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Characterisation of Soils in Angwan Michika, Using Their Compaction Behaviours, Jos, North Central, Nigeria

Abalaka Isaac Edimeh[1]* and Okopi Johnson Odumu[2]

[1]Department of Geology, Faculty of Natural Sciences, University of Jos, Nigeria
[2]Timadix Geomin Consults, Qualitrend Plaza, F.C.T, Abuja, Nigeria

Corresponding Author : abalakai4real@yahoo.com

ABSTRACT

The study area is around Angwan Michika metropolis. Ten (10) soil samples were investigated using compaction test analysis. The study area is located on Latitudes N 9^{0} 84' 72" to 8^{0} 89' 36" and Longitudes E 9^{0} 86' 78" to 8^{0} 90' 44". The compaction tests and their interpretation revealed that, soil samples collected at locations 1, 6, 7, 9 and 10 were inferred to be competent soils since there are (1,6,7,9 and 10) made up of sand and gravel materials. Soil samples collected at locations 2, 3, 4, 5 and 8 were inferred to be incompetent, they are basically clayish in nature. In terms of optimum moisture contents, the incompetent soil materials had a range of 17.20 to 23.70 % while the competent soil samples had a range of 10.40 to 12.80 %. In terms of maximum dry densities, soils in the incompetent areas had a range of 1.67 to 1.84 % while the soils in the competent areas had a range of 1.84 to 1.91 %. According to the specifications for roads and bridges in 2017, soil samples from the incompetent areas have high optimum moisture content and low maximum dry density. As a result, civil engineering structures like roads cannot be constructed in areas that the soil samples are incompetent. The sand and gravels that characterise the competent areas do not pose any threat to civil engineering structures rather they help in concretising and solidifying them. The clay material that characterise the incompetent areas makes them to be susceptible to frequent shrinkage and swelling during variations in climatic conditions. This constant alteration leads to cracks, potholes and complete damage of the road. The soil is there by mechanically unfit for road constructions.

Keywords: Soils; Compaction; Dry Density; Competent; Incompetent

INTRODUTION

Soils in the Angwan Michika metropolis have found wide applications in the construction industry especially in civil engineering structures like buildings, bridges, roads, culverts and dams. The area under investigation is in parts of the Jos – Plateau State, Nigeria. Not even the most experienced engineer would attempt to access the strength of soils without some knowledge of its composition. Some engineers in the past have tried that but failed.

Soil compaction is the process of increasing the density of the soil particles through mechanical means using the compaction equipment. Compacted soils exhibit reduced porosity and increased shear strength there by making it suitable for roads and other structures. The compaction process eliminates air voids between soil particles there by improving the overall load – bearing capacity and minimising settlements.

Soil compaction is an important engineering consideration in construction projects. It directly affects the stability and the load – bearing capacity of the soil. Compaction properties of soils are determined using the Standard Proctor test which involves measuring the dry density and moisture content of the soil after it has been compacted at different moisture levels

Many road constructions have caused monetary losses largely because the site(s) have been badly selected or because the soils were too weak to support them "Oguara (2001)". Soils like any other engineering material distorts when subjected to load and pressure. The resultant effect could be shearing, sliding or distortion and compression. "Olounfemi et al (1987)".

In general, soils cannot withstand tension when placed under load. In a case where the particles are cemented together, a small amount of tension can be bearded but not for long periods. Though evidence of engineering problems can be seen in most places all of these engineering facilities are founded on or in soils. "Malamo et al. (1983)".

Lateritic soils are seen in many rock types especially in different sub – climate and drainage environments. "Macleod et al. (1971)". Every soil often exhibits unique set of physical, chemical and engineering properties.

Therefore, in other to ensure their sustainability, a thorough knowledge of the characteristics of the soils that are to be used as foundation materials must be acquired prior to its utilisation for any engineering purpose. "Gidigasu 1974 Adeyemi (2000)". By supplying the pre knowledge of this kind, it is the function of the soil scientist to show how economic waste can be avoided. Geotechnical properties of the soils need to be determined by carrying out geotechnical analysis on the soils before construction works can be carried out on them. "Gidigasu 1972: Mesida 1985: Adeyemi 1990: Momoh et al (2008)".

Location, Accessibility and General Geology

The areas under investigation is located in Angwan Michika metropolis, Bassa Local Government, Plateau State, North Central Nigeria, covering the two metropolitan Local Governments areas of the state capital. The study area is located on Latitudes N 9^0 84' 72" to 8^0 89' 36" and Longitudes E 9^0 86' 78" to 8^0 90's 44". The Local Governments are Jos North and Jos South respectively. The areas are accessible through tarred and untarred roads. The Topography of the areas is characterized by rugged and rocky terrains in some places and flat land in some other places.

In terms of geology, the area under study is within the Jos-Bukuru granite Complex. This complex is made up of biotite granite rocks. "Falconer (1911)", "Falconer (1921)" and "MacLeod et al (1971)". The study area lies within the Jos-Bukuru granite complex. This complex is made up of six (6) lithologic units. These units are differentiated on the basis of mode of formation, mineralogy and the texture of the rocks. There different rock types include Jos biotite granite and N'gellbiotite granite. Others are Delimibiotite granite, Rayfield Gona – biotite granite, biotite micro-grantie and laterite covering the Older Basalt. "Wright (1971)".

The Jos biotite-granite rock occupies the northern, north-western, central and south-eastern parts of the area under investigation. This rock type has a regular joint system with two equally developed vertical sets. The only pronounced textural variations in this rock type are observed near the margins of the granite against the Basement Complex and the earlier Younger Granite intrusion. There is little compositional variation in the Jos biotite-granite over the greater part of its extent. The exceptionally coarse grain size of the minerals renders it easily recognizable in the field, "Wright (1971)".

The N'gell biotite granite rock is an intrusion into the Jos biotite-granitic rock and occupies an area of about 160.5 km^2 in the central and southern parts of the rock complex. It shows a very large textural variation compared the Jos biotite-granite rock and medium grained in texture. "Wright (1971)".

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The Delimi biotite-granite rock is best exposed in the deeply dissected headwater region of the Delimi River. Its texture is fine-grained and greisens are common in the granite, which has probably made substantial contributions to the alluvial tin deposits in the Delimi valley.

The Rayfield Gona Biotite Granite occupies part of the western, central and south-eastern parts of the Jos Plateau. This granite is best viewed in the the northern arc in the more dissected drainage system of the upper N'gell group. The Rayfield-Gona granite is characterized by its low resistance to erosion. The joints are close and irregular and the granite weathers to low outcrops. Rounded white boulders appears as hills only where they are buttressed by the more resistant earlier granites. The texture of the Rayfield-Gona granite is fine to medium grained. It is characterized by a wealth of accessory minerals assemblages. It is mainly distinguished as the richest granite that has a lot of columbite, thorite and cassiterite, "Mc Curry (1989)".

The biotite microgranite lies below the extreme south-western part of the Jos Plateau. The microgranite is composed of almost equal amounts of quartz, orthoclase and albite, with evenly dispersed flakes of biotite.

Laterite occurs as patches within the study area, and they abound more in the central, western and eastern parts of the Jos Plateau. Lateralized Older Basalts represent lavas which have been decomposed to clays and usually overlain by a thick cap of laterite ironstone. The lateralized basalts occur as erosion ruminants in watershed areas and the associated fluvial sediments include sands, gravels and clays. "Mc Curry (1989)".

The geology of the Jos Plateau comprises of the Precambrian Basement, Migmatie-Gneise-Quartzite complex (which underlies about half of the entire State and in some places has been intruded by Precambrian to the late Paleozoic Pan-African Older Granite), diorite, Charnockite etc. Intrusions in the Basement Complex rocks are the Jurassic androgenic alkali Younger Granites. We equally have the Younger Granites which are volcanic rocks (such as basalts and rhyolites) that overly or cross-cut this formation as well as the Basement rocks. The volcanic rocks originated during the early Cenozoic (Tertiary) "Older Basalts" and Quaternary "Newer Basalts", "MacLeod et al (1971)". The description of MacLeod actually confirmed the presence of minerals of economic importance like tin and columbite that were extensively mined between 1902 and 1978 on the Jos - Plateau. Figure 1 is the geology map of the study area.

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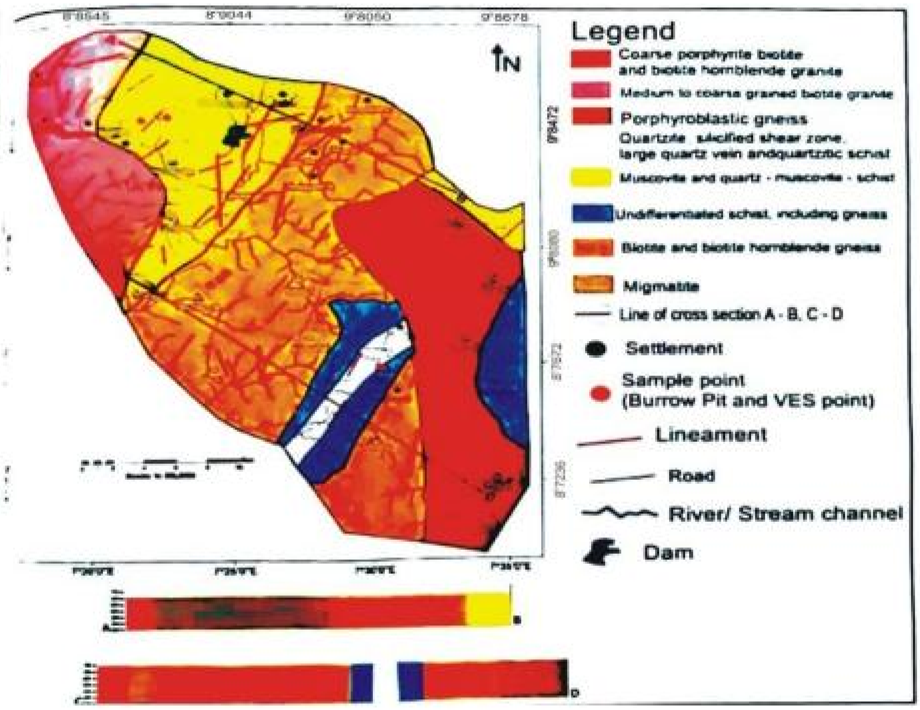

Figure 1: Geological Map of the Study Area.

MATERIALS AND METHODS

Materials used for the sampling includes: Shovel, Digger, GPS, Sampling Bags, Measuring Tape, Cello Tape and a Field Vehicle.

In terms of methodology, the principle of effective stress and critical state theory were applied. The principle of effective stress states that the compressive force exerted on the soil is determined by the difference the total stress on the soil and the pore water pressure in the soil. " Lambe and Whiteman" (1969). The principle of critical state theory states that there is a critical point at which soil can no longer be compacted further without becoming unstable. Ten samples were collected from the survey area (Anwan Michika Metropolis) which involves digging 10 pits up to 2 meters. The samples were labelled and packaged into sampling bags to avoid loss of moisture. The samples were taken to the laboratory for Compaction test analysis.

Compaction Test

Compaction can be seen as a mechanical process whereby mechanical energy is applied on the soil to rearrange the particles and to reduce the void ratio usually by driving out air particles. It is a process whereby mechanical means is used to constrain soil particles together by reducing the air void of the soil, the compaction of a soil is a measure of the dry density of the compacted soil which is the weight of the wet soil divided by the volume of the soil. This test is used to determine the maximum dry density and the optimal water content a soil can achieve for a given compaction effort.

One standard was used in the compaction test, the British standard (BS). The material used in each case was that passing through the 5 mm (3/16 inches). British Standard sieve. The retained portions were discarded. The soil was air dried before the test. In the British Standard test a certain percentage of water was added to the soil and mixed very well until uniform moisture distribution is attained. The mixture was compacted into

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three layers of a Standard proctor mould by the application of 25 blows / layer of a 2.5 kg rammer falling from a height of about 0.3005 m. The sample which was levelled to the top of the empty mould gave the weight of the compacted material. The experiment was repeated by gradual addition of water for each of the percentage mixtures. Figure 2 is a diagram showing the standard proctor compaction test equipment.

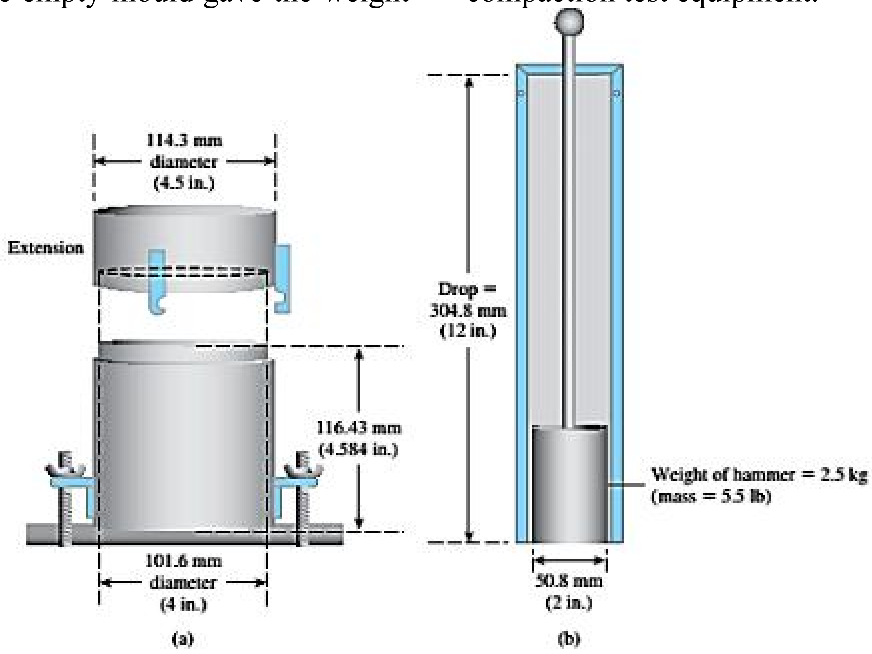

Figure 2: Standard Proctor Compaction Test Equipment.

RESULTS AND DISCUSSION

This research involved both field and experimental work. The field work involves collection of soil samples from one place to another which are then taken to the laboratory for analysis.

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Compaction is purely a mechanical process that involves the application of mechanical energy to the soil in other to rearrange the particles and to reduce the entire void ratio usually by driving out air from it. The

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process involves the use of mechanical means to constrain soil particles together by reducing the air void of the soil. The compaction of a soil is a measure of the dry density of the compacted soil which is the weight of the wet soil divided by the volume of the soil sampled. Compaction test is used to determine the maximum dry density and the optimal water content a soil can achieve for a given compaction effort for each soil sample test.

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The dry densities of the soils and the maximum dry density, moisture contents of the soil and optimum moisture content of the soils were also calculated and determined.

Table 1 shows the soil samples sampled, their maximum dry density and their respective moisture content. According to the specifications for roads and bridges by Attimeyer and in collaboration with the Department of Scientific and Industrial Research in 2017, a table was put forward to establish a link between the type of material, their optimum moisture content and their correspondent maximum dry density as seen in Table 1.

Table 1: Attimeyer: Relationship between the MDD, OMC and the Soil Type (Department of Scientific and Industrial Research, 2017).

Type of material	Maximum dry density	Optimum moisture content
Clay	1.440-1.680	20-30
Silty clay	1.680-1.840	15-25
Sand/gravel	1.840-2.160	8-15

The results of the compaction test results were examined and interpreted by comparing them with table 1.

Table 2: Compaction test results.

Sample Location	Maximum Dry Density	Optimum Moisture Content	Soil Type Infereed	Remarks
Sample 1	1.88	11.30	Sand /Gravel	Competent
Sample 2	1.83	19.60	Silty Clay	Incompetent
Sample 3	1.76	18.30	Silty Clay	Incompetent
Sample 4	1.73	21.20	Silty Clay	Incompetent
Sample 5	1.67	23.70	Clay	Incompetent
Sample 6	1.86	10.50	Sand /Gravel	Competent
Sample 7	1.77	12.80	Sand /Gravel	Competent
Sample 8	1.82	17.60	Silty Clay	Incompetent
Sample 9	1.84	11.50	Sand / Gravel	Competent
Sample 10	1.91	10.40	Sand / Gravel	Competent

From the interpretation above, soil samples collected at locations 1, 6, 7, 9 and 10 are referred as the competent soils since there are made up of sand and gravel materials. Soil samples collected at locations 2, 3, 4, 5 and 8 are incompetent, they are basically clayish in nature. In terms of optimum moisture contents, the incompetent soil materials had a range of 17.20 to 23.70 % while the competent soil samples had a range of 10.40 to 12.80 %. In terms of maximum dry densities, soils in the incompetent areas had a range of 1.67 to 1.84 % while the soils in the competent areas had a range of 1.84 to 1.91 %. According to the specifications for roads and bridges in 2017, soil samples from the incompetent areas have high optimum moisture content and low maximum dry density. As a result, civil engineering structures like roads cannot be constructed in areas that the soil samples are incompetent. The sand and gravels that characterise the competent areas do not pose any threat to civil engineering structures rather they help in concretising and solidifying them. The clay material that characterise the incompetent areas makes them to be susceptible to frequent shrinkage and swelling during variations in climatic conditions. This constant alteration leads to cracks, potholes and complete damage of the road. The soil under investigation is mechanically unfit for road constructions.

CONCLUSION

The compaction tests and their interpretation revealed that, soil samples collected at locations 1, 6, 7, 9 and 10 are referred as the competent soils since there are made up of sand and gravel materials. Soil samples collected at locations 2, 3, 4, 5 and 8 are incompetent, they are basically clayish in nature. In terms of optimum moisture contents, the incompetent soil materials had a range of 17.20 to 23.70 % while the competent soil samples had a range of 10.40 to 12.80 %. In terms of maximum dry densities, soils in the incompetent areas had a range of 1.67 to 1.84 % while the soils in the competent areas had a range of 1.84 to 1.91 %. According to the specifications for roads and bridges in 2017, soil samples from the incompetent areas have high optimum moisture content and low maximum dry density. As a result, civil engineering structures like roads cannot be constructed in areas that the soil samples are incompetent. The sand and gravels that characterise the competent areas do not pose any threat to civil engineering structures rather they help in concretising and solidifying them. The clay material that characterise the incompetent areas makes them to be susceptible to frequent shrinkage and swelling during variations in climatic conditions. This constant alteration leads to cracks, potholes and complete damage of the road. The soil under investigation is mechanically unfit for road constructions.

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