GEOTECHNICAL TEST REPORT

ON

COMPRESSIVE STRENGTH TEST, COMPACTION, CALIFORNIA BEARING RATIO, ATTERBERG LIMITS, LINEAR SHRINKAGE, PARTICLE SIZE DISTRIBUTION (WET / DRY SIEVING TESTS), AND PARTICLE DENSITY TEST (SPECIFIC GRAVITY)

SOIL IMPROVEMENT & CONSERVATION (SIC)

BY

ANAMBRA STATE MATERIALS TESTING LABORATORY

CLIENT:

NEW MIRAE CONSTRUCTION COMPANY, ROOM 805, 389, SINWOL-RO, YANGCHEON-GU, SEOUI, KOREA.

PROJECT:

PAVEMENT DESIGN WITH SOIL IMPROVEMENT AND CONSERVATION TECHNOLOGY

DECEMBER, 2023.

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1.0 INTRODUCTION

NEW MIRAE CONSTRUCTION COMPANY, Commissioned Anambra State Materials Testing Laboratory (**ASMTL**), Awka to carry out geotechnical test on PAVEMENT DESIGN WITH SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY.

Laboratory tests were done to furnish relevant geotechnical information needed for the design, rehabilitation and construction of roads.

FOURTY EIGHT (48numbers) of 2kg moulds of samples were covered in the lab with different mix proportion of soil, cement and SIC enzyme,while compressive strength test were carried out to satisfy the design strength at 3days, 7days & 28days. Also, soil compaction, California bearing ratio (unsoaked), Atterberg limit, particle size distribution (wet or dry sieving test), particle density test and natural moisture content were conducted to satisfy design strength of the base material.

2.0 COMPACTION TEST

Laboratory compaction tests provide the basis for determining the percentage compaction and moisture content needed to achieve the required engineering properties, and for controlling construction to ensure that the required compaction and moisture contents are achieved. It also provides relationships between compacted dry density and soil moisture content using two magnitude of manual compaction effort. During design of an engineering fill, shear, consolidation, permeability, or other tests require preparation of test specimens by compacting at some moisture content to some unit weight. It is common practice to first determine the optimum moisture content and maximum dry unit weight by means of a compaction test. Test specimens are compacted at selected moisture content, either wet or dry of optimum or at optimum, and at a selected dry unit weight related to a percentage of maximum dry unit weight. The selection of moisture content, either wet or dry of optimum or at optimum and the dry unit weight may be based on past experience, or a range of values may be investigated to determine the necessary percent of compaction.

APPARATUS USED

- *Mould*
- *Rammer 4.5Kg*
- Weighing *Balance*
- *Oven*
- *Straight edge*
- *Sieves*
- *Mixing Tray*

TEST PROCEDURE

The test was carried out according to BS 1377 Part 4 1990

RESULTS

Results are expressed in graphical form and are contained in the appendix section.

3.0 CALIFORNIA BEARING RATIO (C.B.R) TEST

The strength of the sub-grade is the main factor in determining the required thickness of flexible pavements for roads and airfield. The strength of a sub-grade, sub-base and base course materials are expressed in terms of their California Bearing Ratio (CBR) value. For applications where the effect of compaction moisture content on CBR is small, such as cohesion less, coarse-grained materials, or where an allowance is made for the effect of differing compaction moisture contents in the design procedure, the CBR may be determined at the optimum moisture content of a specified compaction effort. The dry unit weight specified is normally the minimum percent compaction allowed by field compaction specification. For applications where the effect of compaction moisture content on CBR is unknown or where it is desired to account for its effect, the CBR is determined for a range of moisture content, usually the range of moisture content permitted for field compaction. The CBR test can be conducted on both the un-Soaked and soaked soil samples.

APPARATUS USED

- *CBR Machine*
- *Mould*
- *Displacer Disk*
- *Rammer*
- *Weighing Balance*
- *Miscellaneous Apparatus* such as a mixing Tray, straight edge, scales, soaking tank, oven, fast filtering high wet strength filter paper, dishes, and 2-in., 3/4-in. and No. 4 sieves.

TEST PROCEDURE

This test was done according to BS 1377 Part 4 1990

RESULTS

Results are expressed in graphical form and are contained in the appendix section.

4.0 ATTERBERG LIMITS TEST

These test methods are used as an integral part of several engineering classification systems to characterise the fine-grained fractions of soils and to specify the fine-grained fraction of construction materials. The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behaviour such as compressibility, hydraulic conductivity (permeability), compatibility, shrink-swell and shear strength. The liquid limit, plastic limit of a soil and its moisture content can be used to express relative consistency and liquidity index. In addition, the plasticity index of the percentage finer than 2μ-m particle can be used to determine its activity number. These methods are sometimes used to evaluate the weathering characteristics of clay-shale materials. When subjected to repeated wetting and drying cycles, the liquid limits of these materials tend to increase. The amount of increase is considered to be a measure of shale's susceptibility to weathering.

APPARATUS

- *Liquid limit device (Cassagrande Apparatus)*
- *Glass or Hard Rubber Base*
- *Moisture Content Containers*
- *Weighing Balance*
- *Mixing and Storage Containers*
- *Spatula*
- *Drying Oven*
- *Wash Bottle*

Test procedure:

The test procedure was according to BS 1377 part 2:1990.

RESULT:

Results are contained in the appendix section.

5.0 PARTICLE SIZE DISTRIBUTION (WET / DRY SIEVING TESTS)

This method is used primarily to determine the grading of materials. The results are used to determine compliance of particle size distribution (Wet/Dry sieve) with applicable specification requirements and to provide necessary data.

Apparatus Used

- A sample divider
- A thermostatically controlled oven
- Weighing balance
- BS Test sieves
- A mechanical sieve shaker
- Trays
- Containers

Test procedure

The test procedure was according to BS 1377: Part 2: 1990

RESULTS

Results are contained in the appendix section.

6.0 PARTICLE DENSITY TEST (SPECIFIC GRAVITY)

Specific gravity is defined as the ratio of the density of a given solid or liquid substance to the density of water at a specific temperature and pressure, making it a dimensionless quantity. It is also the ratio of the density of the aggregate to the density of water. Specific gravity is determined if the aggregate is wet, that is, if the absorption potential has been satisfied. Substances with a specific gravity greater than one are denser than water, and so will sink in it, and those with a specific gravity of less than one are less dense than water, and so will float in it.

Apparatus Used

- Weighing Balance
- Density bottle (50ml)
- Thermostatically controlled oven
- Distilled water

Test procedure

The test procedure was according to ASTM 128

- **Result:** ***The particle density test result is 2.65Mg/m³ which fall within the specification range.***

7.0 CONCLUSION

The following analyses were deduced from the laboratory results obtained from the Compaction test, C.B.R test, Atterberg Limits and Particle Size Distribution (Wet / Dry Sieving Tests) and Particle Density test (Specific Gravity).

- *The* **Compaction curve** *of the soil was done with moisture content ranging from (5.81% to 9.58%) and dry density ranging from (1.92Mg/m³ to 2.03Mg/m³).*
- *The CBR result for unsoaked test shows GOOD strength percentage at 95% for base-course.*
- *Note: The FEDERAL MINISTRY OF WORKS AND HOUSING (FMWH) 1970, REVISED 1997 specifications for sub-grade, sub-base and Base Course materials are 10%, 30% and 80% respectively.*
- *The Atterberg liquid limits result gave 39%, 19% of plastic limit and 19% of plasticity index, then the linear shrinkage is 8%. This shows that these samples are reddish brown sand with traces of clay & gravel.*
- *The sieve analysis of the soil samples show that the sample has silt (fines) contents of 19%, 82% of Sand and 2% of gravel. These values put the sample under (A-2-6) classification and thus be described as reddish brown sand with traces of clay & gravel.*
- *The particle density test result is 2.65Mg/m³ which fall within the specification range.*
- *The natural moisture content result is 2%.*

In conclusion, the soil is a GOOD Base – Course material.

Moreover, Soil Improvement & Conservation Technology is very effective on the design strength when compared with soil base and soil cement stabilization.

NOTE: The details of these reports are shown in the appendix section.

We trust you shall find the contents of this report useful and we are at your disposal for any further clarifications that you may require.

For: Anambra State Materials Testing Laboratory.

11/12/2023

TESTING OFFICER **HEAD LAB** **QUALITY CONTROL OFFICER (MINISTRY OF WORKS)**

ANAMBRA STATE MATERIALS TESTING LABORATORY

APPENDIX

CLIENT: ***NEW MIRAE CONSTRUCTION COMPANY***

PROJECT: SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY

SAMPLE LOCATION: *UMUOKEOKPA, OBA BORROW PIT*

TYPE OF TEST: *COMPRESSIVE STRENGTH TEST FOR* ***10% CEMENT*** *(DANGOTE 3X), SOIL $ SIC ENZYME*

DAYS	MASS (Kg)	DENSITY (Kg/m^3)	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	REMARK
3	2.45	2600.85	42.6	5.42	5.65	GOOD
	2.45	2600.85	46.3	5.89		
	2.45	2600.85	44.5	5.67		
7	2.45	2600.85	58.6	7.46	7.84	GOOD
	2.40	2547.77	62.52	7.96		
	2.45	2600.85	63.70	8.11		
28	2.50	2653.93	148.5	18.91	18.78	GOOD
	2.50	2653.93	147.99	18.84		
	2.50	2653.93	146.02	18.58		

SPECIFICATIONS: 3DAYS ≥5.55N/mm²; 7 DAYS ≥7.84N/mm²; 28DAYS≥18.25N/mm².

11/12/2023

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HEAD LAB

CLIENT: *NEW MIRAE CONSTRUCTION COMPANY*

PROJECT: SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY

SAMPLE LOCATION: *UMUOKEOKPA, OBA BORROW PIT*

TYPE OF CEMENT/ TYPE OF TEST: *COMPRESSIVE STRENGTH TEST FOR SOIL ONLY*

DAYS	MASS (Kg)	DENSITY (Kg/m^3)	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	REMARK
3	2.25	2388.53	7.8	0.9	0.87	POOR
	2.30	2441.61	6.8	0.8		
	2.25	2388.54	7.7	0.9		
7	2.30	2441.61	10.4	1.32	1.27	POOR
	2.30	2441.61	10.1	1.20		
	2.30	2441.61	10.2	1.30		
28	2.40	2547.77	20.2	2.57	2.58	POOR
	2.40	2547.77	20.3	2.58		
	2.40	2547.77	20.5	2.60		

SPECIFICATIONS: 3DAYS ≥5.55N/mm²; 7 DAYS ≥7.84N/mm²; 28DAYS≥18.25N/mm².

11/12/2023

TESTING OFFICER

ANAMBRA STATE MATERIALS TESTING LABORATORY

Head of Laboratory

HEAD LAB

CLIENT: *NEW MIRAE CONSTRUCTION COMPANY*

PROJECT: SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY

SAMPLE LOCATION: *UMUOKEOKPA, OBA BORROW PIT*

TYPE OF TEST: *COMPRESSIVE STRENGTH TEST FOR 5% CEMENT (DANGOTE 3X), SOIL $ SIC ENZYME)*

DAYS	MASS (Kg)	DENSITY (Kg/m^3)	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	REMARK
3	2.45	2600.85	30.2	3.84	3.49	POOR
	2.45	2600.85	27.8	3.54		
	2.50	2653.93	24.2	3.08		
7	2.50	2653.93	35.5	4.52	4.77	POOR
	2.50	2653.93	38.5	4.90		
	2.50	2653.93	38.5	4.90		
28	2.50	2653.93	58.3	7.42	7.53	POOR
	2.50	2653.93	59.4	7.56		
	2.50	2653.93	59.9	7.62		

SPECIFICATIONS: 3DAYS ≥5.55N/mm²; 7 DAYS ≥7.84N/mm²; 28DAYS≥18.25N/mm².

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ANAMBRA STATE MATERIALS TESTING LABORATORY
Head Of Lab

HEAD LAB

CLIENT: *NEW MIRAE CONSTRUCTION COMPANY*

PROJECT: SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY

SAMPLE LOCATION: *UMUOKEOKPA, OBA BORROW PIT*

TYPE OF TEST: *COMPRESSIVE STRENGTH TEST FOR 5% CEMENT (DANGOTE 3X) & SOIL*

DAYS	MASS (Kg)	DENSITY (Kg/m^3)	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	REMARK
3	2.45	2600.85	20.0	2.5	2.47	POOR
	2.40	2547.77	16.8	2.1		
	2.35	2600.85	21.7	2.80		
7	2.40	2547.77	34.5	4.39	4.12	POOR
	2.35	2496.69	30.5	3.88		
	2.40	2547.77	32.5	4.10		
28	2.40	2547.77	50.5	6.43	6.34	POOR
	2.40	2547.77	49.2	6.26		
	2.40	2547.77	49.8	6.34		

SPECIFICATIONS: 3DAYS ≥5.55N/mm²; 7 DAYS ≥7.84N/mm²; 28DAYS≥18.25N/mm².

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Compaction Test

CLIENT: MIRAE CONSTRUCTION COMPANY LIMITED

SAMPLE LOCATION: UMUOKEOKPA, OBA BORROW PIT

PROJECT: SOIL IMPROVEMENT & CONSERVATION TECHNOLOGY

SAMPLE DESCRPTION: REDDISH BROWN SAND WITH TRACES OF CLAY & GRAVEL

DATE TESTED: 1/12/2023

NO OF LAYERS: 5

BLOWS PER LAYER: 27

RAMMER : 4.5KG

DEPTH: 1.5m

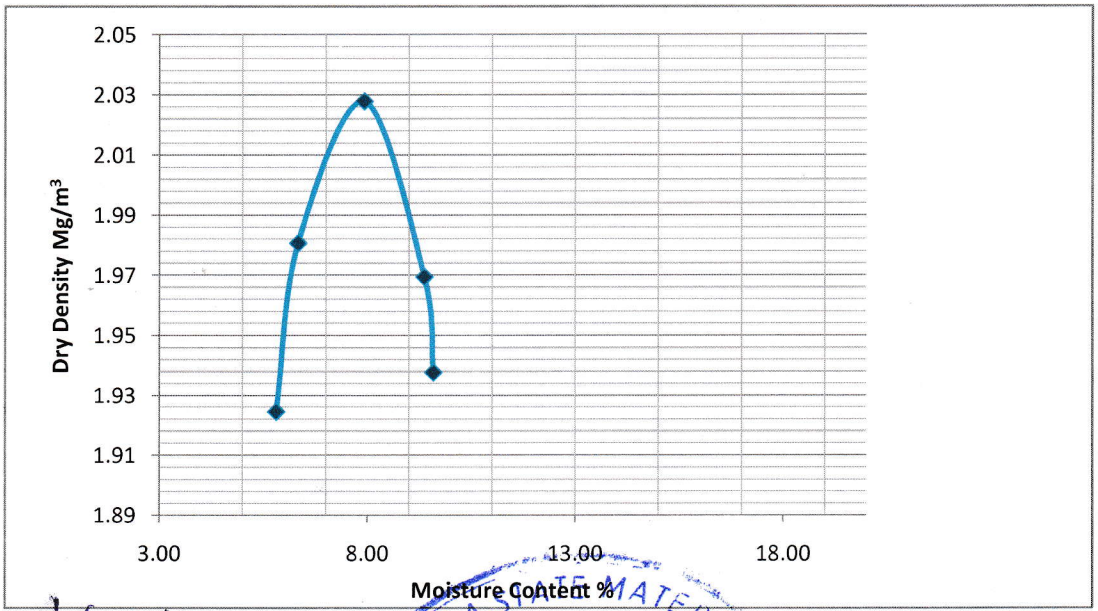
Maximum Dry Density	2.03Mg/m^3
Optimum Moisture Content	8.00%

MOISTURE CONTENT DETERMINATION

Tin No.	u	iv	T	A	G
Tin + Wet Soil (g)	24.24	70.90	70.63	71.60	71.50
Tin + Dry Soil (g)	22.90	69.43	68.80	69.43	69.24
Weight of Tin (g)	45.97	46.20	45.70	46.26	45.66
Weight of Water (g)	1.34	1.47	1.83	2.17	2.26
Weight of dry soil (g)	23.07	23.23	23.10	23.17	23.58
M. C. (%)	5.81	6.33	7.92	9.37	9.58

DRY DENSITY DETERMINATION

Weight of mould + wet soil (g)	7520	7680	7870	7790	7720
Weight of mould (g)	2840	2840	2840	2840	2840
Weight of wet soil (g)	4680	4840	5030	4950	4880
Volume of cylinder (cm3)	2298.32	2298.32	2298.32	2298.32	2298.32
Wet density of sample(Mg/m3)	2.04	2.11	2.19	2.15	2.12
Dry density of sample(Mg/m3)	1.92	1.98	2.03	1.97	1.94



11/12/2023

TESTING OFFICER

HEAD LAB

ANAMBRA STATE MATERIALS TESTING LABORATORY Head Of Laboratory

QUALITY CONTROL OFFICER (MINISTRY OF WORKS)

ANAMBRA STATE MATERIALS TESTING LABORATORY

CALIFORNIA BEARING RATIO (B.S 1377: PART 4: 1990)

CLIENT: NEW MIRAE CONSTRUCTION COMPANY

PROJECT: PAVEMENT DESIGN WITH SOIL IMPROVEMENT CONSERVAION TECHNOLOGY

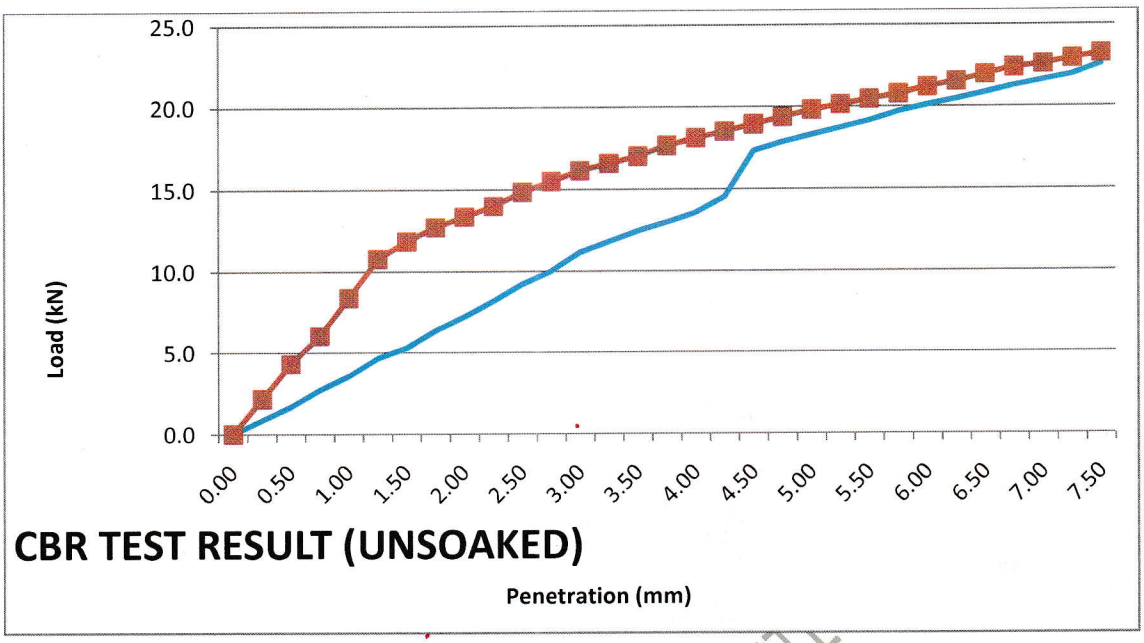
SAMPLE LOCATION: UMUOKEOKPA, OBA BORROW PIT

***SAMPLE DESCRIPTION:* REDDISH BROWN SAND WITH GRAVEL & TRACES OF CLAY**

TEST TYPE: UN*SOAKED CBR*

DATE TESTED: *04/12/2023*

Plunger Penetration	Force Reading Top	Bottom	Force on Plunger Top	Bottom
0.00	0.00	0.00	0.00	0.00
0.25	40.00	100.00	0.86	2.15
0.50	78.00	200.00	1.68	4.30
0.75	125.00	280.00	2.69	6.02
1.00	165.00	390.00	3.55	8.39
1.25	215.00	500.00	4.62	10.75
1.50	245.00	550.00	5.27	11.83
1.75	295.00	590.00	6.34	12.69
2.00	335.00	620.00	7.20	13.33
2.25	380.00	650.00	8.17	13.98
2.50	428.00	690.00	9.20	14.84
2.75	465.00	720.00	10.00	15.48
3.00	518.00	750.00	11.14	16.13
3.25	548.00	770.00	11.78	16.56
3.50	578.00	790.00	12.43	16.99
3.75	603.00	820.00	12.96	17.63
4.00	630.00	842.00	13.55	18.10
4.25	675.00	860.00	14.51	18.49
4.50	805.00	880.00	17.31	18.92
4.75	830.00	900.00	17.85	19.35
5.00	850.00	920.00	18.28	19.78
5.25	870.00	935.00	18.71	20.10
5.50	890.00	950.00	19.14	20.43
5.75	915.00	965.00	19.67	20.75
6.00	934.00	985.00	20.08	21.18
6.25	950.00	1000.00	20.43	21.50
6.50	968.00	1020.00	20.81	21.93
6.75	988.00	1040.00	21.24	22.36
7.00	1004.00	1050.00	21.59	22.58
7.25	1020.00	1065.00	21.93	22.90
7.50	1050.00	1080.00	22.58	23.22



BOTTOM
TOP

Corrected Values	Top	Bottom
Offset	0	0
New 2.5 Point	0	0
New 5.0 Point	0	0
For 2.5		
Point Before	2.5	2.5
Point After	2.5	2.5
Average	2.5	2.5
Load	9.20	14.84
For 5.0		
Point Before	5	5
Point After	5	5
Average	5	5
Load	18.28	19.78

At 2.5mm
At 5.0mm

	Top	Bottom
CBR1%	69.50	112.05
CBR2%	91.56	99.10
Max CBR%	90.78	95.33
	Accepted C.B.R	95%

11/12/2023

TESTING OFFICER

ANAMBRA STATE MATERIALS TESTING LABORATORY

HEAD LAB

QUALITY CONTROL OFFICER
(MINISTRY OF WORKS)

ANAMBRA STATE MATERIALS TESTING LABORATORY

PARTICLE SIZE DISTRIBUTION (BS 1377:2:1990)

CLIENT: NEW MIRAE CONSTRUCTION COMPANY

PROJECT: PAVEMENT DESIGN WITH SOIL IMPROVEMENT CONSERVAION TECHNOLOGY

SAMPLE LOCATION: UMUOKEOKPA, OBA BORROW PIT

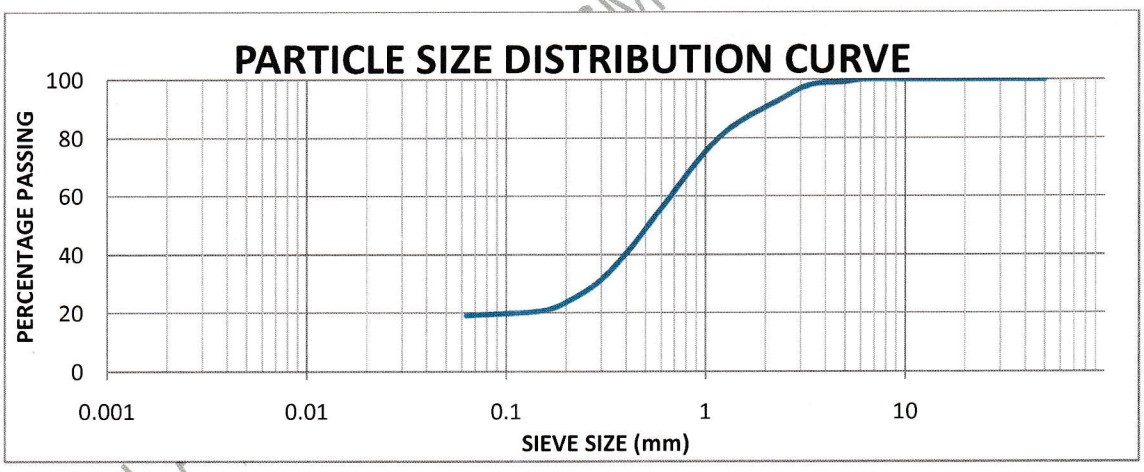
***SAMPLE DESCRIPTION:* REDDISH BROWN SAND WITH GRAVEL & TRACES OF CLAY**

TOTAL MASS OF DRY SAMPLE: 150g

DATE TESTED: *01/12/2023*

Wt Retained	Cumm. Wt Retained	% Retained	Cumm % Retained	Sieve Size	% Passing
0.00	0	0.00	0.00	75	
0.00	0	0.00	0.00	63	
0.00	0	0.00	0.00	50	100.00
0.00	0	0.00	0.00	37.5	100.00
0.00	0	0.00	0.00	25	100.00
0.00	0	0.00	0.00	20	100.00
0.00	0	0.00	0.00	14	100.00
0.00	0	0.00	0.00	10	100.00
0.00	0	0.00	0.00	6.3	100.00
1.37	1.37	0.91	0.91	5	99.09
1.54	2.91	1.03	1.94	3.35	98.06
7.58	0.00	5.05	0.00	2.36	93.01
18.91	18.91	12.61	12.61	1.18	80.40
36.94	55.85	24.63	37.23	0.6	55.77
19.80	75.65	13.20	50.43	0.425	42.57
16.71	92.36	11.14	61.57	0.3	31.43
10.24	102.60	6.83	68.40	0.212	24.61
5.91	108.51	3.94	72.34	0.15	20.67
2.39	110.90	1.59	73.93	0.063	19.07
28.61	139.51	19.07	93.01	Pan	
150.00		100			

SIEVE ANALYSIS	
Coarse Gravel -	
Fine Gravel -	0.00
Coarse Sand -	6.99
Medium Sand -	50.43
Fine Sand -	23.50
Fines -	19.07



11/12/2023

TESTING OFFICER

ANJAMBRA STATE MATERIALS TESTING LABORATORY
Head Of Laboratory

HEAD LAB

QUALITY CONTROL OFFICER
(MINISTRY OF WORKS)