the requirement of standards. In this case, it becomes necessary to investigate the possibility of modifying lateritic material to improve its properties. The need to improve local material to meet the requirement of the standard for pavement construction precipitated the idea of modification. The main objective is to improve the workability, strength, bearing capacity and durability under adverse moisture and stress conditions. Strictly, there are ways of obtaining a significant improvement in the strength of a material. This is done either by increasing the cohesive bond or by increasing the normal pressure of the deposit if the deposit is located above the water table the pore pressure is governed by external pressure [5].

Soil improvement could either be by modification or stabilization or both. Soil modification is the addition of modifier (cement, lime etc) to a soil to change its index properties, while soil stabilization is the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification.

The effort by researchers to obtain cheaper additives that can be used to substitute these expensive industrially manufactured soil improving additives (cement, lime etc.) led to the consideration of industrial waste such as such iron ore tailing, carbide waste and even agricultural waste that have pozzolanic properties. But in this paper we considered carbide waste because it has not been used before. Carbide waste is by-product of Acetylene gas production process which is a slurry that mainly contains Calcium Hydroxide ($Ca(OH)_2$) along with SiO_2, $CaCO_3$ and other metal oxides.

LOCATION AND GEOLOGY OF THE STUDY AREA

LATERITIC SOIL SAMPLE

The soil sample used for this study was collected from Permanent Site, Federal Polytechnic Kaura Namoda Zamfara State (Opposite Civil Engineering Complex under construction), by method of disturbed sampling during the dry season at a depth of 1.5m.

CARBIDE WASTE

The carbide waste used for the study was obtained locally from a welding workshop in Kaura Namoda, Zamfara State. The carbide after used and discarded was collected from the workshop and transported to the laboratory. In the laboratory, the carbide waste was grinded and sieved through BS No. 200 sieve (75µm aperture).

METHODS

Preliminary classification tests were carried out to determine the geotechnical properties of the natural soil sample. The soil sample was then treated with 4,8,12 and 16% carbide waste content by dry weight of the soil sample. Tests were carried out in accordance with BS 1377 (1990) for the natural and treated soil, respectively.

The following tests were conducted on the samples:

1. Natural moisture content
2. Wet sieve analysis
3. Specific gravity
4. Atterberg limits
5. Compaction
6. Shear strength test

RESULTS AND DISCUSSION

INDEX PROPERTIES

The results of the preliminary tests carried out on the natural soil are summarised in Table 1.1. The soil was classified as an A-7-6 based on AASHTO (1982) classification system. It is brownish well-graded fine grained soil with inorganic clay of medium plasticity. The percentage passing BS sieve No. 200 was found to be 94.80.

Table 1: Properties of the Natural Soil

Property	Quantity
Percentage passing No. 200 BS sieve	94.80
Natural moisture content (%)	8.27
Specific gravity	2.19
Liquid limit (%)	28.00
Plastic limit (%)	24.80
Plasticity index (%)	3.20
Linear shrinkage (%)	5.71
AASHTO	A-7-6
Maximum dry density (Mg/m³)	1.58
Optimum moisture content (%)	19.36
Cohesion (KN/m²)	0.4
Angle of internal friction (ø)	5
Colour	Brownish

SPECIFIC GRAVITY

The specific gravity values to the soil sample used increases with an increase in percentage of carbide waste. The specific gravity values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 2.19 – 2.82 (Fig. 1.1).

The specific gravity of the soil increases continuously with an increase in the carbide waste content (CW), this may be as a result of increase in the weight of carbide waste content when mixed with the soil sample and a subsequent reduction in the weight of the water[6].

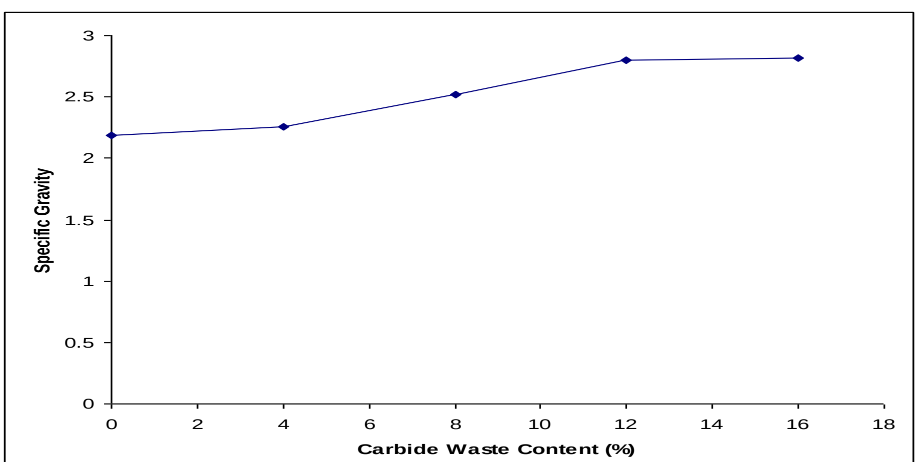

Fig. 1.0: Variation of Specific Gravity with Carbide Waste Content (%)

ATTERBERG LIMIT

LIQUID LIMIT

The liquid limit values to the soil sample used increases with an increase in percentage of carbide waste. The liquid limit values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 28% – 72% Fig.2.0. This is in agreement with the definition of liquid limit as the water content at which the soil exhibits dynamic shear strength. If a soil exists at its liquid limit and an alteration occurs in the system such that repulsive forces are decreased (by increasing calcium strength). Its strength increases to specific values that more water will be required to bring the soil to its dynamic shear strength [6].

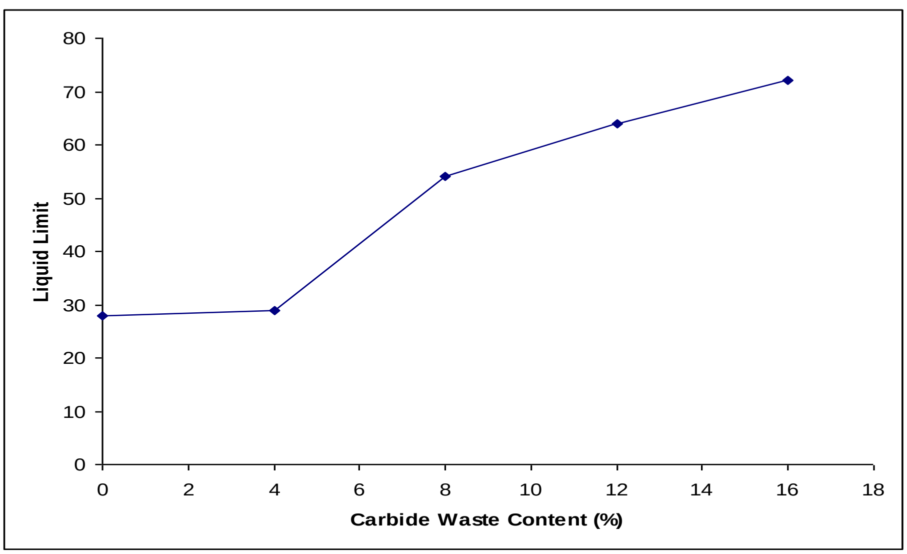

Fig. 2.0: Variation of Liquid Limit with Carbide Waste Content (%)

PLASTIC LIMIT

The plastic limit shows an initial decrease at 4% CW and then increases with increase in the carbide waste content, and then also 16% of carbide waste content added, there was a reduction in the plastic limit. The plastic limit values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 24.8% - 36.46% (Figure. 3.0)

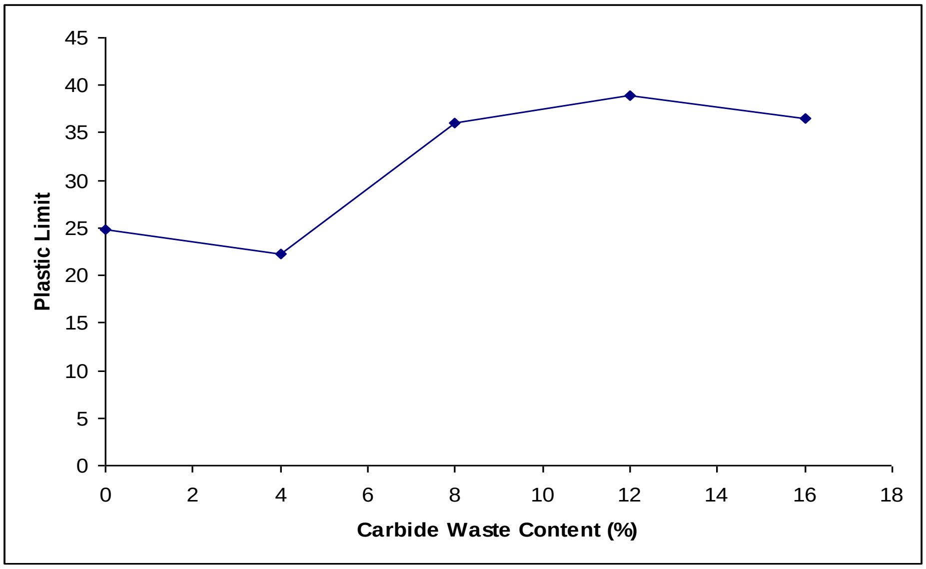

Fig. 3.0: Variation of Plastic Limit with Carbide Waste Content (%)

PLASTICITY INDEX

An increase in carbide waste content increase the liquid limit while the plastic limit increases up to 12%, consequently, plasticity index increases continuously due to the increase in liquid limit. The plasticity limit values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 3.2% - 35.54% (Figure. 4.0)

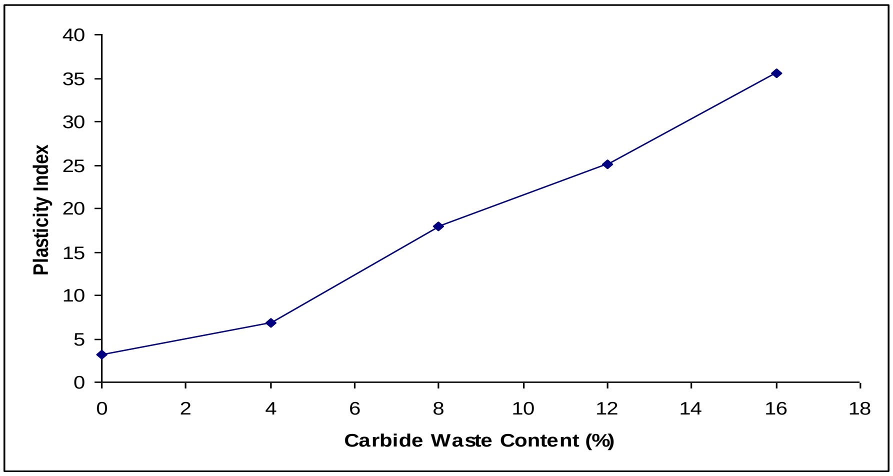

Fig. 4.0: Variation of Plasticity Index with Carbide Waste Content (%)

COMPACTION CHARACTERISTICS

MAXIMUM DRY DENSITY (MDD)

The maximum dry density (MDD) increases with an increase in carbide waste content from 4% up to 8% and a sudden decrease from 8% up to 16%. The maximum dry density (MDD) values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 1.58% - 1.62% (Figure. 5.0). The initial increase in MDD from a minimum at 4% carbide waste content to a maximum at 8% carbide waste content could be attributed to the molecular rearrangement in the formation of transitional compounds which had higher density at 8% carbide waste content, Osinubi (1997) and Cokca(2001)[6],[7]. The decrease in MDD with carbide waste content agrees with the findings of Mohammedbhai and Baguant (1990)[8] as well as Lambe (1957)[9] which might be attributed with the increase in specific gravity of the lateritic soil.

OPTIMUM MOISTURE CONTENT (OMC)

The optimum moisture content (OMC) initially decreases with increasing carbide waste content(i. e. from 4% to 12%).At 12% to 16% carbide waste content, the optimum moisture content increases. The optimum moisture contents (OMC) values for the natural soil treated with up to 16% carbide waste content (CW) were in the range from 19.36% - 17.32% (See Figure. 6.0). The initially decrease of the optimum moisture contents (OMC) with increase in carbide waste content, could be due to the formation of relatively stable compounds at this stage. The later increase of the optimum moisture contents (OMC) could be due to the large quantity of water required for the pozzolanic reactions to take place [10].

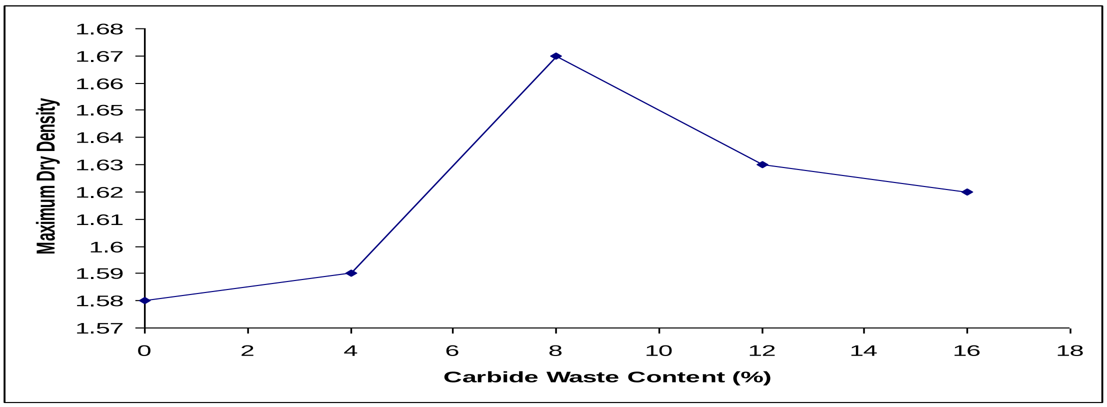

Fig. 5.0: Variation of Maximum Dry Density with Carbide Waste Content (%)

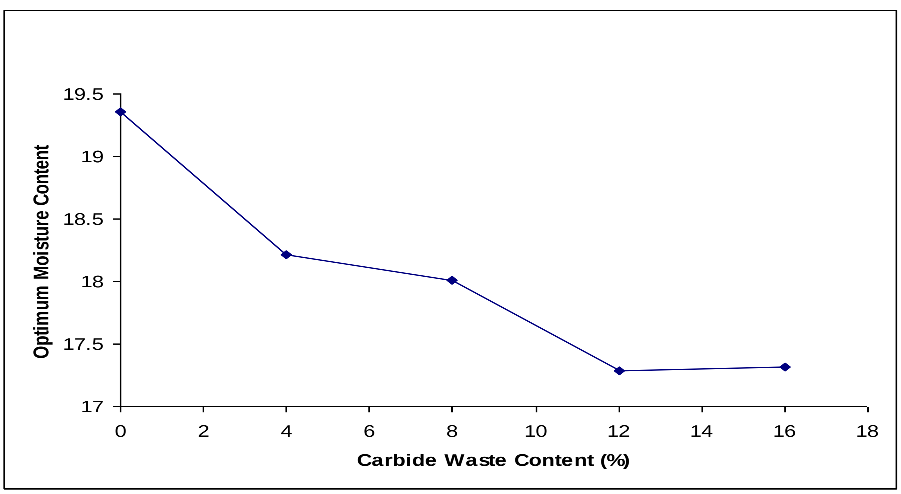

Fig. 6.0: Variation of Optimum Moisture Content with Carbide Waste Content (%)

SHEAR STRENGTH CHARACTERISTICS

COHESION

The cohesion initially increases with an increase carbide waste content up to 4%, and then decreases continuously with an increase in carbide waste contents from 4% up to 16% (see Fig. 7.0). The continuous reduction of cohesion with an increase in carbide waste contents could be attributed to the pozzolanic reaction between the carbide waste content and lateritic soil which causes reduction in clay size fraction [10].

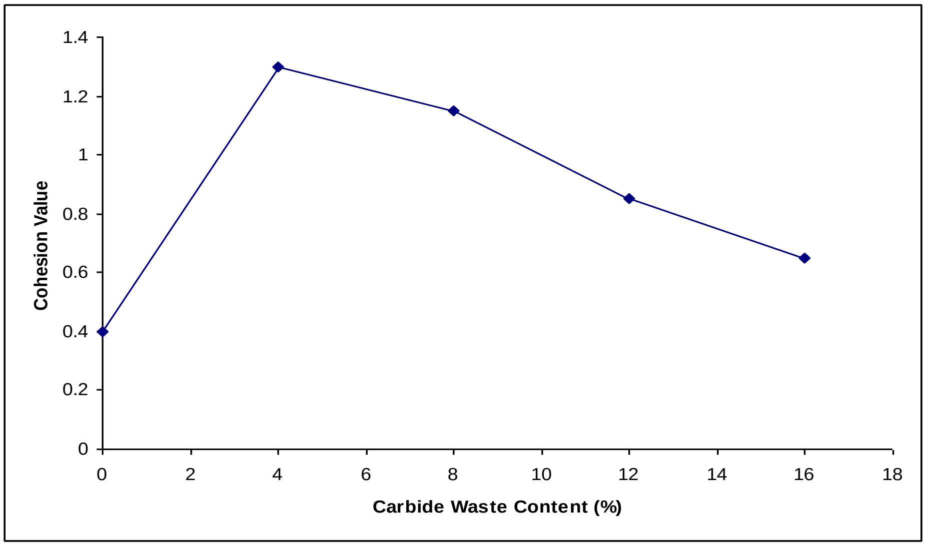

Fig. 7.0: Variation of Cohesion values with Carbide Waste Content (%)

ANGLE OF INTERNAL FRICTION (Φ)

The angle of internal friction (φ)increases continuously with an increase in carbide waste content from 0% up to 16% and were in the range from 5^0 – 20^0 (See Fig. 8.0). The continuous increase of angle of internal friction with an increase in carbide waste contents could be as a result of the increase in the particle size and reduction in the clay content of the soil [11].

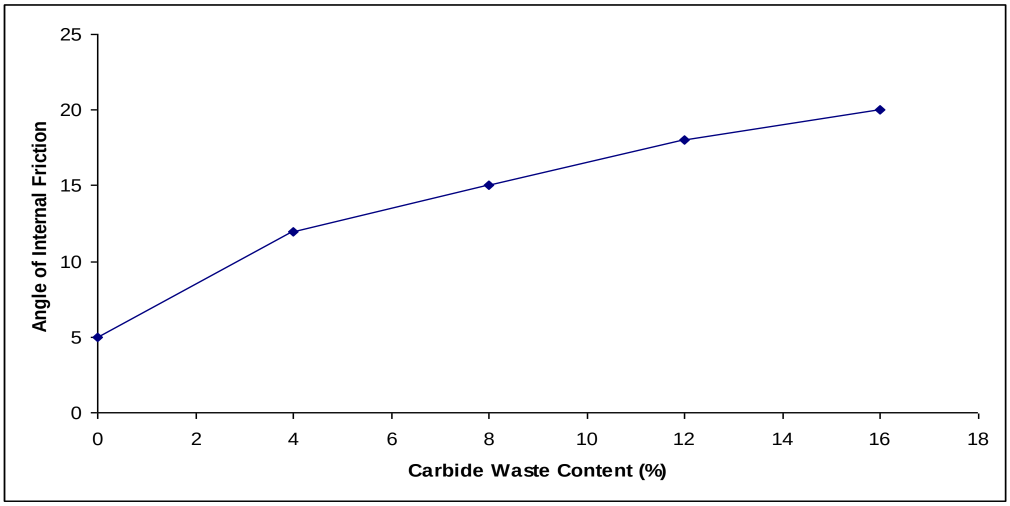

Fig. 10: Variation of Angle of Internal Friction with Carbide Waste Content

CONCLUSION

The preliminary investigation conducted on the natural lateritic soil collected at permanent site, Federal Polytechnic Kaura Namoda, Opposite Civil Engineering Complex shows that it falls under A-7-6 (11) classification (AASHO, 1986). The natural soil has low mixture contents of 8.27% because it was collected during the dry season.

It has liquid limit of 28.00%, plastic limit of 24.80% and plasticity index of 3.20%. These values indicate that the soil is of high plasticity.

Liquid limit of the natural soil increased with higher carbide waste contents. The values increased from 28% for the natural soil to 72% for treatment with 16% carbide waste content. The plastic limit decreased at 4% carbide waste content from 24.80% of the natural soil to 22.22% then it increases at 8%, 12% and 16% carbide waste contents from 24.80% for the natural soil to 36.06%, 38.85% and 36.46% respectively. The plasticity index increases from 3.2% for the natural soil to 35.54% at 16% carbide waste contents.

The maximum dry density (MDD) 1.58mg/m^3 for the natural soil increases with higher compacting effort of carbide water contents 1.59mg/m^3, 1.67mg/m^3, 1.63mg/m^3 and 1.62mg/m^3 at 4%, 8%, 12% and 16% of carbide waste content respectively.

The optimum moisture content (OMC) of the carbide waste modified soil decreases with higher compacting efforts. The OMC of the natural soil (19.36%) decreases to 17.32% at 16% carbide waste content.

The cohesion of the natural soil treated with percentages of the carbide waste content (4%, 8%, 12% and 16%) decreases (1.30KN/m^2, 1.15KN/m^2, 0.85KN/m^2 and 0.65KN/m^2). Cohesion of the natural soil is 0.4KN/m^2 and increases to 0.65KN/m^2 at 16% carbide waste contents.

The angle of internal friction (ø) of 5º was recorded for natural soil which increases to 20ºat 16% carbide waste content.

Based on the requirements of Clause 6201 of the Nigeria General Specification (1997) for sub-base road and General Construction Materials (liquid limit of not more than 35% and plasticity index of not more than 12%), an optimal mix of 4% carbide waste is to be used to the modification of the lateritic soil.

RECOMMENDATION

Based on the results obtained, the optimal mix to be used for the modification of lateritic soil as a sub-base and general construction material is 4% carbide waste.

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