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Cross Examination Of Soil Strength And Suitable Stabilization Approach In The Eastern Part Of Nigeria (Using Nza-Ozubulu In Anambra State As A Case Study).

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ABSTACT
The Engineering research was triggered by the recent collapse of transmission mast in Urueze Nza Ozubulu, which is a town located in Anambra state of Nigeria.The focused was on cross examination of the soil properties and strength of that zone and provision of suitable stabilization measures and neccesary recommendations to ensure the stabilization of soil when such structures are put up, in that area. The soil samples were collected from Ozubulu, in Ekwusigo Local Government Areaof Anambra. From

the soil specimen that was collected, the following were determined; the characterization of the soil, determination of their various particle size distribution, liquid limit and plastic limit, specify gravity and optimum moisture content, compaction and unconfined compression test. From the laboratory test carried out on the natural soil, the characteristics of the natural soil which was investigated in accordance with BS 1377-1990 showed the following results: At 400mm depth, the Liquid Limit was 24.85% and Plastic Limit 44.20%, therefore the soil is classified as clay with high plasticity. At 800mm depth, the Liquid Limit was 25.25%, Plastic Limit 15.79% and at 1200mm depth, the Liquid Limit was 26.81%, Plastic Limit of 19.51%, therefore the soil is classified as clay with low plasticity under the Unified Soil Classification System. Hence, the plasticity of the soil reduces as the depth increases which invariably affects the stability of the transmission mast on the soil. Also, using British Standards for Unconfined Compressive Strength test, the soil sample after being cured for twenty-eight days showed the values 655.87N/mm^2, 566.86N/mm^2 and 777.68N/mm^2 and 1705.27N/mm^2 when stabilized with 2%, 4%, 6% and 8% of cement. This implies that the maximum allowable load carrying capacity of this stabilized soil sample is 1705.27N/mm^2. Therefore considering a factor of safety of 2, the safe bearing load carrying capacity of the soil is 852.64 N/mm^2.

KEYWORDS: *Nza Ozubulu, Liquid Limit, Plastic Limit, Stabilization, Atterberg limit*

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I. INTRODUCTION

When it comes to designing a new structure and finally beginning the construction phase, the soil underneath will play a crucial role. As the soil will come in direct contact with the building, it acts as a sort of load-bearing system and transfers forces from the structure. It's important to analyze the soil to consider stress distribution and shrinking and swelling potential (Earthlok'd 2019). The shrink/swell potential of a soil is the amount that a soil can change in volume depending on the moisture content. This drastic change in volume can easily produce enough force to cause serious damage to a home, building or roadway. Soil stabilization can improve in-situ or natural state. Often soils that provide the structural base for roads, building pads or parking lots are chemically treated to control engineering properties of a soil, such as moisture content. Soil stabilization is accomplished by using lime, lime-based products or other chemicals such as Portland cement (Josh Weser, 2020). These chemicals rely on pozzolanic reactions to form permanent bonds between soil particles (The main mechanism of pozzolanic materials involves the transportation of calcium hydroxide via water within the soil to combine with the aluminates and/or silicate clay minerals, The high surface area aluminates and silicate minerals are pozzolan phases, which in the presence of water and an alkali (e.g., calcium) produce cementitious materials, comprising calcium silicates and aluminates hydrates) (Science Direct, n.d). The stabilization of soils also involves the utilization of engineering techniques to turn weak soil into a strong base for construction projects. The stabilization process ensures the soil is stable by reducing the permeability and increasing its overall strength. The result is a strong soil with enhanced bearing capacity (Earthlok'd 2019). Stabilization is accomplished by increasing the shear strength and the overall bearing capacity of a soil. Soil stabilization is a process by which a soils physical properties are transformed to provide long-term permanent strength gains. These physical properties of soil are; soil texture, soil structure and soil color. It is a general term for any physical, chemical, mechanical, biological or combined method of changing a natural soil to meet an engineering purpose. Improvements include increasing the weight bearing capabilities, tensile strength, and overall performance of in-situ sub soils, sands, and waste materials in order to strengthen road pavements. A mast is a ground-based or rooftop structure that supports antennas at a height where they can satisfactorily send or receive radio waves. Typical masts are of steel lattice or tubular steel construction. Masts themselves play no part in the transmission of mobile telecommunications. Masts (to use the civil engineering terminology) tend to be cheaper to build but require an extended area surrounding them to accommodate the guy wires. The steel lattice is the most widespread form of construction. It provides great strength, low weight and wind resistance, and economy in the use of materials. Lattices of triangular cross-section are most common, and square lattices are also widely used. Guyed masts are often used; the supporting guy lines carry lateral forces such as wind loads, allowing the mast to be very narrow and simply constructed. A mast radiator or mast antenna is a radio tower or mast in which the whole structure is an antenna. Mast antennas are the transmitting antennas typical for long or medium wave broadcasting. Structurally, the only difference is that some mast radiators require the mast base to be insulated from the ground. In the case of an insulated tower, there will usually be one insulator supporting each leg. Some mast antenna designs do not require insulation, however, so base insulation is not an essential feature The mast itself has the compressive strength to support its own weight, but does not have the shear strength to stand unsupported. It requires guy lines to stay upright and to resist lateral forces such as wind loads. Guy lines are usually spaced at equal angles about the structure's base. Two subtypes exist. A partially guyed tower is a structure consisting of a guyed mast on top of a freestanding tower. The guys may be anchored to the top of the freestanding structure, or to the ground. A famous tower of this type is the Gerbrandy Tower. An additionally guyed tower is a freestanding tower which either has guys attached temporarily to add stability, for example during construction, or guys attached in only one direction to support unidirectional shear stresses. An example of the latter type is a utility pole at the end of a power line where the line ends or angles off in another direction. The pole requires guys in only one direction to support the unbalanced lateral load of the power line in the other direction.

1.2Problem Statement

The major challenge facing the civil/ telecommunication industry is the failure of structures as well as transmission mast. From research conducted, it was discovered that the possible causes of failure are; Strong wind, which in essence means that the maximum wind speed of the location of failure was not considered. Wrong design of steel members by engineers. Inadequate depth of foundation as regard the height of the mast and loading on the soil. Soil test was not properly conducted which in return led to the failure and collapse of the radio transmission mast and caused a bridge in communication.

1.1 Objective of Study

The main objective of this study is the soil stabilization and recommendations to ensure the stabilization of soil with heavy weight structure like transmission mast using Urueze Nza Ozubulu radio collapse incident in Anambra state, as a custody. The specific objectives of the project are: To characterize the optimum moisture content and the specific gravity of the soil specimen. To determine the Atterberg limit: liquid limit, plastic limits and particle size distribution of Nza Ozubulu soil sample. To determine compaction and unconfined compression of the soil. To recommend possible stabilization solutions in the installation of transmission mast in Nza Ozubulu and other areas with the same soil properties,

1.3 Significance of study

This work is expected to ascertain the current reasons for the collapse of transmission mast in Anambra and render necessary solutions to counter this collapse from occurring around the state and country at large. To contribute to existing literature in the subject matter under investigation.
The work will serve as a reference material for upcoming students as steps on how to carry out test geotechnical properties of soils are contained in this book.

1.4 Scope of this work

This research is limited to the use of soil samples from the radio transmission mast failure located in Ozubulu, Ekwusigo Local Government Area of Anambra State.

II. MATERIALS AND METHODS

2.1 Materials

The materials used in this project research work are an Auger, sack bag, sieve machine, other test apparatus, soil samples and cement.

2.2 Methods

Soil samples

The soil samples that was used to carry this research work was obtained from Nza Ozubulu in Anambra state, Nigeria. The samples were taken from top surface of the soil to at least a depth of 800mm to 1200mm with the help of an Auger. it color comprises a black and a brownish color. It was collected with one sack bag which was transported to civil engineering geotechnical laboratory at Federal university of Technology, Owerri.

Test to be carried out on the soil samples

The soil sample which contains the same particle size distribution as in the in-situ stratum, but the natural structure of sample gets partly or entirely disturbed and modified. The test carried out on this soil sample are atterberg limits, specific gravity and compaction test. Other tests that were conducted in this research work include; Optimum moisture content. Specific gravity test. Particle size distribution (sieve analysis). Atterberg limit test, Liquid limit test and Plastic limit test. Compaction test. Unconfined compression test.

Characterize the soil and stabilizing agent

Water content

The water content of the area was derived using the Oven drying method and calcium carbide methods These are the two popular methods of determining of water content of an area. It is an accurate method of determining water content of soil in the laboratory. This is also a standard test described in section 3 page1 of BS 1377 part 2. All apparatus and procedures used were stated in this section.

***Specific gravity test (particle density test*)**

Another import test conducted was Specific gravity test This was done to determines the engineering strength of the soil in Nza Ozubulu. The apparatus and procedures to be considered will be carried out in accordance to section 8 page 28 BS 1377 part 2, 2001.

Particle size distribution (Sieve analysis)

Sieve analysis was also carried out. This help to determine the particle distribution of the soil sample got from Nza Ozubulu. The test was carried out as described in section 9 page 32 of BS 1377 part 2, 2001 .

To determine the liquid limit, plastic limit and particle size distribution of the soil

The liquid limit, plastic limit and particle size distribution test was conducted on the soil samples. The purpose of this test is to be able to ascertain the point at which the soil begins to flow as a liquid and to be able to determine the plasticity of the soil.

Compaction

Compaction is the process of reducing the air voids in a soil. The degree of compaction of a given soil is measured in term of its dry density. The dry density is maximum at its optimum water content. The procedures of this test was carried out as described BS 1377 part 2, 2001.

Unconfined compression test

The unconfined compression test is used to measure the unconfined compressive strength of a cohesive soil. The unconfined compression test is applicable only to coherent materials such as saturated clays or cemented soils that retain intrinsic strength after removal of confining pressure. The apparatus and procedures were used for this test were be in accordance to section 7

III. RESULTS

Characterization of the Natural Soil Sample

The soil sample used for this work was obtained from Urueze Nza Ozubulu in Ekwusigo Local Government Area of Anambra State. Auger was used to collect the soil in three different layers, namely:
First layer: EL + 400 mm (dark brown),
Second layer: EL + 800mm (reddish-brown),
Third Layer: EL + 1200mm (reddish-brown).

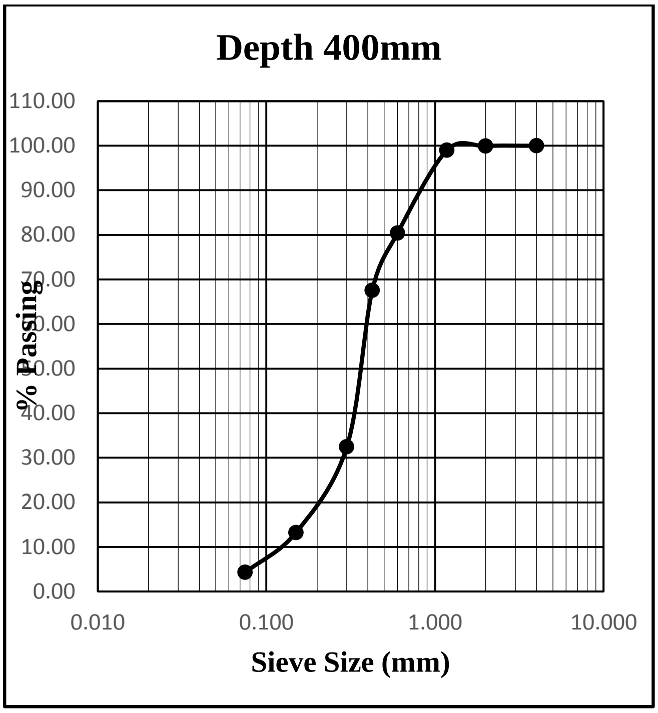

Fig 4.1 Particle Size Distribution Curve (Depth 400mm)

Specific Gravity of the Natural Soil Sample

Specific Gravity (Depth 400mm**)**

From test carried out in the laboratory, the

Specific Gravity (GS) at 400mm = 2.60, the Specific Gravity (GS) at 800mm = 2.6, the Specific Gravity (GS) at 1200mm = 2.62

3.1 ANALYSIS OF PARTICLE SIZE DISTRIBUITION

Fig 4.1, Fig 4.2 and Fig 4.3 show the plot of semi-logarithm for the particle size distribution test.
From the plot for sieve analysis in the appendix, the following values were determined.

$D_{10\,=}$ 0.125 $D_{30\,=}$ 0.285 $D_{60\,=}$ 0.400

$C_{u\,=}$ D_{10}/ $D_{60\,=}$ 0.125/ 0.400 = 0.313

Since $C_{u\,<}$4, the soil is uniformly graded.

$C_{c=}$ D_{30}^2/ (D_{60} * $D_{10)}$ = 1.66

Since C_c is 1 < C_c < 3: the soil is well graded.

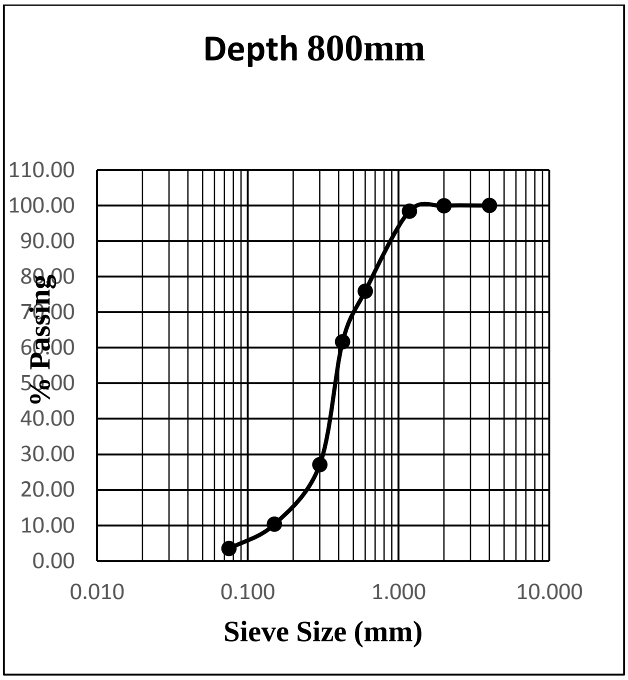

Fig 4.2 Particle Size Distribution Curve (Depth800mm)

From the plot for sieve analysis in the appendix, the following values were determined.

D_{10} = 0.16 D_{30} = 0.32D_{60} = 0.41

$C_u = D_{10}/ D_{60} = 0.16/ 0.41 = 0.39$

Since $C_u < 4$, the soil is uniformly graded.

$C_c = D_{30}^2/ (D_{60} * D_{10}) = 1.56$

Since C_c is $1 < C_c < 3$: the soil is well graded.

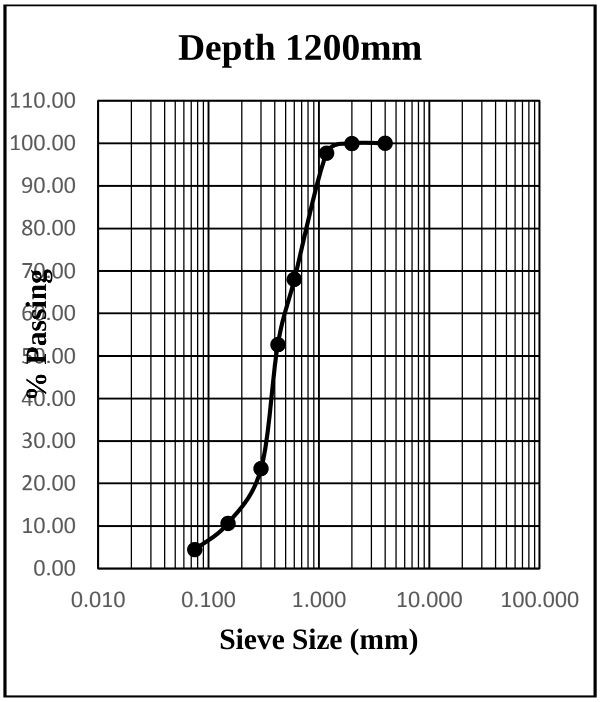

Fig 4.3 Particle Size Distribution Curve (Depth1200mm)

From the plot for sieve analysis, the following values were determined.

$D_{10} = 0.15$ $D_{30} = 0.35$$D_{60} = 0.50$
$C_u = D_{10}/ D_{60} = 0.15/ 0.50 = 0.30$
Since $C_u < 4$, the soil is uniformly graded.
$C_c = D_{30}^2/ (D_{60} * D_{10}) = 1.63$
Since C_c is $1 < C_c < 3$: the soil is well graded.

3.2 Atterberg's Limit Test for the Natural Soil Sample
The results obtained from Atterberg's limits for the natural soil for depth 400mm,depth 800mmand depth 1200mm are shown in section 4.1.2.1, 4.1.2.2 and 4.1.2.3 respectively.

4.3.1 Atterberg's Limit Test Results (Depth 400mm)

Table 4.4: Liquid Limit

S/No	Description	Trial No.			
		I	II	III	IV
1	Empty Weight of Container(M1) in g	13.60	13.81	13.91	13.66
2	Weight of Container + Wet Soil in g (M2)	28.48	34.76	33.23	33.92
3	Weight of Container + Dry Soil in g (M3)	25.32	30.49	29.63	30.04
4	No. of Blows	10	17	30	42
	Calculation				
1	Weight of Moisture = M2-M3	3.16	4.27	3.60	3.88
2	Weight of dry Soil = M3-M1	11.72	16.68	12.72	16.38
3	Water Content = ((M2-M3)/(M3-M1)) *100	26.96	25.60	28.30	23.69
	Average Liquid Limit	**26.14**			

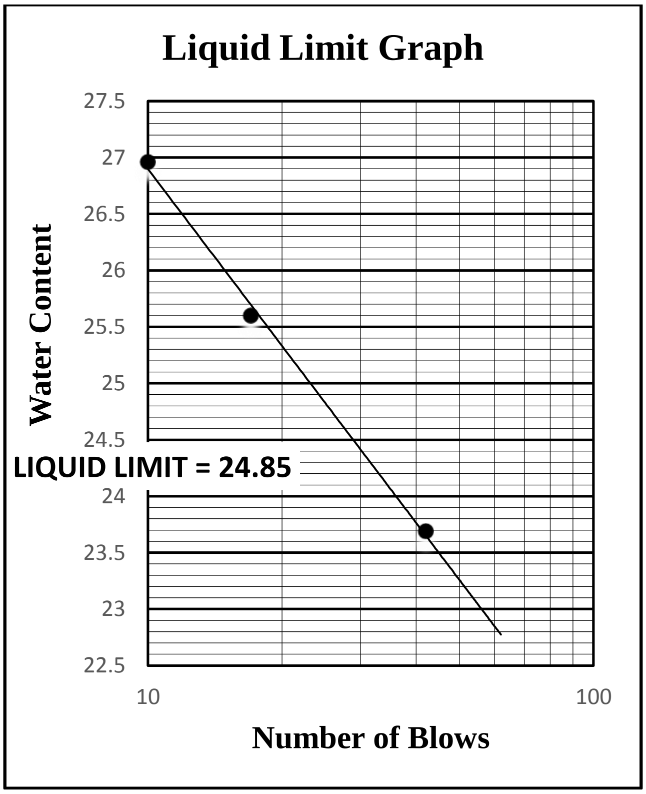

Table 4.4: Plastic Limit

S/No	Description	Trial No.	
		I	II
1	Empty Weight of Container(M1) in g	16.43	15.11
2	Weight of Container + Wet Soil in g (M2)	27.60	22.86
3	Weight of Container + Dry Soil in g (M3)	22.95	21.73
	Calculation		
1	Weight of Moisture = M2-M3	4.65	1.13
2	Weight of dry Soil = M3-M1	6.52	6.62
3	Water Content = ((M2-M3)/(M3-M1)) *100	71.32	17.07
	Average Plastic Limit	**44.20**	

Atterberg's Limits Test Results (Depth 800mm)

Table 4.5: Liquid Limit

S/No	Description	Trial No.			
		I	II	III	IV
1	Empty Weight of Container(M1) in g	8.22	8.11	8.18	8.25
2	Weight of Container + Wet Soil in g (M2)	27.11	29.19	19.39	23.70
3	Weight of Container + Dry Soil in g (M3)	23.08	25.02	17.02	20.59
4	No. of Blows	10	25	29	36
	Calculation				
1	Weight of Moisture = M2-M3	4.03	4.17	2.19	3.11
2	Weight of dry Soil = M3-M1	14.86	16.97	8.84	12.34
3	Water Content = ((M2-M3)/(M3-M1)) *100	27.12	24.57	24.77	25.20
	Average Liquid Limit	**25.42**			

Table 4.6: Plastic Limit

S/No	Description	Trial No.	
		I	II
1	Empty Weight of Container(M1) in g	13.92	17.93
2	Weight of Container + Wet Soil in g (M2)	24.58	35.03
3	Weight of Container + Dry Soil in g (M3)	23.12	32.71
	C Calculation		
1	Weight of Moisture = M2-M3	1.46	2.32
2	Weight of dry Soil = M3-M1	9.20	14.78
3	Water Content = ((M2-M3)/(M3-M1)) *100	15.87	15.70
	Average Plastic Limit	**15.79**	

Atterberg's Limit Test Result (Depth 1200mm)

Table 4.7 Liquid Limit

S/No	Description	Trial No.			
		I	II	III	IV
1	Empty Weight of Container(M1) in g	13.63	19.42	16.93	18.83
2	Weight of Container + Wet Soil in g (M2)	25.29	35.70	31.80	33.72
3	Weight of Container + Dry Soil in g (M3)	22.75	32.33	28.58	30.60
4	No. of Blows	11	20	25	37
	Calculation				
1	Weight of Moisture = M2-M3	2.54	3.37	3.22	3.12
2	Weight of dry Soil = M3-M1	9.12	12.90	11.65	11.77
3	Water Content = ((M2-M3)/(M3-M1)) *100	27.85	25.81	27.64	26.51
	Average Liquid Limit	**26.95**			

Results obtained from Plastic Limit

S/No	Description	Trial No.	
		I	II
1	Empty Weight of Container(M1) in g	6.84	14.33
2	Weight of Container + Wet Soil in g (M2)	23.67	31.62
3	Weight of Container + Dry Soil in g (M3)	20.98	28.74
	Calculation		
1	Weight of Moisture = M2-M3	2.69	2.88
2	Weight of dry Soil = M3-M1	14.14	14.41
3	Water Content = ((M2-M3)/(M3-M1)) *100	19.02	19.99
	Average Plastic Limit	**19.51**	

Table 4.8: Plastic Limit

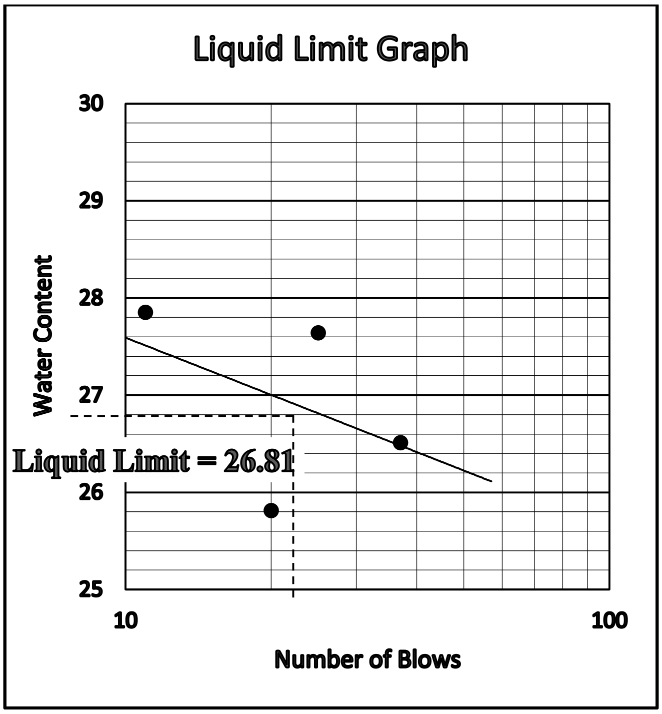

Fig 4.6 Shows the Liquid Limit Graph for the Soil Sample (Depth 1200mm)

3.4 Compaction Test for the Natural Soil Samples

Results obtained from the compaction of the soil stabilized with cement are shown below
Compaction Test Result (Depth400mm**)**

Table 4.9 Compaction Test

Dry Density/Moisture Content Determination			
Trial No.	**1**	**2**	**3**
Weight of Can (g)	14.13	17.03	21.43
Weight of Can + Wet Soil (g)	87.25	106.84	126.88
Weight of Can + Dry Soil (g)	83.61	102.06	121.31
Moisture Content (%)	5.20	5.62	5.58
Average Moisture Content (%)	5.47		
Density(g/cm^3)	1.71		
Dry Density (kg/m^3)	1.62		

Compaction Test Result (Depth 800mm)Table 4.10 Compaction Test

Dry Density/Moisture content determination			
Trial No.	**1**	**2**	**3**
Weight of Can (g)	16.10	22.11	17.24
Weight of Can + Wet Soil (g)	109.77	116.19	114.92
Weight of Can + Dry Soil (g)	103.99	109.93	108.77
Moisture Content (%)	5.78	6.26	6.15
Average Moisture Content (%)	6.06		
Density (kg/m^3)	1.74		
Dry Density (kg/m^3)	1.64		

Compaction Test Result (Depth 1200mm)

Table 4.11 Compaction Test

Dry Density/Moisture content determination			
Trial NO.	**1**	**2**	**3**
Weight of Can (g)	19.4	18.81	19.36
Weight of Can + Wet Soil (g)	105.97	102.65	112.59
Weight of Can + Dry Soil (g)	100.04	96.84	106.86
Weight of Moisture (g)	5.93	5.81	5.99
Average Moisture Content (g)	5.91		
Moisture Content (%)	1.78		
Dry Density (kg/m^3)	1.68		

3.5 Unconfined Compression Test Results

Table 4.12 shows the unconfined compression test results for the natural soil while Fig 4.10 shows the plot of semi-logarithm for the unconfined compression test.

Table 4.12 Unconfined Compression Test Result For Different Percentage Replacement of Cement.

	24 HRS	7 Days	14 Days	28 Days
0%	86.67	515.33	393.53	596.42
2%	163.97	550.33	599.65	655.87
4%	290.46	557.49	796.41	566.86
6%	496.59	683.98	946.33	777.68
8%	627.76	679.3	833.9	1705.27

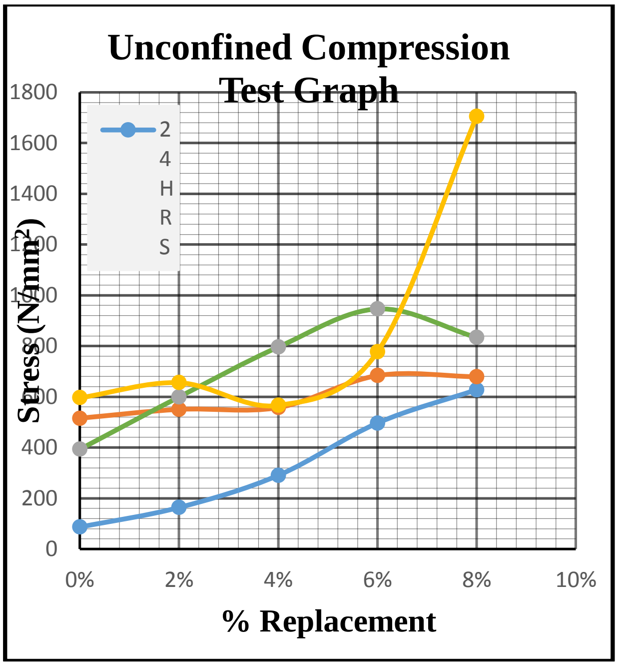

Fig 4.7 Unconfined Compression Test

IV. DISCUSSION

From the laboratory test carried out on the natural soil, the characteristics of the natural soil which was investigated in accordance with BS 1377-1990 showed the following results:At 400mm depth, the Liquid Limit was 24.85% and Plastic Limit 44.20%, therefore the soil is classified as clay with high plasticity. At 800mm depth, the Liquid Limit was 25.25%, Plastic Limit 15.79% and at 1200mm depth, the Liquid Limit was 26.81%, Plastic Limit of 19.51%, therefore the soil is classified as clay with low plasticity under the Unified Soil Classification System. Hence, the plasticity of the soil reduces as the depth increases which invariably affects the stability of the transmission mast on the soil.Also, using British Standards for Unconfined Compressive Strength test, the soil sample after being cured for twenty-eight days showed the values 655.87N/mm^2, 566.86N/mm^2 and 777.68N/mm^2 and 1705.27N/mm^2 when stabilized with 2%, 4%, 6% and 8% of cement. This implies that the maximum allowable load carrying capacity of this stabilized soil sample is 1705.27N/mm^2. Therefore considering a factor of safety of 2, the safe bearing load carrying capacity of the soil is 852.64 N/mm^2.

V. Recommendation

It is recommended that for any soil with the same properties as that of Urueze Nza Ozubulu in Ekwusigo L. G. A, Anambra radio, the maximum load applied in the soil should be 1705.27N/mm2, considering a factor of safety of 2, the safe bearing load carrying capacity of the soil is 852.64 N/mm? or the structure will fail. There should be proper consideration of the wind load in the design of the radio mast so as to avoid possible failures in real life construction dueto adverse horizontal force impact. In addition, the foundation type and depth are another very important factors that should be considered and changed. The depth should be deep enough and the thorough supervision should be carried out in casting the foundation work of such project.

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