UNIVERSITY OF MAIDUGURI

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND WATER RESOURCES ENGINEERING

SOIL MECHANICS LABORATORY

PRACTICAL REPORT ON;

Some Tests on the Geotechnical Properties of Soil

BY

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CERTIFICATION

We certify that this report has been conducted by all the members of the group under the supervision of Daniel A. Suno of Civil and Water Resources Engineering, Faculty of Engineering, University of Maiduguri.

DEDICATION

This Practical Report is dedicated to Almighty God, Our Lovely Parents and Guardians.

ACKNOWLEDGEMENT

First of all, we thank Almighty God who has given us ability to sail through the undulating pathways. May his peace and blessings be upon on us and our families. Our ample thanks and inevitable appreciation with great honour to goes to our parents, for their unending supports and prayers, care and non-fading love from cradle to adulthood. Our profound gratitude and appreciation goes to our erudite lecturer and supervisor, Daniel A. Suno. We will not forget our friends and colleagues, indeed you have inspired something into our work and life.

ABSTRACTS

Understanding of soil properties for good construction decision leads to a success project. The structural engineers can effectively and accurately design the structural elements of a structure based on the result of the soil test analysis, so that the structure's long term variability and soundness is achieved. The result of soil tests and investigations also helps to determine whether there is need for stabilization and the foundation depth to attain the required bearing capacity. The method of soil test adopted in the practical are the physical and mechanical properties test. Therefore, the particle size distribution chart indicates the soil sample as a well graded silty-clay soil with more than 40% particles for both silt and clay within its mass. The consistency limits of the soil sample are within the range that categorized the sample as a small particle soil because its liquid limit ranges between 24.3%-36.5% which indicates also indicates fine particles are present in the soil and the plastic limit is moderate which shows that there is cohesion within the soil's particles, this is a characteristic of silt and clay. The shrinkage limit of the samples is 2% which indicates little bulking factor as well as cracking and swelling of the soil mass and it also indicates the fact that the volume of the sample will decrease when the moisture is drain out of the soil sample mass. The specific gravity of the soil sample ranges within the range of 2.65-2.68, which is an indication of fine particles within the soil samples. Therefore, with all the results compared and contrast with the standards, the soil sample is a silty-clay soil.

INTRODUCTION

Site investigation are done for obtaining the information about sub-surface condition at site of proposed construction [10]. Soil exploration consist of determining the profile of soil, taking the soil samples and determining engineering properties of the soils [11]. A wide variety of laboratory test can be performed on soil properties. Some soil properties are intrinsic to the composition of the matrix and are not affected by sample disturbance, while other properties depend on the structure of the soil as well as its composition, and can be only be effectively tested on relatively undisturbed sample [12].

Field and laboratory investigation required to obtain necessary for soil types encountered when acted upon by structural loads, water and temperature [10]. Soil investigation is a crucial part of foundation design and we should conduct soil test and analysis for any construction [2]. Usually the soil at the site to be develop is not ideal from the view point of soil engineering; in such situation, the soil in the site is either removed and its behaviour, the approach is more feasible and is generally termed as soil stabilization [4].

The bearing capacity of soil is the average contact stress between a foundation and the soil which will cause shear failure in the soil. Allowable bearing capacity divided by a factor of safety. Sometimes, on soft soil sites, large settlements may occur under loaded foundation without actual shear failure occurring; in such cases, the allowable bearing stress is determined with regard to the maximum allowable settlement. It is important during construction and design stage of a project to evaluate the sub-grade strength [7].

METHODOLOGY

SIEVE ANALYSIS

AIMS AND OBJECTIVES

- To obtain the particle size distribution of the soil.

APPARATUS

- A set of fine BS sieves of sizes; 4.75mm, 4.00mm, 3.35mm, 1.40mm, 600 μ m, 425 μ m, 300 μ m, 150 μ m and 75 μ m.
- Weighing balance, with an accuracy of 0.1%.
- Mechanical sieve shaker.
- Wire brushes.
- Pans.
- Stop watch.

PROCEDURE

- After washing the soil sample of 700g and obtaining the retain part of that sample on sieve No. 200, we oven dry it and weigh it.
- The measured sample was found to be 266.52g of the oven dry soil sample.
- We then arrange the sieves according to their sizes ranging from maximum diameter from top to the pan below.
- Pour the oven dry soil sample from top sieve and allow passing through to the pan.
- Put the BS sieve set into the mechanical shaker and allow it to shake for 10 minutes.
- Remove the sieve from the mechanical shaker and measure the sample retained on each sieve and record.

ATTERBERG'S LIMITS

LIQUID LIMIT

AIMS AND OBJECTIVES

- To obtain the liquid limit of the soil.

APPARATUS

- i. Liquid limit device (Casagrande Cup).
- ii. Weighing balance accurate to 0.01g.
- iii. Spatula.
- iv. Drying Oven.
- v. Flats plate (about 500mm²).

PROCEDURE

- i. Distilled water is mixed to the soil to obtain a uniform paste.
- ii. A platform of the paste is placed in the cup of the liquid limit device and spread into portion with few strokes of spatula.
- iii. Trim it to a depth of 1cm at point of maximum thickness and return excess of soil to the dish.
- iv. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the cup.
- v. Lift and drop the cup by turning the crank at the rate of two revolutions per second until the two halves of soil come in contact with each other for a length of about 1cm by flow only.
- vi. The number of blows required to cause the groove to close for about 1cm should be recorded.
- vii. Repeat the test with different moisture content at least three more times for blows between 10 and 40.

PLASTIC LIMIT

AIMS AND OBJECTIVES

- To obtain the plastic limit of the soil.

APPARATUS

- i. Flat plate for rolling the sample.
- ii. Weighing balance accurate to 0.01g.
- iii. Oven.
- iv. Spatula.

PROCEDURE

- i. Take about 20g of thoroughly mixed portion of the sample passing through 425 μ m BS sieve.
- ii. Mix thoroughly with distilled water on the glass plate till the soil mass becomes plastic enough to be easily moulded with fingers.
- iii. Allow it to season for sufficient time to allow water to permeate throughout the soil mass.
- iv. Take about 10g of the soil mass and roll it between finger and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter through its length.
- v. Continue rolling till you get a threaded of 3mm diameter.
- vi. Knead the soil together to a uniform mass and re-roll.
- vii. Continue the process until the thread crumbles when the diameter is 3mm.
- viii. Collect the pieces of the crumbled thread in a drying container for moisture content determination.
- ix. Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.

SHRINKAGE LIMIT

AIMS AND OBJECTIVES

- To obtain the shrinkage limit of the soil.

APPARATUS

- i. Shrinkage mould.
- ii. Oven.
- iii. Flat plate.
- iv. Spatula.

PROCEDURE

- i. Take about 100g of soil sample passing through 425 μ m BS sieve size.
- ii. Place about 30g of the soil sample on the glass plate and mix thoroughly with distilled water and make a creamy paste.
- iii. Coat the inside of the shrinkage mould with a thin layer of lubricant to prevent the soil from sticking to the dish.
- iv. Fill the mould in three layers by placing approximately $\frac{1}{3}$ rd of the amount of wet soil with the help of spatula.
- v. Repeat this process for 2nd and 3rd layers also till the mould is completely filled with wet soil.
- vi. Strike off excess soil and make the top of the shrinkage mould smooth.
- vii. Put the shrinkage mould in the oven to dry for 24 hours.
- viii. Remove the mould, the measure the length of the shrinkage mould and the shrinkage and record it.
- ix. Repeat the procedure for other samples.

SPECIFIC GRAVITY

AIMS AND OBJECTIVES

- To obtain the particle density of the soil.

APPARATUS

- i. Density Bottles or Pycnometer. with stoppers.
- ii. Weighing balance, with an accuracy of 0.01g.
- iii. A rod small enough to go through the neck of the density bottle.
- iv. Scoop.
- v. Wash bottle with distilled water.

PROCEDURE

- i. Weigh the pycnometer and record it as M_1 .
- ii. Fill the pycnometer with water to its full capacity and measure the weight and record it as M_4 .
- iii. Empty the pycnometer and refill it with 500g of the oven dry sample then measure the weight and record it as M_2 .
- iv. Add water to the sample and let the pycnometer to be full to its capacity then stirred until there are no more air bubbles observed in the soil then measure the weight and record it as M_3 .
- v. The procedure was repeated again for the coarse sample.
- vi. Take at least two observations for the same soil sample.

COMPACTION TEST (STANDARD PROCTOR TEST)

AIMS AND OBJECTIVES

- To obtain the optimum moisture content as well as the maximum dry density of the soil.

APPARATUS

- i. A cylindrical mould with an internal diameter of 105mm and an internal effective height of 115.5mm with detachable base plate and a removable extension collar.
- ii. A Metal Rammer with a face diameter of 50mm and a varying of height and weight such as 300mm and 2.5kg as well as a 450mm and 4.5kg.
- iii. Weighing balance readable to 5g.
- iv. Oven.
- v. A Metal Laboratory Tray for mixing.
- vi. A Jacking apparatus for extracting the compacted material from the mould and a hammer or a rubber mallet.

PROCEDURE

- i. The soil sample is being sieved through 4.75mm B.S Sieve size.
- ii. First weigh the cylindrical mould.
- iii. Fix the extension collar to the mould.
- iv. After mixing the loose soil with the assume quantity of water in percentage to the mould (in this case, the assumed water quantity in this case is 3% of the total weight of sample to be used for the compaction test which is 3000g) and continue adding 3% for each round with the same soil sample that is mixed and used in the first round (that is 3%, 6%, 9%...etc.).

- v. Place the Rammer as well as the Rammer guide tube gently on the soil and hold it vertically.

Then compact the soil by giving it a number of blows for the separate layers each. The different compaction tests having different number of blows, layers as well as weight of Rammer and its height consider the following test and their recommendations;

- **B.S Reduced**=it consists of 15 blows from a 2.5kg Rammer in 3 equal layers.
- **B.S Light**=it consists of 27 blows from a 2.5kg Rammer in 3 equal layers.
- **B.S Heavy**=it consists of 27 blows from a 4.5kg Rammer in 5 equal layers.
- **W.A.S.C (Nigeria)** =it consists of 10 blows from a 4.5kg Rammer in 5 equal layers.

- vi. The blows are uniformly distributed over the whole area and then set a second layer, approximately equal to the first one then compact until all successive blows as well as layers are completed, the compacted surface in the extension collar should be more than 6mm above the level of the mould body.
- vii. Then either the extension collar is removed or is left fixed on the cylindrical mould, weigh the cylindrical mould with the compacted soil and record it.
- viii. Take some piece of the compacted sample soil and put them in a container, weigh the empty container and record it then put the piece of the compacted soil sample into the container, weigh it and record it, take at least two containers as well as the sample soil.
- ix. Then take the container to the Drying Oven and allow the sample soil to dry at 105°C for 24hours, then remove it and weigh it again for the second time to obtain the dry mass of the soil sample.
- x. Remove the extension collar carefully and scrap out the compacted soil out of the mould by using the Jacking apparatus.

- xii. Note, that the maximum weight of the mould and wet soil combined must fall at least twice for the test to proceed to the next test.
- xiii. Repeated the procedure for all the type of tests considering their recommendations.

ENGINEERING SOIL CLASSIFICATION

AIMS AND OBJECTIVES

- To classify soil into group of similar particles, nature, texture and behaviours.

DATA NEEDED IN ORDER TO CLASSIFY THE SOIL

- i. Percentage of the soil sample passing through sieve No. 200.
- ii. Liquid limit of the soil sample.
- iii. Plastic limit of the soil sample.
- iv. Coefficient of Uniformity of the soil sample.
- v. Coefficient of Curvature of the soil sample.

PROCEDURE FOR AASHTO CLASSIFICATION

- i. Determine the percentage of soil passing through Sieve No. 200.
- ii. Determine the groups or sub-groups.
- iii. Determine the group index.
- iv. Give the expression for soil classification of the soil sample.

PROCEDURE FOR UNIFIED CLASSIFICATION SYSTEM

- i. Determine the percentage of soil passing through Sieve No. 200 (F_{200}).
- ii. Determine the percentage of soil retained on Sieve No. 200 ($R_{200}=100-F_{200}$).
- iii. Determine the percentage of Gravel fraction retained on Sieve No. 4 (R_4).

- iv. Determine the percentage of Sand fraction($R_{200}-R_4$).
- v. Determine the Coefficient of Uniformity and Curvature.
- vi. Use the Unified Classification System Standard Tables to identify the soil.

RESULTS AND DISCUSSIONS

This part of the report display data and results as well as their discussions according to the effective observations. The data and results are presented in tables, graphs, and charts.

SIEVE ANALYSIS TEST

Table 1: Particle Size Distribution

<i>Sieve size (mm/μm*)</i>	<i>Material retained (g)</i>	<i>Material passing (g)</i>	<i>Percentage passing (%)</i>
4.75	0.0	266.52	100.00
4.00	0.4	266.12	99.85
3.35	1.4	264.72	99.32
1.40	2.1	262.62	98.54
600*	4.3	258.32	96.92
425*	6.9	251.42	94.33
300*	13.3	238.12	89.34
150*	29.1	209.02	78.43
75*	67.7	141.32	53.02
pan	141.29	0.0	00.00

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

In table 1 and figure 1, it shows that the soil sample is a well graded silty-clay soil with fine silt of 48%, clay of 34%, fine sand of 3%. There is no gravel, coarse or medium sand particles in the sample, the soil sample constitute of 58% silt and 41% clay.

Figure 1: Particle Distribution Chart.

Table 2: Percentage of particles sizes in the soil samples.

<i>Clay (%)</i>	<i>Sand (%)</i>	<i>Silt (%)</i>	<i>Gravel (%)</i>	<i>Total (%)</i>
41	1	58	0	100

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

In table 2 and figure 2, you can observe that the sand particles increase with depth, the soil sample at all depth consist of a very high percentage of sand particles which when considering McKenzie’s opinion that soil with 80% of sand tends to have less amount of pore space and tends to have low moisture content.

Figure 2: Particles Percentage Chart

ATTERBERG'S LIMIT TESTS

LIQUID LIMIT TEST

Table 3: Liquid Limit Determination of Sample Soil

<i>No. of trials</i>	<i>10-15</i>	<i>15-25</i>	<i>25-35</i>	<i>35-40</i>
<i>No. of blows</i>	13	23	35	37
<i>Container I.D.</i>	A	B	C	D
<i>Mass of container (g)</i>	12.3	12.2	12.1	12.3
<i>Mass of wet soil + container (g)</i>	46.88	47.79	49.07	51.29
<i>Mass of dry + container (g)</i>	37.21	38.01	39.33	45.32
<i>Mass of wet soil (g)</i>	34.58	35.59	36.87	38.99
<i>Mass of dry soil (g)</i>	24.91	25.81	27.23	29.12
<i>Mass of moisture (g)</i>	9.67	9.78	9.64	9.87
<i>Moisture Content (%)</i>	38.8	37.9	35.4	33.9
<i>Liquid Limit (%)</i>	36.5			

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

Figure 3: Liquid Limit Representation on a Flow Chart

Therefore, in table 3 and figure 3, it can be observed that the moisture contents decrease with increases of the dry soil sample. Thus the liquid limit of the soil sample as seen from the flow chart of moisture content against number of blows shows the liquid limit at 25 blows corresponding to 36.5% of the moisture content. Hence, the soil sample will flow under its own weight at 36.5% moisture.

PLASTIC LIMIT TEST

Table 4: Determination of Plastic Limit

<i>Container I.D.</i>	<i>A</i>	<i>B</i>	<i>C</i>
<i>Mass of container (g)</i>	13.1	13.3	13.0
<i>Mass of wet soil + container (g)</i>	32.77	30.95	33.15
<i>Mass of dry + container (g)</i>	28.9	29.4	29.3
<i>Mass of wet soil (g)</i>	19.67	17.65	20.15
<i>Mass of dry soil (g)</i>	15.8	16.1	16.3
<i>Mass of moisture (g)</i>	3.87	3.99	3.85
<i>Moisture Content (%)</i>	24.5	24.8	23.6
<i>Plastic Limit (%)</i>	24.3		

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

Therefore, table 4 shows that the moisture contents decrease with increases of the dry soil sample. Thus the plastic limit of the soil sample is very high indicating the presence of fine particles within the soil mass. Hence, the soil sample will behave like plastic below at 24.3% moisture content.

SHRINKAGE LIMIT TEST

Determination of Shrinkage Limit

Therefore, the soil samples show a very little sign of shrinkage, thus the following data had been collected during the laboratory test;

- i. Final length = 11.9cm
- ii. Initial length = 12.1cm

$$\text{Shrinkage limit} = 1 - \frac{\text{Final length}}{\text{initial length}} \times 100$$

$$\text{Shrinkage limit} = 1 - \frac{11.9}{12.1} \times 100$$

$$\text{Shrinkage limit} = 2\%$$

Therefore, no volume of the soil will decrease below **2%** moisture content.

PLASTICITY INDEX

Determination of Plasticity Index

$$\text{P.I} = \text{LL} - \text{PL}$$

$$\text{P.I} = 36.5 - 24.3$$

$$\text{P.I} = 12.2\%$$

Therefore, the soil has **12.2%** plasticity index value.

SPECIFIC GRAVITY TEST

Table 5: Determination of Specific Gravity

<i>Sample Type</i>	<i>Fine Sample</i>			<i>Coarse Sample</i>		
<i>Trials</i>	1 st trial	2 nd trial	3 rd trial	1 st trial	2 nd trial	3 rd trial
<i>Mass of Pycnometer M_1 (g)</i>	95	95	95	395	395	395
<i>Mass of pycnometer + Water M_4 (g)</i>	360	360	360	1350	1350	1350
<i>Mass of pycnometer + soil M_2 (g)</i>	218.02	227.0	223.03	709.01	711.0	715.04
<i>Mass of pycnometer + soil + water M_3 (g)</i>	330.0	344.02	334.0	1545.0	1548.01	1552.0
<i>Specific Gravity</i>	0.80	0.89	0.83	2.64	2.68	2.71
<i>Average Specific Gravity</i>	0.84			2.68		

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

$$\text{Specific Gravity} = \frac{M_2 - M_1}{(M_4 - M_1) - (M_3 - M_2)}$$

Therefore, from table 5, you can observe that the soil sample is relatively having a moderate value of specific gravity which shows that it contains fine-medium silt and clay particles and it shows that the particle density of the soil sample is within average.

COMPACTION TEST

B.S LIGHT OR STANDARD PROCTOR TEST

This method of compaction, consist of 27 blows from a 2.5kg Rammer in 3 equal layers.

Table 6: Determination of Laboratory Compaction By Standard Proctor

TEST	B.S LIGHT											
Vol. of Mould (cm^3)	1000											
Mass of Mould (g)	3600											
Mass of Soil +Mould (g)	5280											
Mass of Wet Soil (g)	1680											
Assume H_2O (%)	3											
Container I.D	A ₃	B ₃	A ₆	B ₆	A ₉	B ₉	A ₁₂	B ₁₂	A ₁₅	B ₁₅	A ₁₈	B ₁₈
Mass of Container (g)	18.9	20.4	16.27	17.8	18.1	23.4	21.3	17.3	15.3	16.1	14.7	17.1
Mass of Container+ wet Soil (g)	67.1	54.4	58.91	69.9	78.0	50.86	69.7	74.1	74.6	75.7	81.9	73.5
Mass of Wet Soil (g)	48.2	34.0	42.7	52.1	60.0	27.5	48.4	56.8	59.3	59.6	67.1	56.4
Mass of Dry Soil (g)	46.9	33.0	40.3	49.2	55.2	25.2	43.2	50.7	51.6	51.9	56.9	47.8
Moisture Content (%)	2.8	3.0	6	5.9	8.7	9.1	11.8	12.0	14.9	14.8	17.9	18.0
Average Moisture Content (%)	2.9		6.0		8.9		11.9		14.9		18.0	
Bulk Density (g/Cm^3)	1.68		1.74		1.80		1.85		1.79		1.70	
Dry Density (g/Cm^3)	1.63		1.64		1.65		1.65		1.56		1.44	

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources,
Laboratory Test, 2017.

Figure 4: B.S Light Representation on a Graph

B.S REDUCED PROCTOR TEST

This method of compaction, consist of 15 blows from a 2.5kg Rammer in 3 equal layers.

Table 7: Determination of Laboratory Compaction By B.S Reduced

TEST	B.S REDUCED											
Vol. of Mould (cm ³)	1000											
Mass of Mould (g)	3600											
Mass of Mould+Soil (g)	5190											
Mass of Wet Soil (g)	1590											
Assume Moisture Content (%)	3											
Container I.D	C ₃	D ₃	C ₆	D ₆	C ₉	D ₉	C ₁₂	D ₁₂	C ₁₅	D ₁₅	C ₁₈	D ₁₈
Mass of Container (g)	15.7	19.2	18.1	15.2	19.2	14.1	15.3	16.5	15.7	17.1	14.1	15.3
Mass of Container+wet Soil (g)	66.7	60.9	64.3	60.5	59.4	66.6	58.08	74.72	75.03	86.0	104.0	76.5
Mass of Wet Soil (g)	51.0	41.7	46.2	45.2	40.2	52.5	42.8	58.2	59.3	68.9	90.0	61.2
Mass of Dry Soil (g)	49.5	40.5	43.7	42.7	36.9	48.3	38.2	52.0	51.6	60.0	76.4	51.9
Moisture Content (%)	3.0	3.0	5.7	5.9	8.9	8.7	12.0	11.9	14.9	14.8	17.8	17.9
Average Moisture Content (%)	3.0		5.8		8.8		12.0		14.9		17.9	
Bulk Density (g/Cm ³)	1.59		1.68		1.79		1.87		2.02		2.00	
Dry Density (g/Cm ³)	1.54		1.59		1.65		1.67		1.76		1.70	

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

Figure 5: B.S Reduced Representation on a Graph

MODIFIED OR B.S HEAVY PROCTOR TEST

This method of compaction, consist of 27 blows from a 4.5kg Rammer in 5 equal layers.

Table 8: Determination of Laboratory Compaction By B.S Heavy

TEST	B.S HEAVY											
Vol. of Mould (cm^3)	1000 1000 1000 1000 1000 1000											
Mass of Mould (g)	3600 3600 3600 3600 3600 3600											
Mass of Mould+Soil (g)	5560 5640 5750 5680 5650 5620											
Mass of Wet Soil (g)	1960 2040 2150 2080 2050 2020											
Assume Moisture Content (%)	3 6 9 12 15 18											
Container I.D	E ₃	F ₃	E ₆	F ₆	E ₉	F ₉	E ₁₂	F ₁₂	E ₁₅	F ₁₅	E ₁₈	F ₁₈
Mass of Container (g)	23.7	23.4	25.7	24.8	34.5	33.8	17.7	18.9	15.7	16.2	33.4	19.7
Mass of Container+wet Soil (g)	61.5	72.3	64.8	75.5	61.0	78.1	97.7	64.4	71.0	83.2	51.2	49.3
Mass of Wet Soil (g)	37.8	48.9	39.1	50.7	26.5	44.3	80.0	45.5	55.3	67.0	17.8	29.6
Mass of Dry Soil (g)	36.8	47.5	36.9	47.9	24.4	40.6	71.5	40.7	48.1	58.3	15.1	25.2
Moisture Content (%)	2.7	2.9	6.0	5.8	8.6	8.8	11.9	11.8	15.0	14.9	17.9	17.5
Average Moisture Content (%)	2.8		5.9		8.7		11.9		15.0		17.7	
Bulk Density (g/Cm^3)	1.96		2.04		2.15		2.08		2.05		2.02	
Dry Density (g/Cm^3)	1.91		1.93		1.98		1.86		1.78		1.72	

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources,
Laboratory Test, 2017.

Figure 6: B.S Heavy Representation on a Graph

WEST AFRICAN STANDARD COMPACTION TEST

This method of compaction, consist of 10 blows from a 2.5kg Rammer in 5 equal layers. It is a West African Standard Compaction (Nigeria Standard).

Table 9: Determination of Laboratory Compaction By W.A.S.C

TEST	W.A.S.C									
<i>Vol. of Mould (cm³)</i>	1000									
<i>Mass of Mould (g)</i>	3600									
<i>Mass of Mould+Soil (g)</i>	5440									
<i>Mass of Wet Soil (g)</i>	1840									
<i>Assume Moisture Content (%)</i>	3									
<i>Container I.D</i>	G ₃	H ₃	G ₆	H ₆	G ₉	H ₉	G ₁₂	H ₁₂	G ₁₅	H ₁₅
<i>Mass of Container (g)</i>	20.7	31.0	16.1	23.1	15.7	16.9	15.8	16.3	15.9	17.2
<i>Mass of Container+wet Soil (g)</i>	69.9	65.2	68.5	67.9	75.5	58.5	83.5	60.1	77.1	66.4
<i>Mass of Wet Soil (g)</i>	49.2	34.2	52.4	44.8	59.8	41.6	67.7	43.8	61.2	49.2
<i>Mass of Dry Soil (g)</i>	47.8	33.3	49.6	42.4	55.0	38.2	60.6	39.2	53.3	42.8
<i>Moisture Content (%)</i>	2.9	2.7	5.6	5.7	8.7	8.9	11.7	11.7	14.8	14.7
<i>Average Moisture Content (%)</i>	2.8		5.7		8.8		11.7		14.8	
<i>Bulk Density (g/Cm³)</i>	1.84		1.92		2.05		2.05		1.99	
<i>Dry Density (g/Cm³)</i>	1.79		1.82		1.88		1.84		1.73	

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test, 2017.

Figure 7: W.A.S.C Representation on a Graph

Table 10: Determination of Zero Air Voids

<i>Specific Gravity</i>	<i>Moisture Content (%)</i>	<i>Zero Air Void (KN/m³)</i>
2.68	2.90	2.48
2.68	6.00	2.31
2.68	8.90	2.16
2.68	11.90	2.03
2.68	14.90	1.91
2.68	18.00	1.81

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources,
Laboratory Test, 2017.

**Figure 8: Effect of Varying Compaction Energies; and Zero Air Void Line Representation
on a Graph**

DETERMINATION OF THE SOIL SAMPLE CLASS

Classifying the Soil Sample using AASHTO

- Percent passing No. 4 sieve = 100%
- Percent passing No. 10 sieve = 99.32%
- Percent passing No. 40 sieve = 94.33%
- Percent passing No. 200 sieve = 53.02%
- Liquid Limit = 36.5%
- Plastic Limit = 24.3%
- Plasticity Index = $36.5 - 24.3 = 12.2\%$

The Soil Classification Properties

- The soil has 53.02% which is more than 35% passing through No. 200 Sieve. It shows that the soil is a fine-grained soil.
- The liquid Limit of the soil is 36.5%
- The plasticity Index of the soil is 12.2%
- The Plastic Limit of the soil is 24.3%
- Therefore, from Table A of the AASHTO Classification for fine-grained soils in the Appendix of this report, by matching the soil sample's properties from column 2, starting from top line to the bottom line. It has been found to be in the A-6 Group.
- The Group Index;

$$G.I = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(P.I - 10)$$

$$G.I = (53.02 - 35)[0.2 + 0.005(36.5 - 40)] + 0.01(53.02 - 15)(12.2 - 10)$$

$$G.I = (18.02)[0.2 + 0.0175] + 0.01(21.5)(2.2)$$

$$G.I = 3.29 + 0.47$$

$$G.I = 3.76 \text{ approximately } 4.00$$

- ✓ Finally, the soil sample is Classified in the **A-6(4)** and it's a **Silty-Clay** Soil.

CONCLUSION

In conclusion, the bulk density of the soil sample is within the range that it defines the soil sample as a fine-medium textured soil with about 5% pore space. The result of the soil sample's content defines it as a slightly cohesive soil with fine-medium particles which tends to have small surface area and it does allow the soil to hold more water, which is a typical characteristic of silt or clay soil. the particles do bind with water, a lot of water will be hold within due to gravity before field capacity is reached and for this reason silt and clay mostly holds 41% moisture at its maximum capacity. The particle size distribution graph gives a conclusive result on the soil samples, being a silty clay soil with more than 51% and 48% silt and clay particles respectively and also shows the samples as a well-graded soil. silty or clay soils with little or much fines do not have excellent drainage characteristics, although the drainage characteristic of soil is a direct reflection of its permeability. Well-graded soil usually has good bearing capacity; finer soils consisting of well-graded materials furnish better compaction results than poorly graded soils. Silty or clayey soil has a considerably high slopes stability, since it is caused by water absorption.

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