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Original Research Article

Investigation of Index Properties of Soils along Jos-Makurdi Road in North Central Nigeria

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Abstract

Index properties of soil forms part of the precondition for its use in civil engineering construction works. The neglect of it will give investors a wrong idea about the properties of the soil material. This research investigates the index properties of soils along jos-makurdi road in north central Nigeria. A trial pit was dug under four different bridges to a depth of 1m each and soil samples were collected by method of disturbed sampling and analyzed using the following tests: Moisture content test, Particle size distribution test, Atterberg limit test and Specific gravity test. All these tests were carried out according to procedure highlighted in BS1377 1990. By visual inspection Grey colours were observed of both soil sample SS1and SS2; while light brown and brownish colours were observed from SS3and SS4 respectively. The natural moisture content of the soil sample SS1, SS2, SS3 and SS4, are 6.56, 7.89. 52.52 And 54.72%. Using the unified soil classification system (USCS), the SS1 and SS2 were classified as well graded sand (SW) while SS3 as silt sand (SM) and SS4 was classified as clay sand (SC), respectively. The SS1 and SS2 were non-plastic while SS3 have liquid limit (LL) of 33.62%, plasticity index of 32.06% and linear shrinkage of 3.85%; and SS4 have liquid limit (LL) of 52.40%, plasticity index of 41.28% and linear shrinkage of 2.5%. The specific gravity (GS) obtained from the test results are 2.66, 2.65, 2.38 and 2.27, for SS1, SS2, SS3 and SS4 respectively. Based on the test results obtained from the study trial pits, SS1 and SS2 are well graded sand (SW) which is suitable for most engineering construction while silt sand (SM) and clay sand (SC) will require stabilasation or modification for possible use in engineering application. Based on these investigations, the index properties of the soil sample, SS1, SS2, SS3 and SS4 varies with the location.

Keywords: Index properties, Soil, Soil location, Disturbed soil sampling.

1.0 INTRODUCTION

Soil is the complex material, which is available over 1/4th part of the Earth, which results in formation of the rock. A sample of soil in the form of rock, dust, stones etc., may be composed of soil grains, water and air. The soil grains are non-identical with other adjacent soil grains. A soil type is characterized as having the same geologic depositional history(Andavan et al. 2018) and which also depends on the rock type, its mineral constituents and the climatic regime of the area (Surendra et al. 2017). Different soils have significant difference in exhibiting their properties when compared to the adjacent soil with soil strata from long distance (Andavan et al. 2018). Soils are used as construction materials or the civil engineering structures are founded in or on the surface of the earth (Laskar et al. 2012), while the nature and characteristics of the soil influence their engineering performance (Ademila 2016). To check the suitability of soil to be used as foundation or as construction materials, its properties are required to be assessed (Laskar et al. 2012). Soil index properties are the properties of soil that help in identification and classification of soil. These are properties of soil that indicate the type and conditions of the soil and provide a relationship to structural properties. Soil index properties are used extensively by engineers to discriminate between the different kinds of soil within a broad category (ELE, 2013). Globally, engineering structures are constructed with the expectation to stand a test of time (Ademila 2016) and so, this is always big challenge to Geotechnical Engineer to analysis the engineering as well as Index property of the soil. Based on the index properties, some information about engineering properties such as permeability, compressibility and shear strength can be estimated (Andavan et al. 2018). A good knowledge about a site including its subsurface conditions is very important in its safe and economic development. It is therefore an essential preliminary to the construction of any civil engineering work such as roads, buildings, dams, bridges, foundations, etc., (Adeyeri 2015). It is unfortunate to note that in developing countries like Nigeria only few investors in the construction industry take time to execute subsoil investigation prior to commencement of construction activities on their projects. The result is the calamitous consequences such as failure or collapse of buildings and other massive engineering structures which often cause untold hardship and damage and sometimes even loss of lives and properties (Eze et al. 2017). It is a clear indication that there is lack of in-depth understanding and neglect of the index properties of sub soils which form part of the precondition for its use in civil engineering construction works. Therefore, this work is aimed at assessing the index properties of sub soil along Jos-Makurdi road.

2.0 MATERIAL AND METHOD

Four different trial pits with co-ordinates as shown in table 1 were dug under the bridges along Jos-Makurdi road. A disturbed method of sampling was employed in collecting the soil samples (SS1, SS2, SS3 and SS4) each at 1m depth. Care was taken when collecting the samples to ensure that the analyzed samples are true representatives of the insitu materials. The samples were excavated and collected with the help of a digger, shovel and a scoop. The samples were packaged in polyethylene bags, clearly labeled and sent to the geotechnical laboratory of the Nigerian building and road research institute, North central zonal office Jos for relevant laboratory tests. Soil samples collected were visually inspected. Disturbed sample were air dried and test including natural moisture content, manual sieve analysis and hydrometer analysis, liquid limit (LL), plastic limit (PL) linear shrinkage limit(SL) and specific gravity (SG) were carried out according to procedure highlighted in BS1377 1990.

Table-1: Co-ordinates of trial pits

S/N	Soil Samples	Co-ordinates
1	SS1	N09^{0}39.130$^{|}$ E008^{0}46.475$^{|}$
2	SS2	N09^{0}38.008$^{|}$ E008^{0}45.157$^{|}$
3	SS3	N09^{0}32.656$^{|}$ E008^{0}38.154$^{|}$
4	SS4	N09^{0}31.137$^{|}$ E008^{0}37.495$^{|}$

3.0 RESULTS AND DISCUSSION

Table.2 shows the result of the index properties of the soil sample and figure 1 and 2 illustrate the typical soil particle size gradation curve.

Table-2: Result of the soil index properties

SOIL SAMPLE(SS)	NMC %	GS	LL %	PL %	PI %	SL %	% PASSING BS SIEVE		USCS
							4.75MM	0.075MM	
SS1	6.56	2.66	-	-	-	-	72	0.48	SW
SS2	7.89	2.65	-	-	-	-	97	0.84	SW
SS3	52.52	2.38	33.62	32.06	1.56	3.85	96	29.55	SM
SS4	54.72	2.27	52.40	41.28	11.12	2.5	99	30.31	SC

3.1 visual inspections

Grey colours were observed of both soil sample SS1and SS2; while light brown and brownish colours were observed from SS3and SS4 respectively.

3.2 Moisture content

The result of moisture content showed that both soil sample SS1 and SS2 have low moisture content of 6.56% and 7.89%, which cannot hold water while SS3 and SS4 have high moisture content of 52.52% and 54.72% respectively.

3.3 Atterberg Limit

Atterberg limits are water contents that correspond to changes of state of a soil. It is a useful indices often used directly as specifications for controlling soil for used in engineered fills. The water contents corresponding to transition from one state to the next are known as the liquid limit (LL).the plastic limit (PL) and the shrinkage limit (SL). The liquid limit of a soil is the water content, expressed as percentage of the weight of the oven dried soil, at the boundary between the liquid and plastic states of consistency of the soil. The plastic limit of a soil is the water content, expressed as a percentage of the weight of oven dried soil, at the boundary between the plastic and semi-solid states of consistency of the soil. The range of the plastic state is given by the difference between liquid limit and plastic limit and is defined as the plasticity index (PI). The plasticity index is used in soil classification and in various correlations with other soil properties as a basic soil characteristic. The result showed that SS3 and SS4 soils have LL of 33.62% and 52.40% respectively. This LL indicates that the soil has negligibly small shear strength. The result also showed that SS1and SS2 soils are non-plastic which is an indication of high shear strength soil; the PI of SS3 soil is 1.56%, which is an indication of low plastic soil, while PI of SS4 is 11.12% which indicate that the soil is a medium plastic.

3.4 Linear Shrinkage

The shrinkage limit is the maximum water content expressed as a percentage of oven-dried weight at which any further reduction in water content will not cause a decrease in volume of the soil mass. Generally, the lower the linear shrinkage, the lesser the tendency for the soil to shrink when dried According to Prakash and Jain (2002), it gives an idea about the suitability of the soil as a construction material in foundations, roads, embankments and dams.

3.5 Particle Size Distribution Analysis

The percentage of different sizes of soil particles coarser than 75 µ is determined by sieve analysis whereas less than 75 µ are determined by hydrometer analysis. Based on the particle size analysis, particle size distribution curves are plotted as shown in figure 1 and 2. The particle size distribution curve (gradation curve) represents the distribution of particles of different sizes in the soil mass. According to the unified soil classification system (USCS), SS1 and SS2 are classified as well graded sand, with little or no fines (SW); and according to Dafalla, (2013) which is an indication of high shear strength of the soil. SS3 is silty sand, sand silt mixtures(SM); and according to Raj (2012) the particle size of sands and silts has some practical value in design of filters and in the assessment of permeability, capillarity, and frost susceptibility; and in terms of sub-grade, silty sand will require stabilasation for possible use in geotechnical engineering application (Rabbani et al., 2012 and Nader & Masoud, 2018). SS4 is clayed sand, sand clay mixtures (SC). Stephen and Ikani (2012), reported that clayed sand would make better sub-grade materials for civil engineering construction than clayed soil which are unsuitable for most engineering construction because they have poor bearing capacities.

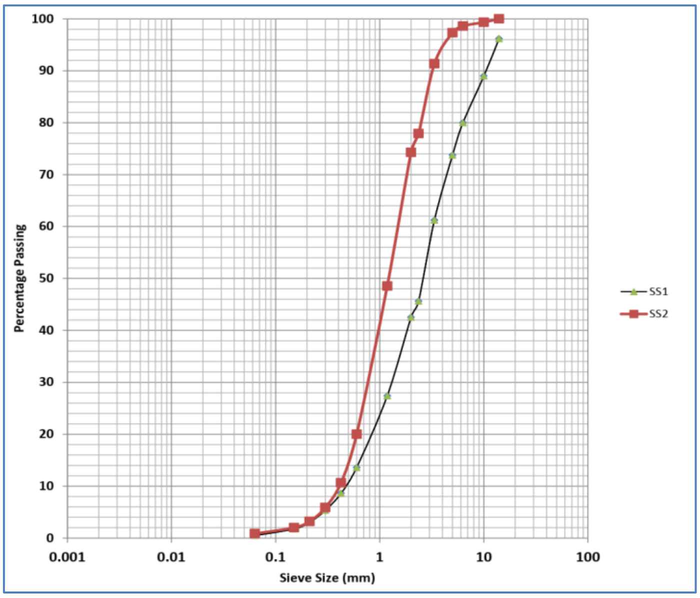

Fig-1: Gradation curve of the study materials, SS1 and SS2

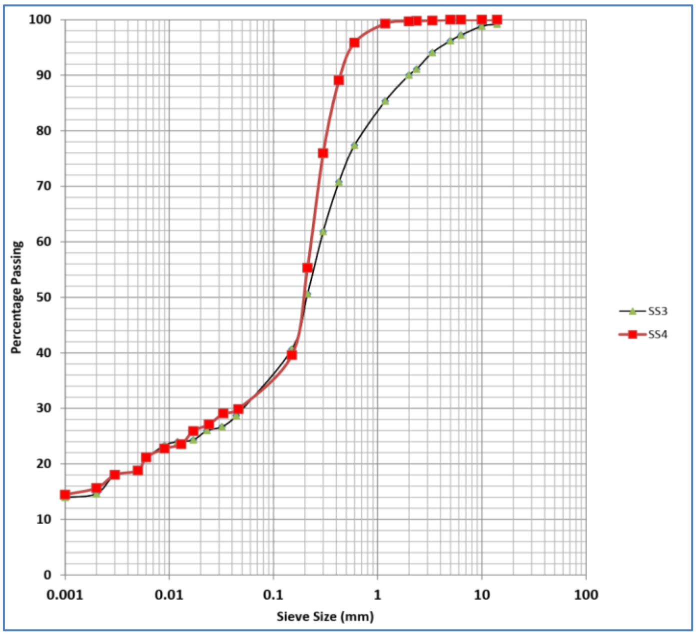

Fig-2: Gradation curve of the study materials, SS3 and SS4

3.5 Specific Gravity

Specific gravity is the ratio of the mass of soil solids to the mass of an equal volume of water. According to Prakash and Jain (2002), it gives an idea about suitability of the soil as a construction material; higher value of specific gravity gives more strength for roads and foundations. The results show that the specific gravity of the soil samples SS1, SS2, SS3 and SS4 are 2.66, 2.65, 2.38 and 2.27 respectively. The types of the soil samples based on specific gravity according to Bowles (2012), both SS1 and SS2 are clean sand while SS3 and SS4 are organic soil respectively.

4.0 CONCLUSION

The index properties obtained shows that the soil sample SS1 and SS2 are well graded sand (SW) which are suitable for most engineering construction because well-graded materials provide more grain to grain area contact than poorly graded materials, which is an indication of a high shear strength soil. Soil sample SS3 and SS4 have some quantity of fine which will present risk of failure when to be used in construction. SM may be susceptible to expansion when come in contact with water and SC may contain clay minerals or some organic particles, which therefore will make them unsuitable for most engineering construction. The soil sample SS3 and SS4 will require stabilasation or modification for possible use in engineering application.

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