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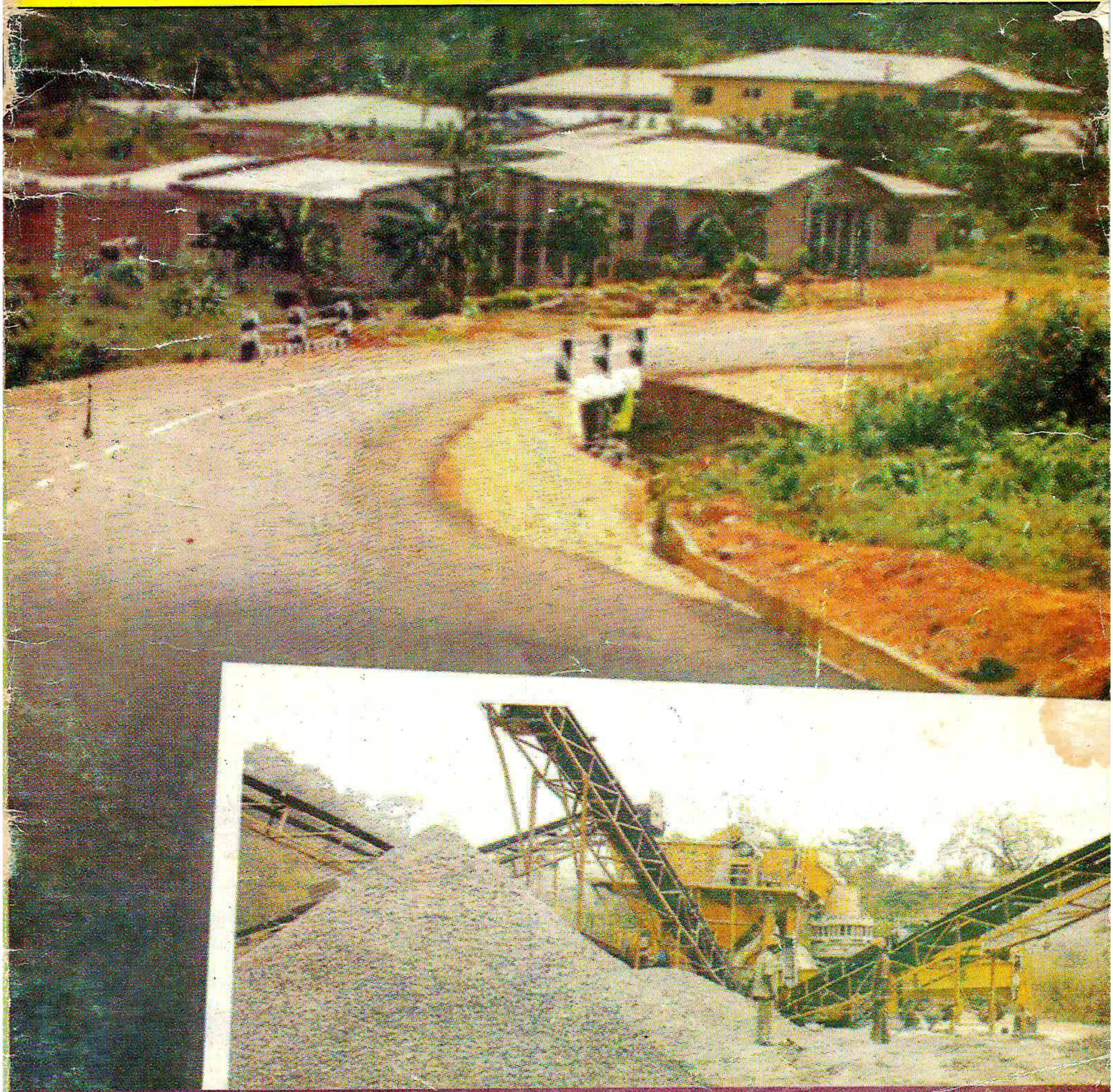

VISION:

Our vision is that the Nigerian Institution of Civil Engineers shall be a world renowned body which will be a pride to all Civil Engineers in Nigeria.

MISSION:

1. To make unique contributions to the development process of the country by constituting itself such that it would be a reservoir of Civil Engineers with specialized knowledge, experience and skill, constantly updated through the highest standard of Continuing Professional Development programmes.

2. To establish and maintain standards and codes for the practice of Civil Engineering.

3. To be constantly in touch with the Government at all levels, for necessary inputs and contributions to policies and matters affecting members and the development of the profession.

4. To encourage the study of and research in Civil Engineering and bridge the gap between Industry and Institutions involved in Civil Engineering Research.

5. To relate with and promote cooperation of similar professional organisations the world over.

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Editorial

The Editorial Board presents this mid-year edition with great joy. The challenges of keeping the pace of this publication has continued to increase. It is, however, glad to note the support of various contributors from within the Nigeria institution of Civil Engineers (NICE) family.

To this end, the Board wished to solicit the continued support of members both in publishing and publicising of the journal. It shall also welcome adverts from members.

Finally, the Board reaffirm its stand to always do its best to maintain the expected high standard of Journal.

- Editor

President's Corner

Greetings to all members of the Civil Engineering family. I wish to use this medium to once again commend the effort of members towards building the institution. I am particularly delighted about the continued massive attendance of our AGM, the presentation and publication of papers and also the regularity of the NICE journal. All these are in line with our mission statement, and coming this far has been through the support of everyone of you.

I therefore wish to solicit for continued support. This is the case especially as we prepare for another Annual General Meeting/Conference tagged ***"Warri 2007". The theme***: *"Maintenance & Management of Civil Engineering Infrastructure in Nigeria for the MDGs"* cannot be more relevant than now. For example, the highways built decades back are in serious state of disrepair. Dams built for various purposes in the past require serious desilting now to make them serve their intended uses. Many public utilities, ranging from water pipe network to electricity installations are now near abandonment as they are near unserviceability state due to poor management. This is the state of the nation's infrastructures.

As Nigeria joins the rest of the world to set developmental agenda towards realizing the MDGs, Civil Engineer have the responsibility to call attention to this menace. We must research to find out the extend of this poor management as well as be thoroughly equipped to redress the situation.

The forth-coming conference will be an eye opener to many issues relating to management and maintenance of civil engineering infrastructures. It is therefore a conference all members of the Civil Engineering family must endeavour to attend. See you there!

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EFFECT OF COMPACTION METHOD ON THE COMPACTION CHARACTERISTICS OF LATERITE

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ABSTRACT

Four lateritic soil samples collected from different borrow pits in Niger State, Nigeria, were classified as A-7 - 6, A-2 - 6, A-7 - 6, and A - 4 according to American Association of State Highways and Transportation Officers (AASHTO) soil classification system. They were compacted using the two compaction methods highlighted in BS 1377 (BSI,1990); The first method is that specified for soils that do not crumble under repeated loading using one sample unit which is repulverised and recompacted at each testing point. The second method is that specified for soils that are susceptible to crumble under repeated loading using a fresh sample for each compaction test point. It was observed that the second method yielded higher maximum dry densities (MDD) and lower optimum moisture contents (OMC) for all the soil samples tested. However, the advantage of small soil sample required for the first method out-weighed the increased (MDD) obtained in the second method.

1.0 INTRODUCTION

Compaction is a process of increasing the density of a soil by mechanically packing the particles of unsaturated soils closer together with a reduction in the volume of soil and without significant change in the volume of water in the soil (Craig, 1992) and (Osinubi, 2003). Since 1933 when R. R. Proctor presented four articles in the Engineering News Record, which served as the base for the standard proctor test currently used (Bowles, 1978), the test has been applied to improve almost all the engineering properties of soils with a lot of other necessary modifications using the same techniques.

The standard proctor test consists of taking about 3kg of soil passing 20mm British Standard (BS) sieve size, adding water, and compacting the soil into 944 cm^3 mould in 3 layers with 25 blows per layer, using a 24.5 N compacting hammer dropping 0.305cm on top of the soil. This delivers nominal compaction energy to the soil of

$$CE=3(25)(24.5)(0.305)/9.44x10^{4}(1000)=593.7Kj/m^3$$

Water content specimen is taken from the compacted soil after which it is broken down and repulverised. More water is then added, the soil thoroughly remixed and the process of compacting a mould of soil is repeated. This sequence is repeated a sufficient number of times that a curve of dry density versus water content can be drawn which has a zero slope (a maximum value) with sufficient points on either side of the maximum dry density point to adequately define its location. The maximum ordinate value is termed maximum dry density (MDD) and the water content at which this dry density occurs is termed the optimum moisture content (OMC).

One of the modifications carried out on standard proctor compaction is the introduction of modified proctor compaction test which involves compacting in to the same volume of mould (944 cm^3) at 5 layers with 25 blows per layer using 44.5N rammer falling through the height of 0.46m. This compaction method gives higher compaction energy of $2710.5KJ/m^3$ and is highlighted in BS 1377. Another modification to standard proctor compaction is the intermediate or West African Standard compaction whose compaction energy lies between that of standard proctor compaction and the modified proctor compaction. The method is commonly used in Nigeria and some other West

African countries and is highlighted in the Highway Manual (FMW&H, 1972). The procedure is the same as that of modified proctor compaction but differ in the number of blows per layer which is 10 in case of West African compaction as against the 25 employed in modified proctor compaction. This method gave intermediate compaction energy of I084.2 KJ/m^3.

Further still is the reduced standard compaction which is highlighted in Ewwaiwu, (2004) and has the same procedure as standard proctor compaction but with less number of blows (15) as against the 25 employed n the standard proctor compaction. Compaction energy generated by this compaction method is 356.2kJ/m^3 and is the lowest of all compaction methods currently in use.

Employing compaction on fills has been reported to have improved almost all the engineering properties of soils - increase in shear strength (embankrnents, earth dams e.t.c.), increase in density (embankmen s, fills etc), decrease in permeability (earth dams etc) and decrease in compressibility (fills, embankments, earth dams etc) (Azizi, 2000), (Bowels, 1978), (Brink et al, 1992), and (Osinubi, 2003). Infact, even for stabilized soils, compaction is carried out on all the admixture ratios and the compaction parameters determined for onward design of the stabilized road on site. In order to achieve all these improvements on site, laboratory results must be properly achieved on site to the highest proportion and hence the introduction of relative density. It is the ratio of the density achieved on site to that achieved in laboratory. 95% and above are usually specified (Gurcharan and Jagdish, 1991).

Meanwhile, BS 1377 has categorized compaction soils In to two; this involves those soils that are susceptible to crushing during compaction (which must be compacted using fresh sample each time), and those other soils that are not susceptible to crushing (which is compacted by breaking compacted soil and recompacting it each time). However, the method of breaking same sample and recompacting it each time is the only method used in Nigeria irrespective of which ever type of soil is to be tested. This study is therefore aimed at studying compaction characteristics of some Nigerian soils, which are residual, as against that of Britain which is mainly transported soils, comparing the two methods of compaction, and deducing which of the methods give higher dry density.

2.0 MATERIALS AND METHODS

2.1 Location of Study Area

The soil used for this study was collected at four different locations around the vicinity of Minna, the capital of Niger state, Nigeria. This city lies between latitude 9°N and 10°N and longitude 6°E and 7°E. Also, from the soil map of Nigeria, this part of Nigeria fall under ferruginous tropical soils (Areola 1982). The location of these borrows pits are: sample A -Maikunkele road, sample B - Bida road, sample C - Chanchaga road and sample D - Kuta road. These represent the four outlet roads from Minna town. Fig. 1 below show the map of the area under study.

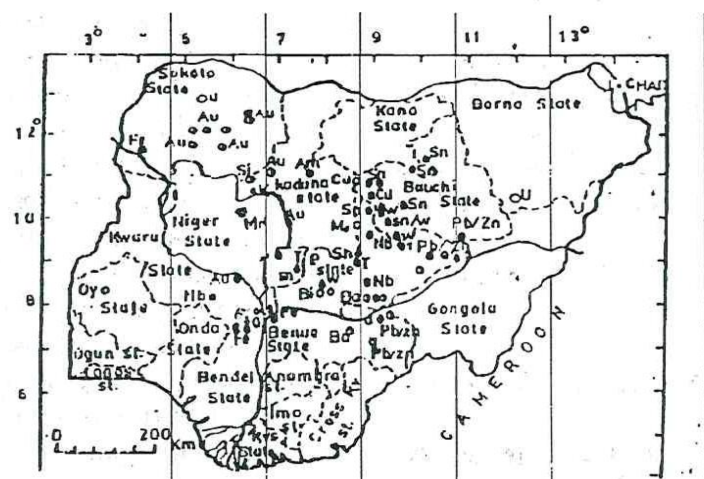

Fig. 1: Map of Nigeria showing Niger State and Minna

2.2 Mechanism of compaction and modalities for achieving reproducible results.

The shearing resistance to relative movement of the soil particles is very high when soils are to be compacted dry. But as water is added and increased, it becomes progressively easier to disturb the soil structure, and the dry density achieved with a given compaction effort increases. However, if the dry density is plotted against the water content for a given compacting effort, it will be seen that the dry density reaches a peak, after which any further increase in water content results in a smaller dry densities. This is because the maximum dry densities occur at about the least void ratio. At this point much of the air remaining in the soil is in the form of small occluded bubbles, entirely surrounded by water and held in position by surface tension. As the compaction proceeds, these bubbles become increasingly difficult to displace, and an increase amount of the compactive effort results only in moment increase in pore pressure, so that there is less and less permanent volume change (Osinubi, 2003).

Meanwhile, Bowles (1978) has highlighted some modalities to be employed during compaction so as to achieve standard and reproducible compaction parameters. Some of these modalities include:

i) The use of fresh sample each time for compaction, which give higher dry densities compared to the method of breaking compacted sample and recompacting it.

ii) The dry soil sample is to be mixed with first increment of water and allowed to cure (stay overnight) so as not to produce curve with erratic points.

iii) The soil mould should be compacted in three approximately equal increments so as not to produce unsmooth curve at both sides of the optimum, and

iv) The compaction mould is placed on a rigid surface to avoid loss of hammer energy to the production of foundation displacement.

Most of these modalities are not put in to consideration in Nigeria during compaction and could lead to over estimation or underestimation of the compaction parameters both of which would give deceptive judgment to its application on site.

2.3 Sample Preparation and Testing

Four samples were collected at four borrow pits around the vicinity of Minna town as stated earlier. Gram size analysis and Atterberg limit tests were carried out on all the four samples according to BS 1377 and classified using American Association of State Highways and Transportation Officers (AASHTO) soil classification system. 3kg of air dried sample of each of the four samples was weighed and compaction test carried out on each of the samples using the method of breaking down molded sample and recompacting it each time as recommended in BS 1377 for soils not susceptible to crushing during compaction. Standard proctor compaction energy was used for the compaction of all the four soil samples.

15kg air dried soil of each of the four soil samples was again weighed, divided into 5 equal 3kg. For each of the 5 subdivision of each sample, first increment of water were added and kept separately in polythene leather over night. Standard proctor compaction was then carried out on each of the samples but this time using the fresh sub-samples after each water increment; i.e. the first sub-sample was compacted using the first increment of water (added the previous day) using the procedure of standard proctor compaction highlighted earlier, after which a specimen was taken for moisture content determination. The first sub-sample was then discarded and the second sub-sample taken and more water added. The process of compaction was again repeated until all the 5 sub-samples were exhausted as specified in BS 1377 for soils susceptible to crushing during compaction and 5 points were obtained sufficient to plot dry density-moisture content curve. This was repeated for the remaining 3 soil samples and all the results recorded.

3.0 Results and Discussion of Results

3.1 Particle size analysis

The particle size distribution for the soil samples A, B, C, and D are shown in figure 2 below. The result show higher percentage gravel fraction of 15% in sample B and least amount of 1.5% in samples A, C and D. Sample D contained the highest sand size fraction of 32% followed by sample B with 25% and sample C with 11%. The lowest value of 6% was recorded in sample A. Also, the highest fine fraction of 76% was obtained for sample A out of which only 11% was clay size fraction. Maximum clay size fraction of 25% was recorded for sample C out of 39% fine fraction obtained for the sample. The lowest percentage clay size fraction of 7 was obtained in sample D out of 33% fine soil fraction.

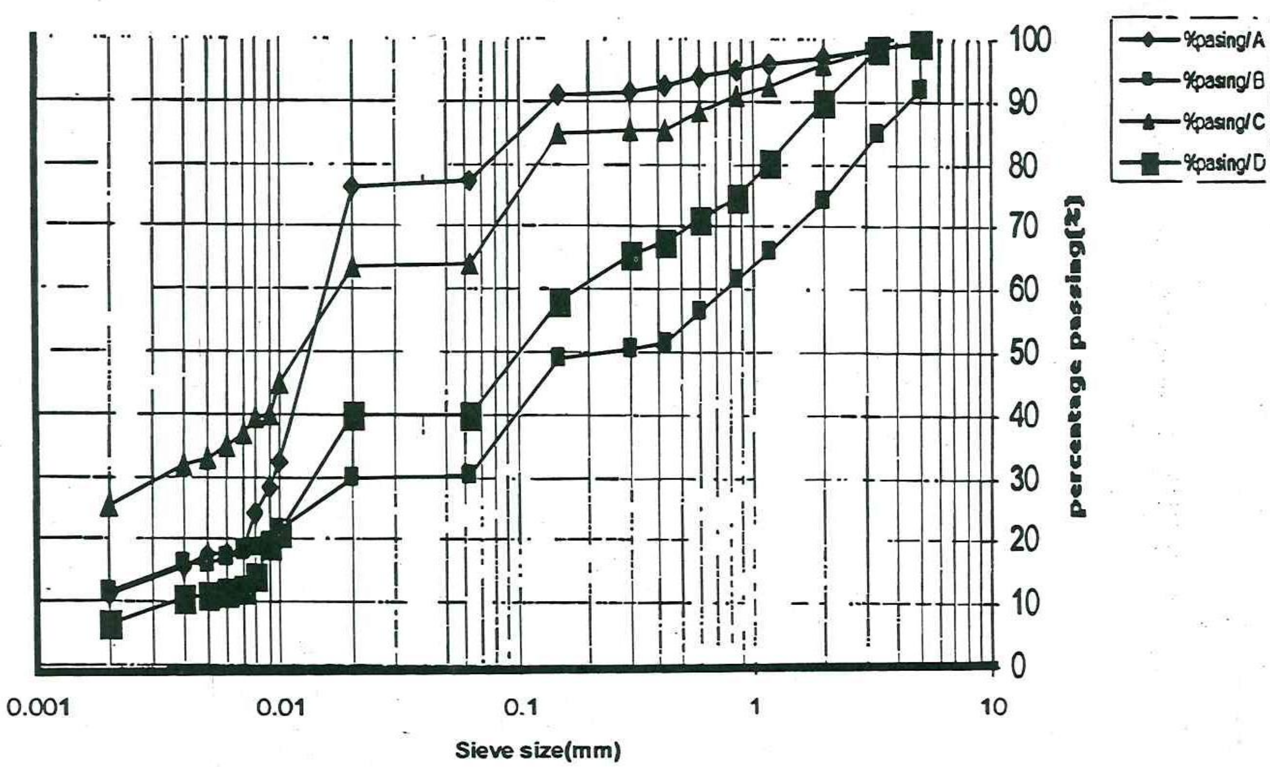

Fig. 2: Particle size distribution for samples A,B,C and D

3.2 Atterberg Limits The result of Atterberg limits are shown in table 1 below for samples A, B, C and D. The trend of 51, 40, 46 and 31% liquid limit and the plasticity index of 27, 19, 22 and 10 recorded for samples A, B, C and D respectively, is in agreement with the percentages of silt and clay size particles present in each of the samples. This is because it has been established that, in the absence of some few oxides like calcium oxide, silicon oxide, iron oxide etc, the main cause of soil plasticity is the silt and clay size fraction contained in the soil as well as the nature of the clay.

The results for grain size analysis and Atterberg limits were used to classify the soil under (AASHTO) soil classification system and are shown below:

Sample	A	B	C	D
Liquid Limit (%)	51	40	46	31
Plastic Limit (%)	24	21	24	21
Plasticity Index	27	19	22	10
Percentage Passing sieve 0.063mm	76	30	64	41

Table 1: Atterberg Limits for Samples A, B, C and D

Sample	Location	AASHTO classification
A	Maikunkele road	A-7-6
B	Bida road	A-2-6
C	Chanchaga road	A-7-6
D	Kuta road	A-4

Table 2: AASHTO soil classification for samples A, B, C and D

Sample No	MDD/method 1 (Mg/m^3)	OMC/method 1 (%)	MDD/method 2 (Mg/m^3)	OMC/method 2 (%)
A	1.528	23	1.606	17
B	1.646	20	1.682	18
C	1.615	17	1.621	23
D	1.707	18	1.720	15

Table 3: Compaction characteristics using the two methods of compaction.

3.3 Compaction Characteristics

The results of the two methods of compaction employed in the study (breaking the molded sample and recompacting it, and using of fresh sample each time) are summarized in table 3 below along with the optimum moisture contents (OMC) for each of the 4 soil samples:

Although both samples A and C are classified under A 7- 6 subgroup in (AASHTO) soil classification, sample C has less percent fine of 64% than sample A which has percent fine of 76%. This factor may have caused the differences in their compaction parameters. It was also observed that dry densities increase from sample A through samples C, then B and finally sample D whose classifications are A-7-6, A - 7-6, A - 2 - 6 and A - 4 respectively. This trend is in agreement with Carter and Bentley (1991) who studied the correlation between soil classes and their maximum dry densities. OMC also decrease with increase in MDD except for sample C which recorded lower OMC at higher MDD. This may be due to the presence of small percentage of active clays or organic soil which may not have absorbed much water when the first method was employed but when cured overnight with water, the active clay particles or organic soils absorb higher water and hence higher OMC was recorded.

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

In conclusion it has been established that the second method (using fresh samples each time) gave higher dry density compared to the first method (breaking molded soil and recompacting it each time). Between $6kg/m^3$ to $78kg/m^3$ increase in dry densities were recorded for the four soil samples studied. However, the disadvantage of collecting substantially large amount of soil from trial pits for compaction test using the second method may out-weigh the underestimated dry density recorded using the first method. The soil Engineer must then weigh these two extreme factors when carrying out compaction test on soils

4.2 Recommendation

(I) Study should be carried out on variation of MDD with depth so as to estimate at which depth representative soil samples should be collected in borrow pits.

(ii) For project sensitive to change in dry density, second method of compaction should be adopted.

(iii) Similar studies should be carried out on soils from other regions in Nigeria to obtain enough data for production of Nigerian standards.

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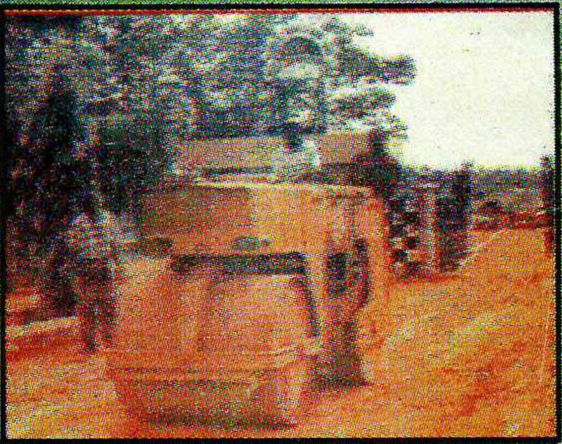

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