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Geotechnical Characterization of Soil, a Tool in Determining The Suitability of Soil for Construction Purpose, A Case Study of Federal Polytechnic Ede, Osun State, Southwestern Nigeria.

[1]OJI A.S, [1]AKINBIYI. O.A, [2]OLAYIWOLA K.O
[1]Department of Geological Technology, Federal Polytechnic, Ede
[2]Department of Survey and Geoinfomatics, The Polytechnic, Ibadan, Ibadan

ABSTRACT - Geotechnical characterization of soil helps to determine and understand the behavior of soil of a particular place, it also helps in determining soil water content, specific gravity, plasticity, strength, size of particles, compressibility, and soil bearing capacity. The focus of the study is to carry out the geotechnical characterization of soil in order to determine the types of soil and its suitability for construction purposes. The study area lies between latitude $007^0 43' 47'' N$ and $007^0 71' 81'' N$ and longitude $004^0 25' 18''$ and $004^0 43' 64''$ East of Greenwich Meridian. Samples of soil were collected at six different points at a depth of 0.5m. Laboratory soil test were conducted according to the BS1991 standard with necessary modification made which include Natural Moisture Content(NMC), Specific Gravity(SG), Grain Size Analysis(GSA), Atterberg's limits (liquid limits, plastic limits, shrinkage limits). From the geotechnical analyses the value of the Natural Moisture Content ranges from 8.8% to 22.9%, the Specific Gravity values ranges from 2.20 to 2.90, the Sieve Analysis indicates fairly well graded soils though with high proportion of gravel and sand with very low fines less than 15%, the soil samples are of low plasticity with plasticity index values ranging from 0.53% to 19.97%, the Shrinkage Limit ranges from 7.2 to 12.5. The analyses indicate that the soil is an inorganic soil of low plasticity and majorly of gravel and sand with very low percentage of fines. The deduction from the result indicates that the soil at federal polytechnic Ede is mainly gavel to sand size with very low fines and plasticity, this shows that the soil is suitable for construction purposes.

Keywords: Geotechnical Characterization, Soil, Grain Size Analysis, Atterberg's limits

1. Introduction

Soil may be described as earthy materials (weathered rocks), inorganic (such as sand, clay, siit e.tc.) or organic (such as peat) in nature. Soil are formed by the disintegration of rocks (Kolay 1993). The geotechnical properties and behavior of soil differ from one place to another. Geotechnical characterization of soil helps to determine its properties and its behavior.

In civil engineering, soils with properties that cannot be safely and economically used for the construction of civil engineering structures without adopting some stabilization measures are known as problem soils. Problem soils are expansive, swelling and collapsing soils. To the geotechnical and highway engineers, a problem soil is one that poses problem to construction. Such problem may be as a result of instability of the soil which makes it unsuitable as a construction material in foundations, buildings, highways, water retaining structures, dams, e.t.c., (Ola, 1987).

Adesunloye (1987), viewed problem soils as those which exhibit low strength and high compressibility; they are also expansive or collapsible. In Nigeria, some of these soils have been identified. They include mainly; the black cotton soils which occur widely in the north-eastern part of Nigeria and the Sokoto soft clay shale (attalpulgite) in the north-western Nigeria (Ola, 1987). Adesunloye (1987), has through standard laboratory testing procedures, identified the problem soils in the Lagos area as peaty clays. In Port-Harcourt area, they occur as clayey peat over the mud plains. He also noted that problem soils tend to fall above the Casagrande's plasticity Chart and this agrees with the submission of Chukweze (1991).

According to Gidigasu (1976), structurally unstable, tropical and residual soils include the following: basic igneous rocks subject to rapid physico-chemical weathering in the wet tropical and subtropical environments, carbonates rocks which are prone to sinkhole formation, expansive and shrinkable soils, sensitive and highly compressible red clays of high rainfall regions, collapsing soils, dispersive and erosive soils, organic soils including peat, saline or salt bearing soils, Pedogenic materials especially lateritic materials, Silcretes, e.t.c.

Failures such as settlements, cracks and collapse of buildings found on these problem soils due to changes in moisture contents have caused considerable loss of life and properties. Swelling and expansive soils are one of Nigeria's prevalent causes of damage to buildings and other construction works. Possible damages that can be caused by expansive soils include; foundation cracks, severe structural damage, heaving and cracking of sidewalks, roads and basement floors, ruptured pipelines, jammed doors and windows. The destructive force may be upward, horizontal or both.

This work presents the geotechnical characterization of soil within Federal Polytechnic Ede. The study aims to determine the suitability of soil for construction purposes and to create a geotechnical database of the soil. The geotechnical database include natural moisture content, specific gravity, grain size distribution and consistency limits of the soil samples collected from the study area.

2. Study Area

The study area is Federal Polytechnic Ede, Osun state, southwestern Nigeria. It lies between latitudes $7^{0}43^{'}47^{''}$N and $7^{0}71^{'}81^{''}$N and between longitudes $4^{0}25^{'}18^{''}$E and $4^{0}43^{'}64^{''}$E of Greenwich Meridian. The study area is accessible by major roads in Ede town (Fig. 1). The study area is underlined by three major rock types which are pegmatite and biotite gneiss and quartzite (Fig. 2).

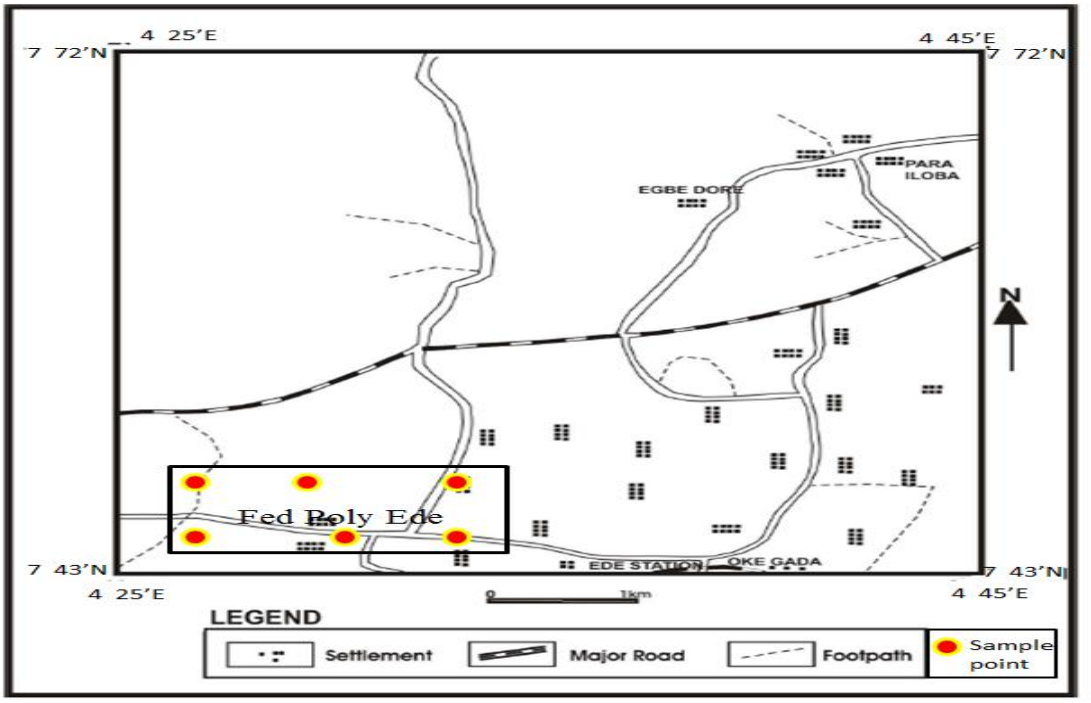


Figure 1: location and accessibility of the study area
Source: Ministry of Lands and surveys, Osogbo

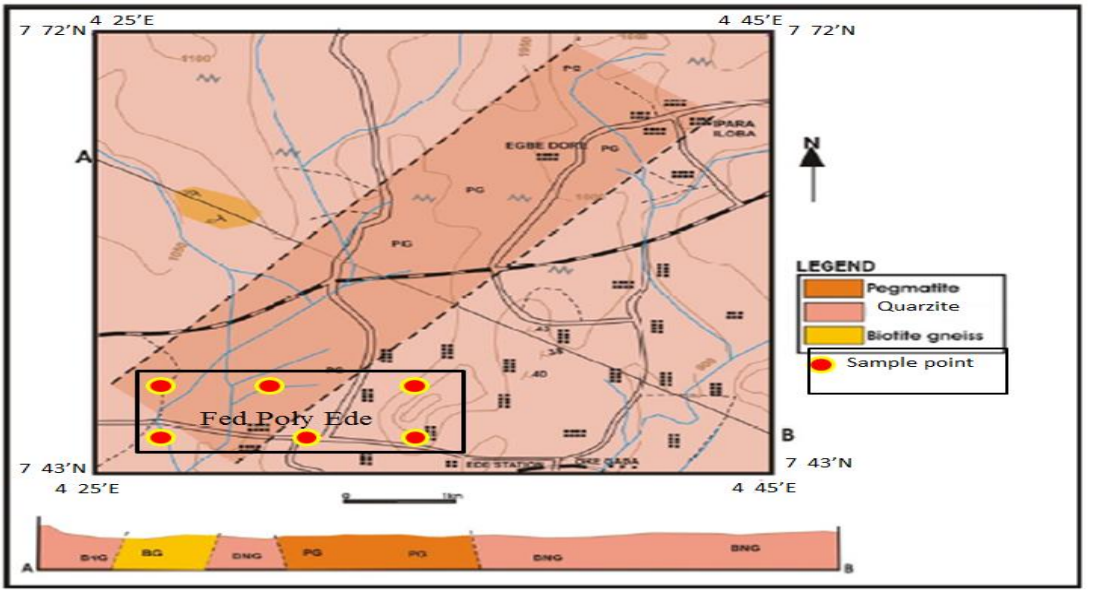


Figure2: Geologic map and cross -section of the study area
Source: Ministry of Lands and surveys, Osogbo

3. Materials and Methods

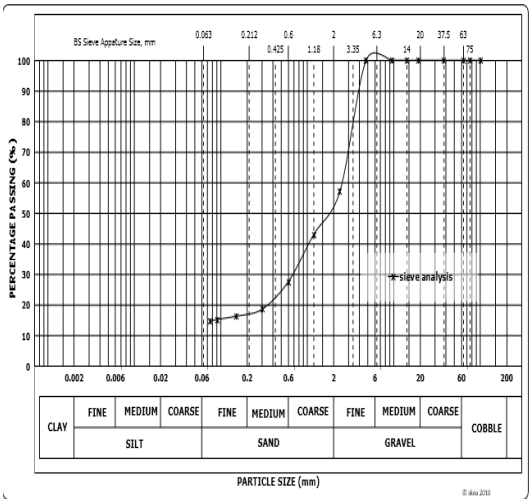
The engineering laboratory test for the classification and evaluation of soil for construction purpose were performed on selected soil samples representative of different location of study. Soil samples were collected at a depth of 0.5m below ground surface by vertical excavation from six different locations inside the Federal Polytechnic Ede and were designated as sample 1, sample 2, sample 3, sample 4, sample 5 and sample 6.The collection of sample involved the use of shovel, digger and sample collected werepreserve in polythene bags to reduce moisture loss and ensure good preservation.
Laboratory tests were performed as per Indian standard specifications to determine the index and engineering properties of the soil.

Index Properties

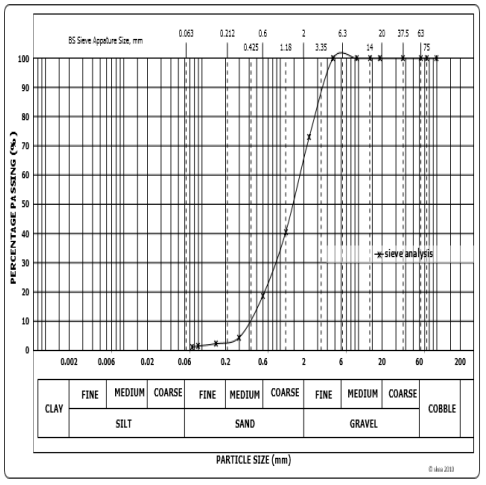
i. Natural moisture content were conducted to determine the natural moisture present in the soil (IS:2720 Part 2- 1973).
ii. Specific gravity test was conducted using specific gravity bottle as per IS:2720 – 1980 on the soil samples
iii. Grain size distribution analysis was performed by dry sieve analysis (IS:2720 Part 4 – 1975)
iv. Liquid Limit of the soil sample was determined by the casagrande apparatus as per IS:2720 Part 5 – 1985. The soil sample was sieved through 425micron sieve and tested. Plastic Limit of the soils was conducted by standard method (IS:2720 Part 5 – 1985). Shrinkage Limit of the soil was also conducted (IS: 2720 Part 20- 1966).

4. Results and Discussion

The natural moisture content values of the samples collected ranges from 8.8% to 22.9%. The natural moisture content for most soils is under 60 percent.
For specific gravity test, the grain size larger than 4.75mm in the soil samples were removed prior to testing. The specific gravity values of the samples range from 2.20 to 2.90.
The grain size distribution analysis was performed by dry sieving to determine the percentage of different grain sizes contained within a soil sample.
The samples taken from the locations contain gravel size fraction of 27.0% to 63.5%, coarse sand fraction ranging from 20.1% to 54.5%, medium sand ranging from 5.5% to 16.3%, fine sand ranging from 0.9% to 2.4% and fine contents ranging from 0.9% to 14.6%.Figure 1 shows the grain size distribution curve for the samples.



A



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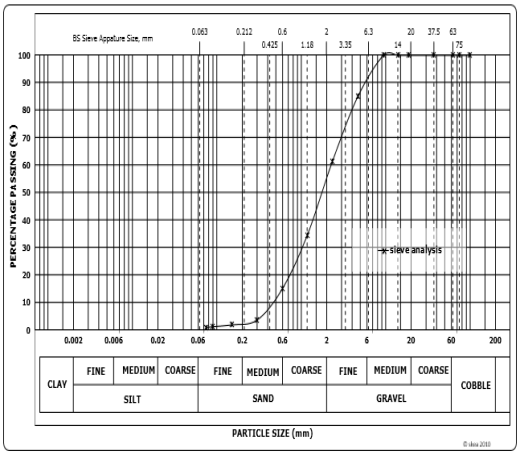

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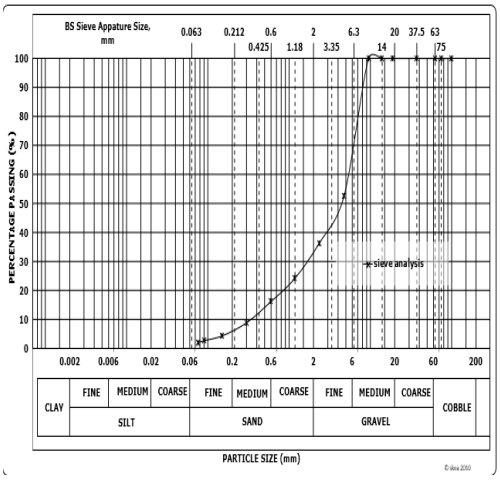

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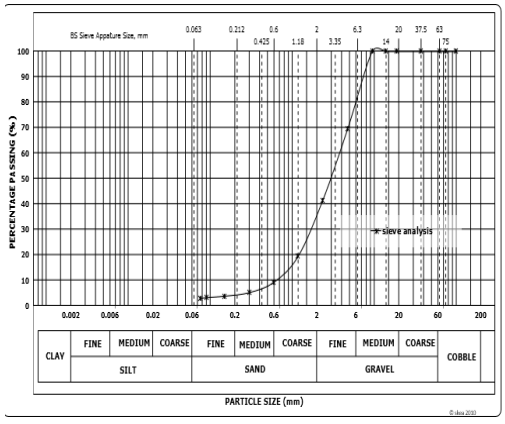

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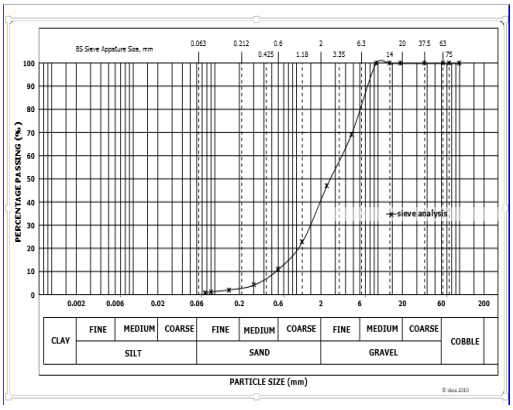

D

Figure 3: A-F shows the Grain size distribution curve for sample 1-6

Atterberg's Limits test were performed to determine the liquid limit, plastic limit and shrinkage limits of fine grained soil samples.
The liquid limit of the samples 1 to 6 varies from 24.1% to 43.2%. The liquid limits of samples 2, 3 and 5are below 35% indicating low plastic soil while that of samples 1, 4 and 6 are greater than 35% but less than 50% indicating medium plastic soil (casagrande, 1948). The plastic limit of the samples varies from 11.5% to 41.7%. The plasticity index of the samples varies from 0.00% to 19.97% indicating low-medium plastic soil (Chandetal 2001).

Table 1: India soil classification system using plasticity index IS 1498-1970 (modified after Chandetal 2001)

Plasticity index	**Degree of plasticity**	**Type of soil**
0-1	**Non-plastic**	**silt**
1-5	**Slight plastic**	**Trace clay**
5-10	**Low plasticity**	**Little clay**
10-20	**Medium plasticity**	**Clay & silt**
20-35	**High plasticity**	**Silt clay**
>35	**Very high plasticity**	**clay**

As per IS soil classification for coarse grained soils, Sample 1 is classified as silty sand (SM), sample 2 and 4 are classified as poorly grade sands, gravelly sand with little or no fines (SP), sample 3, 4 and 6 are classified as well graded sands, gravelly sand, with little or no fines (SW). For fine grained soils, sample1 and 6 are classified as inorganic silt with intermediate compressibility (MI), sample2 and 3 are classified as inorganic clay with low compressibility (CL), sample 4 is classified as inorganic clay with intermediate compressibility (CI), and sample 5 is classified as inorganic silt with low compressibility (ML).

Table 2: summary of the index properties result and classification of the samples collected

Location		Male hostel	Entrepreneur	Staff school	works	Central mosque	library
Tests		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Natural moisture content (%)		22.7	16.4	22.9	8.8	15.2	10.9
Specific gravity (%)		2.44	2.90	2.64	2.20	2.33	2.63
Gravel (%)		43.0	27.0	63.5	38.5	58.6	53.1
Coarsed sand (%)		29.5	54.5	20.1	46.5	32.2	36.0
Medium sand (%)		11.3	16.3	11.9	13.1	5.5	8.8
Fine sand (%)		1.7	1.2	2.4	1.0	0.9	1.3
Fines (%)		14.6	1.1	2.1	0.9	2.8	0.9
D_{10}		0.01	0.43	0.35	0.48	0.65	0.55
D_{30}		0.70	0.90	1.50	1.00	1.50	1.50
D_{60}		2.50	1.50	5.50	2.40	2.49	3.50
Cu		2.50	3.53	15.71	5.0	3.83	6.36
Cc		19.6	1.27	1.17	0.87	1.39	3.50
Ws		7.2	12.5	12.5	6.8	7.7	8.7
W_L		42.2	24.1	31.9	43.2	24.5	41.8
Wp		41.7	11.5	17.0	21.9	29.8	27.7
Ip		0.53	12.60	14.95	19.97	0.00	14.28
Classification(IS:1498-1970)	Coarsed grained soil	SM	SP	SW	SP	SW	SW
	Fine grained soil	MI	CL	CL	CI	ML	MI
G.P.S	latitude	$007^0 71^1 49^{11}$	$007^0 71^1 69^{11}$	$007^0 43^1 47^{11}$	$007^0 67^1 49^{11}$	$007^0 71^1 76^{11}$	$007^0 71^1 81^{11}$
	longitude	$004^0 43^1 64^{11}$	$004^0 43^1 54^{11}$	$004^0 25^1 18^{11}$	$004^0 43^1 42^{11}$	$004^0 43^1 45^{11}$	$004^0 43^1 42^{11}$

5. Conclusion

Experiments were conducted on soil samples to characterize their index properties. The following conclusion has been arrived based on the experimental work on the soil samples collected from six locations within Federal Polytechnic Ede (North Campus).

- The Natural Moisture Content of the soil samples tested gave low percentage value. Excessive moisture content is detrimental to collapsible and swelling soil(Jegede 1994). Soil with low moisture content has low compressibility and high shear strength and are suitable material for engineering constructions.
- Values of specific gravityof soil samples tested are high; higher specific gravity gives more strength for roads and foundations (Murthy 1992). This indicates that the soil tested are suitable for construction purposes.
- According to Unified Soil Classification System (USCS), for coarsed grain soil, sample 3, 5 and 6 are classified as well graded sands, gravelly sands with little or no fine (SW); sample 2 and 4 are classified as poorly graded sands, gravelly sand with little or no fines (SP) while sample 1 is classified as silty sands (SM). The general rating of the soil samples indicates that they are fair to good subgrade and sub-base material.More so the percentage fines of the soils tested are less than 15%, this is in accordance with the specification of soil for roads by the federal ministry of works and transportation and this make it good for construction purposes.
- The result of the Atterberg's Limits tests indicates that the soil samples are soil with low to medium plasticity.

From the results, soil within the Federal Polytechnic Ede has high strength, low compressibility and cohesion and this make it suitable for construction purposes.

6. Recommendation

Aside the initial tests carried out in this research work, there are other final tests like strength test, bearing capacity test, compressibility and settlement test that needs to be carried out on the soil before the erection of any building and construction of roads. The management of Federal Polytechnic Ede should provide grant that will enable these tests to be carried out in order to avoid failure.
Contractors should ensure that foundation meets up standard requirement, bearing capacity of soil march with the capacity of building or structure to be placed on it and adequate quantity and quality material should be used in order to avoid failure.

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