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Compaction Behaviour And Classification Properties Of Soils Of Kwang/Shen, Jos-Plateau North-Central Nigeria

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***Abstract*—A study on the Classification and compaction behaviour of soils of Kwang/Shen is presented in this article. The grain size distribution curves indicate that the soils are poorly graded soils revealing silty - clayey soils while consistency tests show liquid limits and plasticity indices ranging from 33.8 - 46.8% and 9.0 -17.3% respectively, indicating the soils as low - intermediate plasticity soils with low swelling potentials and low compressibility. The moisture density relationship showed a maximum dry density and optimum moisture content ranging from 1.63 - 2.02 g/cm^3 and 7.37 - 22.1 % respectively. The soils would require greater compactive effort to bring it to higher density in order to increase the strength. From engineering point of view, the soils are fair to good construction material and with mechanical stabilization, the soils will be safe and economically fit for construction.**

***Keywords*—Compaction;Construction; Index properties; Jos-plateau; Soil behaviour**

I. INTRODUCTION

Soil condition varies from one place to the other which makes it difficult to predict the general behaviour of soil. Consequently, soil conditions at every construction site must be thoroughly investigated for safety and for proper design. The type of structure, load and its use will largely govern the adaptability of a soil as a satisfactory foundation material. A soil might be entirely satisfactory for one type of construction but might require special treatment for other building. The evaluation of basic engineering properties of soils through laboratory testing is very important in understanding and interpreting how soils will behave in the field. Atterberg limits and laboratory compaction have been found to be very reliable in characterizing, predicting and explaining the behavior of fine grained soils for engineering use (Wesley, 2003; Ramesh et al., 2010; Calik and Sadaglu, 2014). Any good correlation in the prediction of engineering properties with the index properties will enhance the use of simple test for prediction purposes. It is often necessary to identify the basic mechanisms controlling the engineering properties from a micro-mechanistic point of view and correlate with the index properties, thereby facilitating prediction of engineering properties better (Jyothirmayi et al., 2015).

Ground improvement by compaction has been used successfully in many construction projects and is generally defined as the alteration of any property of the soil to improve its engineering performance (Lambe and Whiteman, 1969). Compaction, a process by which a mass of soil consisting of solid soil particles, air, and water is reduced in volume by the momentary application of loads, such as rolling, tamping, or vibration involves an expulsion of air without a significant change in the amount of water in the soil mass. Compaction, a significant part of the building process should be performed properly to avoid settlement of the soils hence, avoiding unnecessary maintenance costs or structural failure. Compaction generally increases shear strength, decreases compressibility, and decreases permeability of the soil and these are significant engineering properties of soil when used as a construction material (Charles Gresser, 2001). Similarly, Atterberg limits are important in engineering works because they help in soil classification for fine grained soil and can also tell about the strength of soil and how the soil will behave under engineering load. The results of this test can be used to help predict other engineering properties. Atterberg limits describe the consistency of fine-grained soils with varying moisture contents.

For most construction projects of any magnitude, it is highly desirable to investigate the foundation characteristics of the soil by means of a field or laboratory test. It is desirable from an engineering standpoint to build upon a foundation of ideal consistent characteristics. It is in this regard that Lar et al. (2011) carried out a study of the geotechnical properties of soil of some parts of Jos-Plateau and environs with the aim of characterization and determining their suitability for construction. They recommended stabilization of the soils for construction work.

With the increased demand for housing in Plateau state, the government has arisen to meet the housing need of its citizenry by earmarking a part of the study area located in part of Shen and Kwang as a construction site of one of its numerous housing schemes. Already, three (3) bedroom flats have been constructed as pilot structures for the scheme. However, the site for this construction has been affected by mining activities and most of the land has and is being reworked hence causing instability of the site. In some places, the land is still undergoing stabilization after reclamation while some are yet to be reclaimed. This has created the need for investing the geotechnical properties of the soil. Previous studies carried out on the geotechnical properties of derelict lands resulting from mining activities within some parts of Jos and environs showed that the geotechnical properties of properly reclaimed mine out lands improved tremendously in comparison to areas not properly reclaimed (Chukwuma, 2010).

It is now very clear that suitability of soils for foundations depends primarily on the strength, cohesion and consolidation characteristic of the soils. But determination of consolidation and strength parameters are usually laborious and time consuming. In order to provide fast and reliable information for the engineering purpose of the study area, compaction and index properties are considered in this research.

2. Geology of the study area

The Jos Plateau Younger Granite is underlain by rocks of the Basement Complexes. A period of erosion followed the emplacement of the Younger Granite leading to the formation of Jos plateau and surrounding plains. Alluvium developed on the Jos Plateau was covered by extensive lava flows of the older basalts in Tertiary times. As they are known today, the rocks occur as hilly massifs, sharply differentiated from the smoother topography of the surrounding basement rocks. The most predominant types among the Younger Granites are biotite granites which have three distinct groups (McLeod et al, 1971). They are (from the oldest to youngest) the Rayfield – Gona biotite granite, N'Gell biotite granite and Jos biotite granite. A soil developing on weathering of granite will be sandy, as sand sized particles of quartz and feldspar are released from the granite. As the feldspar grains weather completely, fine grained clay soils and lateritic soils are formed.

The study area lies within the Jos-Bukuru Complex and consists of four (4) lithologic units differentiated on the basis of mode of formation, mineralogy and texture (Fig. 1). These rock units include Jos biotite granite, N'gell biotite granite, Delimi biotite granite and Rayfield Gona biotite granite. Weathering of granite and basalt rocks had produced the lateritic soil type in most parts of Jos-Plateau with presence of coarse particles of quartz and feldspar (Olowolafe, 2001). These rocks have been modified by chemical weathering, showing vast, dissected etch-plains that are dome-shaped granite hills (inselbergs). These etch plains consist of deep, flat or undulating residual weathering crust dissected by a network of v- shaped valleys that are only a few meters deep. The soils associated with these rocks are essentially clays, lateritic clays or laterite. Most construction works are carried out on these soils and they are usually subject to changes, with changes in volume due to water content, low shear strength, swelling and shrinking characteristics (plasticity), water logging and high settlement, etc. (Cernica, 1995).

3. Materials and methods

3.1 Collection/Preparation of Samples

A total of eight (8) disturbed samples were collected and prepared in accordance with BS1377 of 1990. Prior to testing, the soil materials were air dried for days and carefully pulverized to maintain sizes of individual grains.

3.2 Test Procedures

3.2.1 Soil Compaction

The Standard Proctor test consist of compacting soil at known moisture content into a cylindrical mold of standard dimensions using a compactive effort of controlled magnitude. The soil is usually compacted into the mould to a certain amount of equal layers, each receiving a number of blows from a standard weighted hammer at a specified height. This process is then repeated for various moisture contents and the dry densities are determined for each. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content.

3.2.2 Sieve Analysis

Representative samples of 200g were used for the test after being washed and oven dried. The sieving was done by mechanical method using a set of sieves and sieve shaker.

3.2.3 Liquid limit Determination

Samples weighing 200g were passed through sieve 0.425mm then mixed with distilled water to form a uniform paste. The paste was placed inside the Cassagrande apparatus cup with a groove created and the number of blows to close the grove was recorded. The moisture content at each phase was determined then a graph of moisture content against specified number of blows was plotted. Moisture content at 25th blow gave the liquid limit.

3.2.4 Plastic Limit determination.

20g of dry soil sample used in the liquid limit test was mixed with distilled water to form a paste. A portion of the paste was rolled on a glass plate to form a thread until the thread cracked at approximately 3mm in diameter. The moisture content at that point was calculated.

4. Results and Discussion

Table 1: Summary of classification characteristics of the soil of the study area.

Location	% LL	% PL	%PI	MDD (g/cm3)	OMC (%)	% fines
1	37.9	28.0	9.9	1.63	22.10	23.5
2	45.8	28.5	17.3	1.69	7.37	33.1
3	45.8	28.5	17.3	1.86	15.6	25.1
4	37.9	28.0	9.9	2.02	16.92	37.9
5	33.8	21.9	11.9	1.99	10.95	20.6
6	37.5	28.5	9.0	1.82	8.40	16.3
7	46.8	34..7	12.1	1.82	16.0	37.0
8	41.2	32.0	9.2	1.87	14.70	34.0

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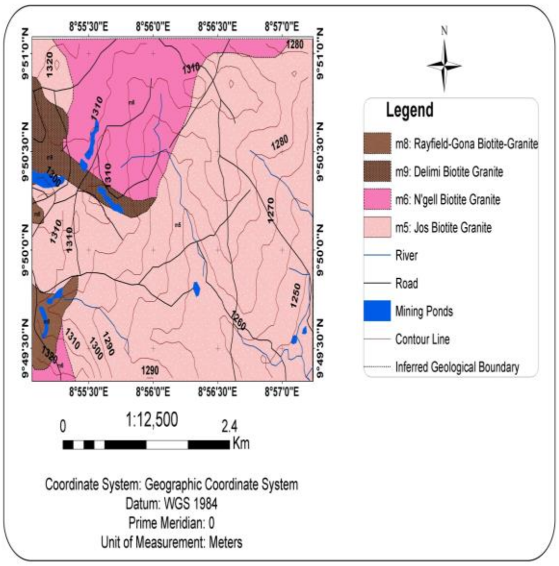

Fig 1: Geology map of study area

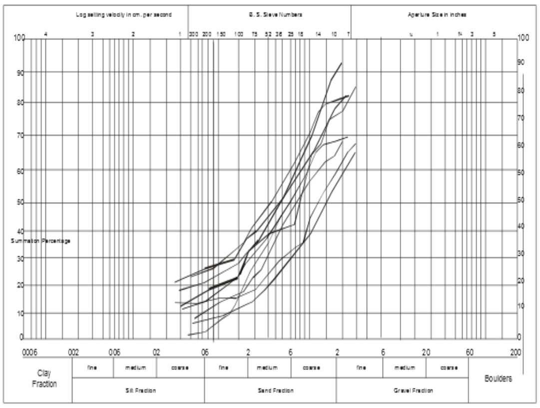

Fig. 2: Particle size distribution curves of study area

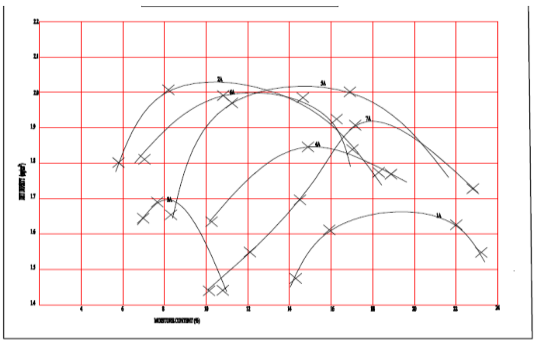

Fig. 3: Compaction curves of study area

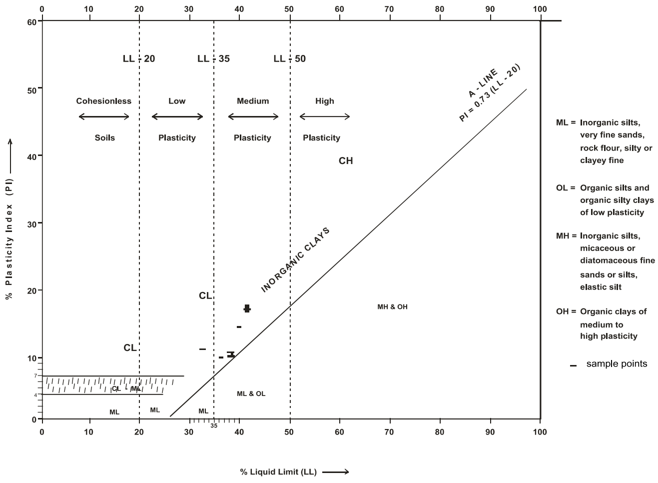

Fig. 4 lasticity Chart (After Casagrande, 1932)

Classification tests results are presented in table 1 and fig. 2 indicating that the soils are poorly graded soils with the grain size distribution characteristics revealing silty - clayey soils. Consistency tests (table 1) show liquid limits and plasticity indices range from 33.8% - 46.8% and 9.0 -17.3% respectively, this indicates the soils are low - intermediate plasticity soils with low swelling potentials (Ola, 1981) and low compressibility according to the Casagrande plasticity chart (fig. 3). Their low plasticity index qualifies the soil as good sub- grade and sub - base materials as corroborated by the work of Lar et al. (2011).

The standard compaction test method was used to estimate the relationship between optimum moisture content and maximum dry unit weight of the soils. Fig.3 depicts typical curve characteristics for all compaction tests. The dry density increased with increase in moisture content until optimum, and then began to decrease with any further increase in moisture. The moisture density relationship showed a maximum dry density and optimum moisture content ranging from 1.63g/cm^3 - 2.02 g/cm^3 and 7.37 and 22.1 % respectively. According to Brady and Well (1999), the curve indicates the maximum bulk density to which the soil may be compacted by a given force and the water content of the soil that is optimum for maximum compaction, if the soil is either drier or wettier than these values, the compaction will be more difficult.

Table 2: Values for maximum dry densities of cohesive soils (Department of Scientific and Industrial Research, 1956

Average values of		**Maximum Dry Density as obtained from standard compaction test Kg/m3**	**Suitability of soil for construction of embankment[s]**
Liquid limit	**Plastic limit**		
>65	>22	<1600	Not suitable to very poor
65 -50	22 – 19	1600 -1730	Poor
50 -32	19 – 16	1730 – 1920	Fair
32 -24	16 – 14	1920 – 2060	Good
<24	<14	>2060	Excellent

According to table 2, the soils in the study area can be considered good to excellent for construction or embankments based on liquid limit and maximum dry density, while based on plastic limit it is poor implying poor load bearing qualities and will compress under the action of sustained load. However, soil stabilization would be needed to improve the engineering properties and remedy the deficiencies. Mechanical stabilization would be appropriate as suggested by Lar et al. (2011) and Chukwuma (2010) in their work on the soils of the Jos Plateau.

Conclusion

Apart from its mechanical strength, the grading of a soil sample is the most important factor in assessing the soil sample as a construction material. In other words, the finer the soil sample, the less its suitability for construction, this is because finer soil particles can be easily washed away by water. From the various tests carried out, the study revealed the soils to be generally silty-clayey with low compressibility. The compaction characteristics of the studied soils characterized the soils as poor based on plastic limit and good based on maximum dry density. The soils would require greater compactive effort to bring it to higher density in order to increase the strength. Mechanical stabilization will do, to help increase the dry density for such soils to be safely and economically used for construction.

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References

[1] Wesley, L. D. (2003). “Residual strength of clays and correlations using Atterberg limits.” Geotechnique, Vol. 53, (7), pp. 669-672.

[2] Ramesh, H. N., Krishna Manoj, and Mamatha, H. V. (2010). “Compaction and strength behavior of lime-coir fiber treated Black Cotton soil.” Geomechanics and Engineering, Vol. 2(1), pp. 19-28.

[3] Calik, U. and Sadoglu, E. (2014). “Engineering properties of expansive clayey soil stabilized with lime and perlite.” Geomechanics and Engineering, Vol. 6 (4), pp. 403-418.

[4] Jyothirmayi, K.H., Gnonananda, T. and Suresh, K. (2015). Prediction of compaction characteristics of soil using plastic limit. International journal of Research in Engineering and Technology (IJSRET), vol. 4(6), pp. 253-256.

[5] Lambe, T.W. and R.W. Whiteman, 1969. Soil Mechanics. John Wiley, N.Y., pp: 46-60.

[6] Charles, S and Gresser, P.E : Construction Materials Testing Division Manager. Retrieved from http://www.gilesengerr.com/literature/soil_compaction_and_stability_long.pdf .

[7] Lar, U.A., Wazoh, H.N., Mallo, S.J. & Chup, A.S (2011): Geotechnical Characterization of Lateritic Soils in Jos and Environs North Central Nigeria. Nigerian Mining Journal, vol.9(1), pp.7-17.

[8] Chuwkuma, R. C. (2010). Geotechnical properties of reclaimed mine out landsites: a case study of Jos and environs, Sheet 168NE and SE. Unpublished master’s thesis, University of Jos, Nigeria, pp.1-178.

[9] MacLeod, W.N., Turner, D.C. & Wright, E.P. (1971). The geology of Jos, Plateau. Bull. Geol. Surv. Nigeria, Vol. 1. (32).

[10] Olowolafe, E. (2001). Chemical and mineralogical characterization of soils developed in volcanic parents materials on the Jos Plateau Nigeria. African Journal of Natural Science, vol. 3, pp.23-25.

[11] Cernica, J.N. (1995). Geotechnical engineering: Soil Mechanics. New York: John Wiley and Sons, Inc. pp. 102-105.

[12] British Standards Institution (1990). Methods of testing soils for civil engineering purposes, BS 1377. British Standard Institute, London.

[13] Ola, S.A. (1978). Geotechnical properties and behavior of some stabilized Nigerian lateritic soils. Quarterly journal of engineering geology,vol 11,pp.145-160.

[14] Casagrande, A. (1932). Research on the Atterberg limits of soils, public roads, vol.13 (8), pp. 121–136.

[15] Brady, C. N. and Well, R.R (1999). The nature and properties of soils, 5th ed. New Jersey Prentice Hall.

[16] Department of Scientific and Industrial research (1956). In Soil mechanics in foundation engineering, theory and practice (Wilun, Z. and Starzewski, K. 1972), vol.11, pp. 158–160.