|  |  |  |
| --- | --- | --- |
| *PROPOSED FOOD TECHNOLOGY AND INNOVATION COMPLEX* |  | **AUGUST, 2022** |

**SUB-SOIL INVESTIGATION REPORT**

**FOR**

**THE PROPOSED FOOD TECHNOLOGY AND INNOVATION COMPLEX, BENUE STATE UNIVERSITY, MAKURDI.**

***PREPARED FOR,***

**CLIENT: BENUE STATE UNIVERSITY**

**AUGUST, 2022**

|  |
| --- |
|  |

***CIVIL ENGINEERING DEPARTMENT, FUAM***

**TABLE OF CONTENTS**

[1.0 INTRODUCTION 2](#_Toc111886782)

[1.1 Background 2](#_Toc111886783)

[1.2 Aim of Study. 2](#_Toc111886784)

[1.3 Scope of Work 2](#_Toc111886785)

[2.0 MATERIALS AND METHODS 2](#_Toc111886786)

[3.0 RESULTS DISCUSSION/INTERPRETATION 3](#_Toc111886787)

4.0 CONCLUSION AND RECOMMEDATIONS 4

REFERENCES 5

APPENDIX 6

# 1.0 INTRODUCTION

# 1.1 Background

Our Client, Benue State University, Makurdi desirous of carrying out the construction of a Proposed Food Technology and Innovation Complex building commissioned Engr. Boloko A. K. of the Civil Engineering Department of Joseph Sarwuan Tarka University, Makurdi to conduct subsoil investigations.

Makurdi is the Capital city of Benue State. The area experiences a typical tropical climate with distinct dry and wet seasons.

The wet season usually starts in April and ends in October. The dry season begins in November and ends in March. The annual total rainfall ranges from 750-1700mm. The vegetation is mainly savannah, with maximum and minimum mean monthly temperatures of 34oC and 18oC respectively.

# 1.2 Aim of Study.

The purpose of the investigation is to characterize the soil with a view to determine its strength parameters which will form the basis for the safe and economic design of the foundations for the infrastructure,

# 1.3 Scope of Work

The investigation involved field sampling, laboratory analysis of soil samples for strength parameters and desk studies.

# 2.0 MATERIALS AND METHODS

Disturbed soil samples were taken from 5 trial pits labelled **Pit 1 – Pit 5**. The disturbed soil samples were collected at the depth of 2.0 m using a manual auger, digger and shovel. Sampling was done in the month of March, which incidentally corresponds with the dry period in the area.

The following laboratory tests were performed on the samples according to BS 1377 (1990): i. Moisture content

1. Particle size distribution test
2. Specific gravity iv. Atterberg limits
3. Compaction test
4. triaxial
5. Shear – box test

# 3.0 RESULTS DISCUSSION/INTERPRETATION

The summary of the results of the laboratory and data analyses are presented in Tables 1 to 3. Detailed results are presented in the appendix. The soil of the site is generally fine sand and can be classified as non-plastic.

The deduced angles of internal friction (Φ) from the plots of the shear strength envelopes for all the samples are shown in the Appendix and are presented in Table 2 with their corresponding cohesion (C) values. The allowable bearing capacity values for the footings at the various pits were calculated based on Terzaghi’s model (see Table 3). It therefore, follows from the Table that the minimum allowable bearing capacity is 111.0 kN/m2. On the basis of these, an allowable bearing capacity value of 110 kN/m2 will be adequate.

**Table 1: Summary of Some Test Results at the Depth of 2.0m**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | | **(Mc)**  **%** | **(Gs)** | **LL %** | **PL %** | **PI**  **%** | **Ls**  **%** | **Compaction** | | **C kN/m2** | **Φo** | **Classification (USCS)** |
| No. | Depth (m) |  |  |  |  |  | **MDD**  **kN/m3** | **OMC**  **(%)** |  |  |
| P1 | 2.0 | 14.0 | 2.80 | NP | NP | NP | NP | 1.66 | 9.3 | 0 | 27 | Silty Sand (SM) |
| P2 | 2.0 | 26.3 | 2.5 | NP | NP | NP | NP | 1.5 | 12.3 | 0 | 26 | Silty Sand |
| P3 | 2.0 | 15.8 | 2.49 | NP | NP | NP | NP | 1.59 | 15.5 | 0 | 26 | Silty Sand with  Clay (SM) |
| P4 | 2.0 | 21.5 | 2.7 | NP | NP | NP | NP | 2.0 | 12.0 | 0 | 25 | SC (SM) |
| P5 | 2.0 | 14.8 | 2.38 | NP | NP | NP | NP | 1.67 | 18.2 | 0 | 28 | Silty Sand (SM) |

**Legend: Mc** - moisture content **Gs** - specific gravity **LL** - liquid limit,

**PI** - Plasticity index **PL** - Plastic Limit **Ls** - Linear shrinkage

**K** - Permeability Coefficient **NP-**Non-Plastic **SM:-** Silty fine Sand

**(Φ)-**Angle of internal friction **C**-cohesion **qa**-Allowable bearing capacity **Table 2:** **Summary of Sample Properties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No** | **Parameters** | |  | **Range** |
| **1** | Natural Moisture Content, Mc | |  | 14.0 – 26.3 % |
| **2** | Specific gravity |  | **Gs** | 2.30 – 2.8 % |
| **3** | Sieve analysis |  | **Sand** | 96 – 99 % |
|  | **Silt & Clay** | 1.0 – 4.0 % |
| **4** | Atterberg Limits |  | **LL** | NP |
|  | **PI** | NP |
|  | **Ls** | NP |
| **5** | Compaction |  | **MDD** | 1.5 – 2.0 kg/m2 |
|  | **OMC** | 9.3 – 18.0 % |
| **6** | Direct share test |  | **Cu** | 0.0 – 0.0 kN/m2 |
|  | **ɸo** | 25.0 – 28.00 |
|  | **ϒ** | 18.0 – 18.6 kN/m2 |

**Table 3: Allowable bearing capacity using results from the Shear Box test**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bore-**  **hole No.** | **Depth**  **Z (m)** | **Undrained cohesion, C**  **(kN/m2)** | **Angle of int. friction ɸ(degrees)** | **Unit weight ϒ**  **(kN/m2)** | **Nc** | **Nq** | **Nϒ** | **Qunet**  **(kN/m2)** | **Qsafe**  **(kN/m2)** |
| Pit 1 | 2.0 | 0 | 27 | 18.2 | 23.9 | 13.2 | 9.3 | 276 | **111.0** |
| Pit 2 | 2.0 | 0 | 26 | 16.4 | 32.4 | 20.5 | 17.5 | 430 | **173.0** |
| Pit 3 | 2.0 | 0 | 26 | 18.6 | 6.5 | 1.6 | 8.2 | 342 | **137.0** |
| Pit 4 | 2.0 | 0 | 25 | 16.5 | 8.5 | 2.6 | 8.4 | 364 | **145.0** |
| Pit 5 | 2.0 | 0 | 28 | 18.4 | 25.8 | 14.7 | 10.9 | 390 | **156.0** |

**4.0 CONCLUSION AND RECOMMEDATIONS**

The processes of field observation/sampling of subsoil, laboratory analyses and discussion of results have being presented in this report. This investigation has revealed that the soil is mainly Silty Sand.

It is therefore, recommended that an allowable bearing capacity of **110 kN/m2** should be adopted for foundation design at the proposed depth of 2.0 m.

We shall be available if our services are required in the course of execution of this project.

**Engr. Boloko Augustine K.**

*Senior Chief Engineering Technologist*

*Civil Engineering Department, JOSTUM.*

**REFERENCES**

**BS1377** (1990) Methods of Test for Soils for Civil Engineering Purposes, part 2. British Standard Institution London

**Ola, S.A. (1983)** Geotechnical Properties of Sokoto Clay Shales of Northern Nigeria. In Tropical soils of Nigeria in Engineering Practice .Edited by S.A. Ola Pp131-144

**Whitlow, R. (1990):** Basic Soil Mechanics 2nd edition, Longman Group UK Ltd. Pp 376.

**ASTM D2487** (1948) as Unified Soil Classification System (USC)

**APPENDIX**

**NATURAL MOISTURE CONTENT DETERMINATION RESULT**

Project:  **Proposed Food Technology and Innovation Complex**

Contractor: Date: 14/07/2022

(Pits)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Pit 1** | | **Pit 2** | |
| Depth of sample (m) | 2.0 m | | **2.0 m** | |
| Container No. | **24** | **20** | **60** | **71** |
| Mass of container + wet soil (g) | 67.0 | 67.6 | 54.5 | 65.8 |
| Mass of container + dry soil (g) | 60.1 | 61.9 | 46.6 | 45.4 |
| Mass of container (g) | 14.2 | 18.0 | 17.2 | 16.0 |
| Mass of dry soil (g) | 45.9 | 43.9 | 29.4 | 29.4 |
| Mass of moisture (g) | 6.9 | 5.7 | 7.9 | 7.6 |
| Moisture content (%) | 15.0 | 13.0 | 26.8 | 25.8 |
| Average moisture content (%) | **13.9** | | **26.3** | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Pit 3** | | **Pit 4** | |
| Depth of sample (m) | **2.0 m** | | **2.0 m** | |
| Container No. | **4** | **1** | **7** | **5** |
| Mass of container + wet soil (g) | 67.7 | 80.0 | 62.2 | 61.7 |
| Mass of container + dry soil (g) | 62.0 | 68.9 | 54.3 | 53.5 |
| Mass of container (g) | 11.7 | 14.0 | 16.7 | 16.3 |
| Mass of dry soil (g) | 50.3 | 54.9 | 37.6 | 37.2 |
| Mass of moisture (g) | 5.7 | 11.1 | 7.9 | 8.2 |
| Moisture content (%) | 11.3 | 20.2 | 21.0 | 22.0 |
| Average moisture content (%) | **16.0** | | **21.5** | |

**NATURAL MOISTURE CONTENT DETERMINATION RESULT**

Project:  **Proposed Food Technology and Innovation Complex**

Contractor: Date: 14/07/2022

Pits

|  |  |  |
| --- | --- | --- |
| **Sample No.** | **Pit 5** | |
| Depth of sample (m) | 2.0 m | |
| Container No. | **8** | **3** |
| Mass of container + wet soil (g) | 52.5 | 64.0 |
| Mass of container + dry soil (g) | 48.2 | 57.3 |
| Mass of container (g) | 17.2 | 14.8 |
| Mass of dry soil (g) | 31.0 | 42.8 |
| Mass of moisture (g) | 4.3 | 6.7 |
| Moisture content (%) | 13.9 | 15.7 |
| Average moisture content (%) | **14.8** | |

|  |  |  |  |
| --- | --- | --- | --- |
| *PROPOSED FOOD TECHNOLOGY AND INNOVATION COMPLEX* |  |  | ***AUGUST, 2022*** |

**SPECIFIC GRAVITY OF SAMPLES**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample No. | Pit 1 | | Pit 2 | | Pit 3 | | Pit 4 | | Pit 5 | |
| Depth | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m | 2.0 m |
| Mass of jar + soil + water (m3) | 78.8 | 78.5 | 85.4 | 85.5 | 77.9 | 78.8 | 85.6 | 85.5 | 78.8 | 76.8 |
| Mass of jar + soil (m2) (g) | 32.4 | 31.9 | 46.6 | 46.7 | 31.8 | 32.4 | 45.7 | 46.6 | 32.4 | 31.7 |
| Mass of jar + water (m4) (g) | 71.8 | 71.8 | 20.5 | 20.5 | 71.8 | 71.8 | 20.5 | 20.5 | 71.8 | 71.8 |
| Mass of jar (m1) (g) | 21.5 | 21.5 | 70.0 | 70.0 | 21.5 | 21.5 | 70.0 | 70.0 | 21.5 | 21.5 |
| M2 – m1 | 10.9 | 10.4 | 26.1 | 26.2 | 10.3 | 10.9 | 25.2 | 26.1 | 10.9 | 10.2 |
| M4 – m1 | 50.3 | 50.3 | 49.5 | 49.5 | 50.3 | 50.3 | 49.5 | 49.5 | 50.3 | 50.3 |
| M3 – m2 | 46.4 | 46.6 | 38.8 | 38.8 | 46.1 | 46.0 | 37.9 | 38.9 | 46.4 | 45.1 |
| (m4 – m1) – (m3 – m2) | 3.9 | 3.7 | 10.7 | 10.7 | 4.2 | 4.3 | 9.6 | 10.6 | 3.9 | 5.2 |
| Gs = (m2 – m1)/[(m4 – m1)-(m3 – m2)] | 2.79 | 2.81 | 2.44 | 2.45 | 2.45 | 2.53 | 2.63 | 2.46 | 2.79 | 1.96 |
| Average | **2.80** | | **2.5** | | **2.50** | | **2.7** | | **2.40** | |

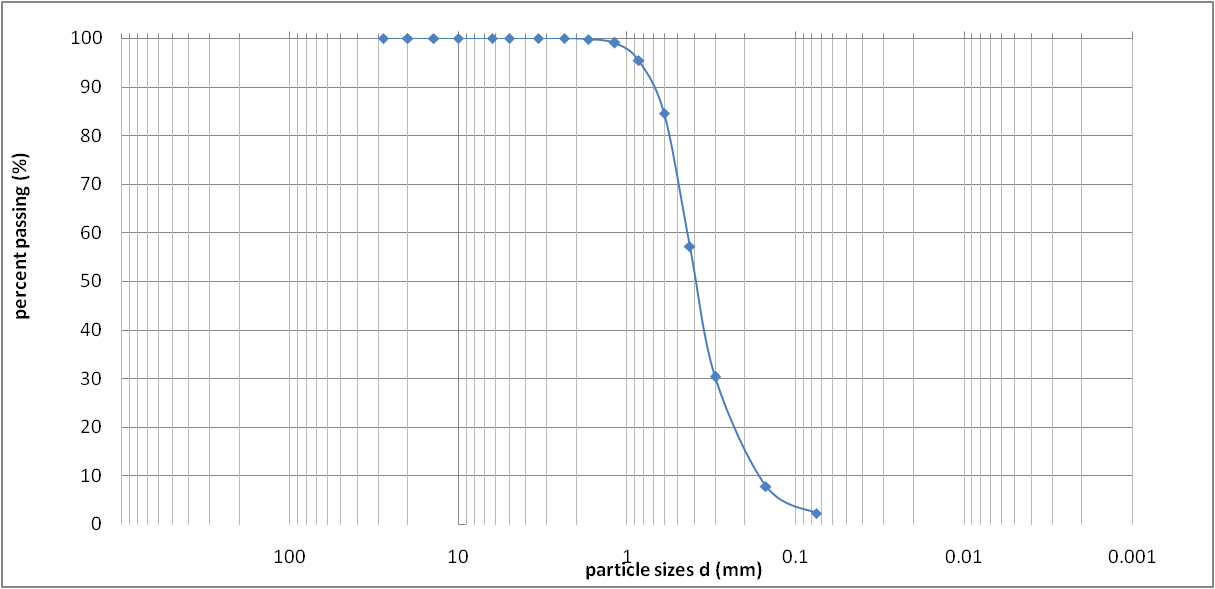
|  |
| --- |
| 11 |

### CIVIL ENGINEERING DEPARTMENT, JOSTUM

**GRAIN SIZE ANALYSIS RESULT (**pit 1)

|  |  |  |  |
| --- | --- | --- | --- |
| Sieve Diameter | Mass Retained | % Retained | %Passing |
| 20 mm | - | - | 100 |
| 14 mm | - | - | 100 |
| 10 mm | - | - | 100 |
| 6.3 mm | - | - | 100 |
| 5.3 mm | - | - | 100 |
| 3.35mm | - | - | 100 |
| 2.36mm | 1 | 0.2 | 99.8 |
| 1.7mm | 2.2 | 0.44 | 99.36 |
| 1.18mm | 6.1 | 1.22 | 98.14 |
| 850µm | 16.6 | 3.36 | 94.98 |
| 600µm | 74.7 | 14.94 | 79.84 |
| 425µm | 122.2 | 24.44 | 55.40 |
| 300µm | 130.5 | 26.1 | 29.30 |
| 150µm | 109.1 | 21.82 | 9.48 |
| 75µm | 20.6 | 4.12 | 3.36 |
| Passing | 16.8 | 3.36 | - |

|  |  |  |
| --- | --- | --- |
| *PROPOSED FOOD TECHNOLOGY AND INNOVATION COMPLEX* |  | ***AUGUST, 2022*** |



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cobles | Gravel | |  | Sand |  | Silt | Clay |
| Coarse | Fine | Coarse | Medium | Fine |

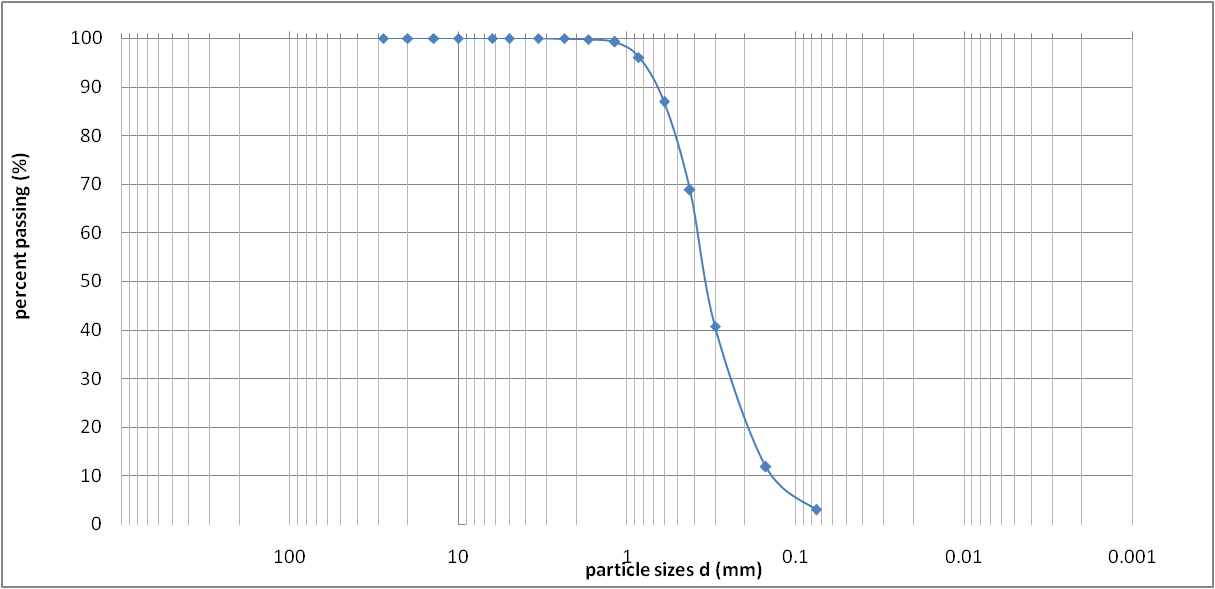
Figure 1: Particle size distribution of **Pit 1**

|  |
| --- |
| 13 |

### CIVIL ENGINEERING DEPARTMENT, JOSTUM

**GRAIN SIZE ANALYSIS RESULT (**pit 2)

|  |  |  |  |
| --- | --- | --- | --- |
| Sieve Diameter | Mass  Retained | % Retained | %Passing |
| 20 mm | - | - | 100 |
| 14 mm | - | - | 100 |
| 10 mm | - | - | 100 |
| 6.3 mm | - | - | 100 |
| 5 mm | - | - | 100 |
| 3.35mm | 7.4 | 1.48 | 98.52 |
| 2.36mm | 3.8 | 0.76 | 97.75 |
| 1.7mm | 4.8 | 0.96 | 96.8 |
| 1.18mm | 7.5 | 1.5 | 95.3 |
| 850µm | 17.4 | 3.48 | 91.82 |
| 600µm | 50.9 | 10.18 | 81.64 |
| 425µm | 195.6 | 39.12 | 42.52 |
| 300µm | 111.4 | 22.28 | 20.24 |
| 150µm | 87.7 | 17.54 | 2.70 |
| 75µm | 0.8 | 2.16 | 0.54 |
| Passing | 2.7 | 0.54 | - |

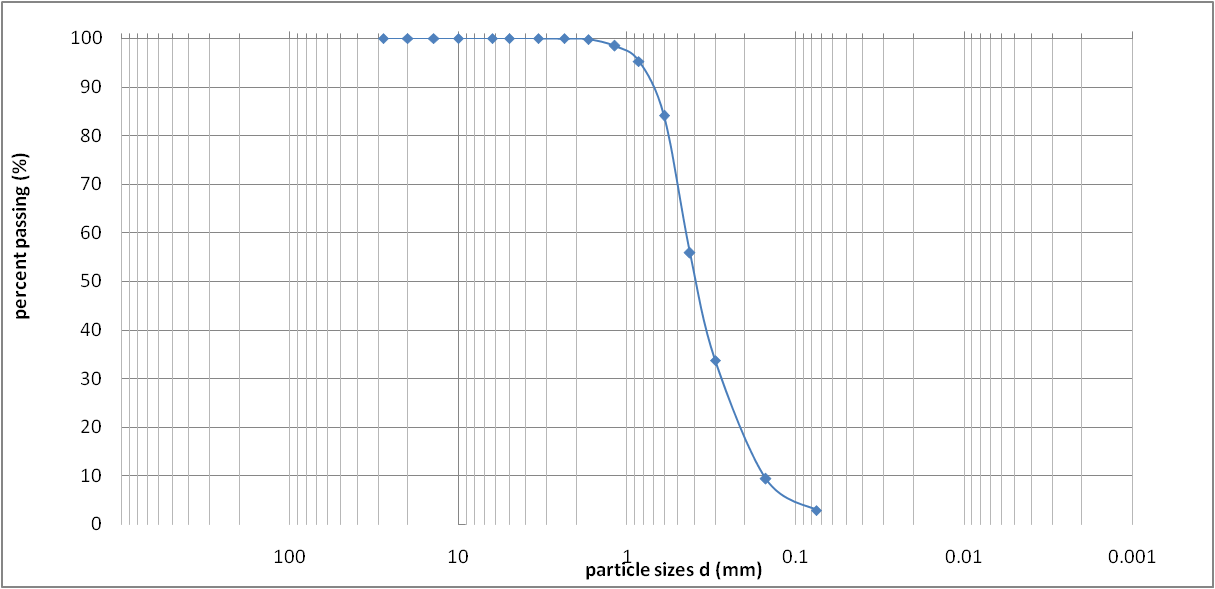


|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cobles | Gravel | |  | Sand |  | Silt | Clay |
| Coarse | Fine | Coarse | Medium | Fine |

Figure 2: Particle size distribution of Pit 2

## GRAIN SIZE ANALYSIS RESULT (pit 3)

|  |  |  |  |
| --- | --- | --- | --- |
| Sieve Diameter | Mass  Retained | % Retained | %Passing |
| 20 mm | - | - | 100 |
| 14 mm | - | - | 100 |
| 10 mm | - | - | 100 |
| 6.3 mm | - | - | 100 |
| 5mm | - | - | 100 |
| 3.35mm | 0.7 | 0.14 | 99.86 |
| 2.36mm | 1.0 | 0.2 | 99.66 |
| 1.7mm | 2.7 | 0.54 | 99.12 |
| 1.18mm | 7.6 | 1.52 | 97.60 |
| 850µm | 15.6 | 3.12 | 94.48 |
| 600µm | 95.2 | 19.04 | 75.44 |
| 425µm | 170.4 | 34.08 | 41.36 |
| 300µm | 127.6 | 25.52 | 15.84 |
| 150µm | 66.4 | 13.28 | 2.56 |
| 75µm | 8.3 | 1.66 | 0.9 |
| Passing | 4.5 | 0.9 | - |

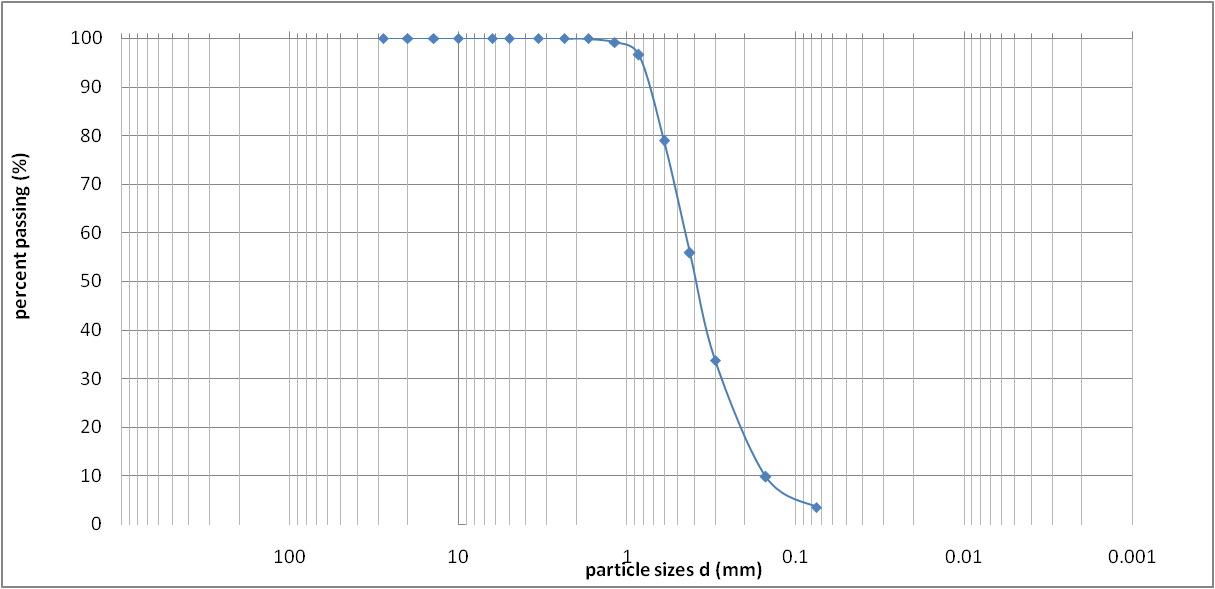


|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cobles | Gravel | |  | Sand |  | Silt | Clay |
| Coarse | Fine | Coarse | Medium | Fine |

Figure 3: Particle size distribution of Pit 3

## GRAIN SIZE ANALYSIS RESULT (pit 4

|  |  |  |  |
| --- | --- | --- | --- |
| Sieve Diameter | Mass  Retained | % Retained | %Passing |
| 20 mm | - | - | 100 |
| 14 mm | - | - | 100 |
| 10 mm | - | - | 100 |
| 6.3 mm | - | - | 100 |
| 5mm | - | - | 100 |
| 3.35mm | - | - | 100 |
| 2.36mm | - | - | 100 |
| 1.7mm | 1.70 | 0.34 | 99.66 |
| 1.18mm | 5.30 | 1.06 | 98.6 |
| 850µm | 22.3 | 4.46 | 94.14 |
| 600µm | 81.8 | 16.36 | 77.78 |
| 425µm | 176.8 | 35.36 | 42.42 |
| 300µm | 112.9 | 22.58 | 19.84 |
| 150µm | 83.8 | 16.76 | 3.08 |
| 75µm | 9.50 | 1.9 | 1.18 |
| Passing | 5.90 | 1.18 | - |

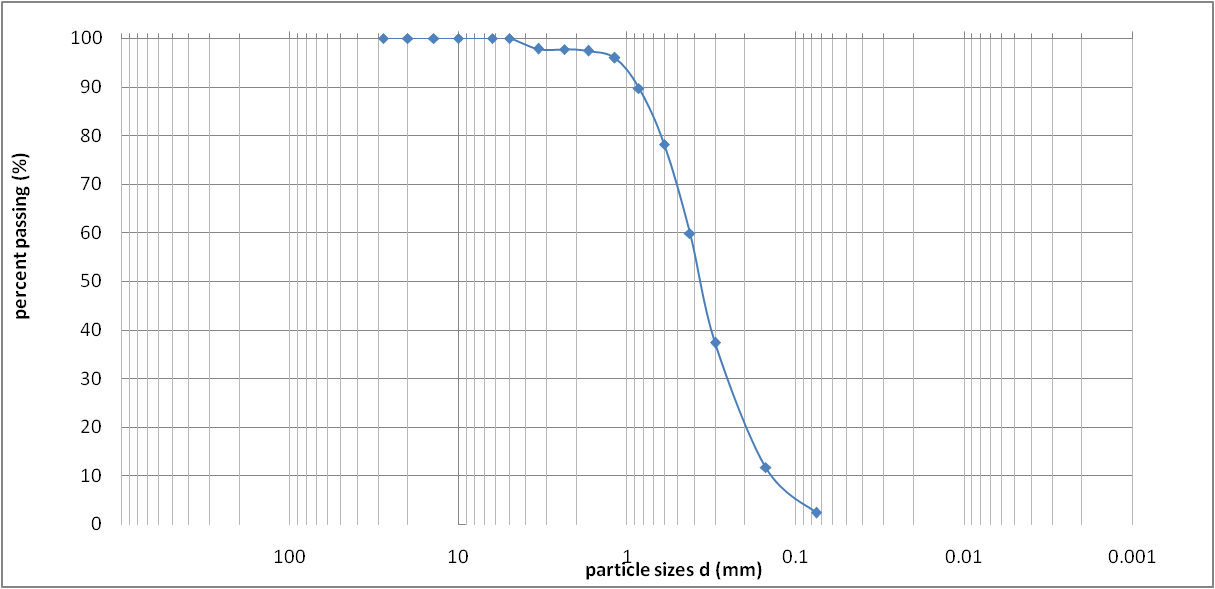


|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cobles | Gravel | |  | Sand |  | Silt | Clay |
| Coarse | Fine | Coarse | Medium | Fine |

Figure 4: Particle size distribution of Pit 4

## GRAIN SIZE ANALYSIS RESULT Pit 5

|  |  |  |  |
| --- | --- | --- | --- |
| Sieve Diameter | Mass  Retained | % Retained | %Passing |
| 20 mm | - | - | 100 |
| 14 mm | - | - | 100 |
| 10 mm | - | - | 100 |
| 6.3 mm | - | - | 100 |
| 5mm | - | - | 100 |
| 3.35mm | 25.3 | 5.06 | 94.94 |
| 2.36mm | 4.3 | 0.86 | 94.08 |
| 1.7mm | 4.0 | 0.8 | 93.28 |
| 1.18mm | 7.2 | 1.44 | 91.84 |
| 850µm | 21.8 | 4.36 | 87.48 |
| 600µm | 47.0 | 9.4 | 78.08 |
| 425µm | 177.2 | 35.44 | 42.64 |
| 300µm | 111.6 | 22.32 | 20.32 |
| 150µm | 77.6 | 15.52 | 4.8 |
| 75µm | 9.5 | 1.9 | 2.9 |
| Passing | 14.5 | 2.9 | - |



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cobles | Gravel | |  | Sand |  | Silt | Clay |
| Coarse | Fine | Coarse | Medium | Fine |

Figure 5: Particle size distribution of **Pit 5**

**LIQUID, PLASTIC LIMITS AND LINEAR SHRINKAGE**

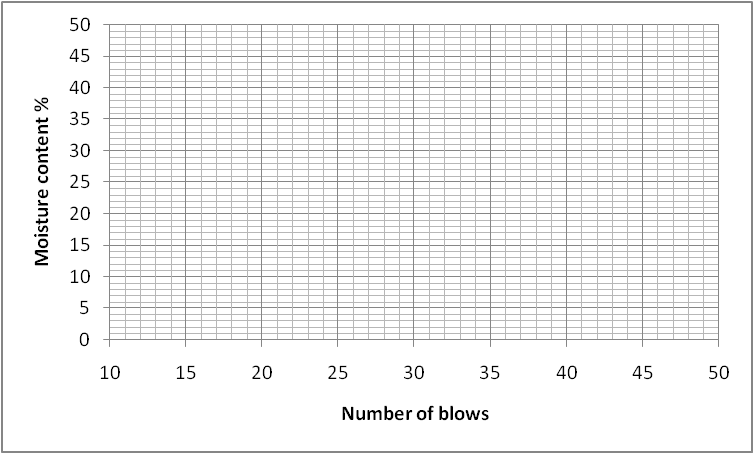
Project: **Proposed Food Technology and Innovation Complex**

Client: **Benue State University, Makurdi** Date: 18/07/2022

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borehole No: |  | Sample No.  **Pit 1** | | | Depth (m) | |  | 2.0 m |
| Total weight of sample (g) | |  | Weight passing No.40(0.425mm | | | | ) sieve |  |
| Soil/water curing time(hr) | |  | %passing No.40 (0.425 mm) sie | | | | ve |  |
| Test | | Plastic Limits | | | Liquid limit | |  | |
| Number of Can/No .of blows | |  |  |  |  |  |  |  |
| Weight of Can + wet soil g | |  |  |  |  |  |  |  |
| Weight of Can + Dry soil g | |  |  |  |  |  |  |  |
| Weight of moisture g | |  |  |  |  |  |  |  |
| Wt. of container g | |  |  |  |  |  |  |  |
| Weight of dry soil g | |  |  |  |  |  |  |  |
| Wt of moisture % | |  |  |  |  |  |  |  |
| Average % | |  | |  |  | |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| Liquid limit (LL) % |  | Linear shrinkage LS =(L1-L2/ L1 ) x 100 |  |
| Plastic limit (PL) % |  | L1= Initial length of specimen (mm) | **140** |
| Plastic Index(PI) % |  | L2= Final length of specimen (mm) |  |
| Liquid Index(LI) % |  |  |  |
| Linear Shrinkage (LS) % |  |  |  |

**Ajoh Engr. Boloko A. K**



**NON PLASTIC**

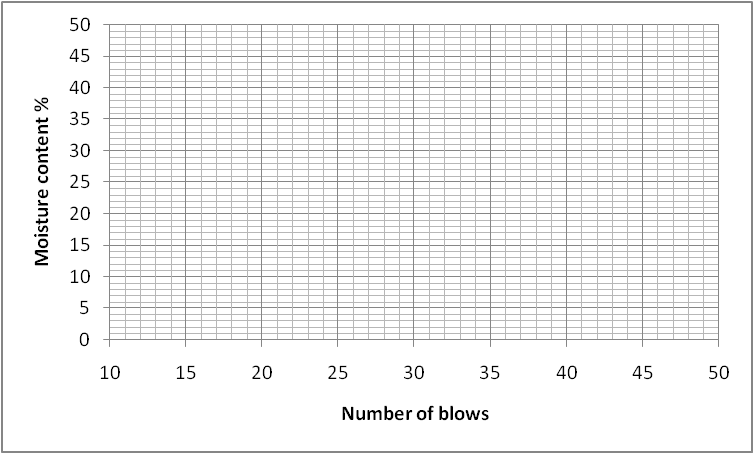
Project: **Proposed Food Technology and Innovation Complex**

Client: **Benue State University, Makurdi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borehole No: |  | Sample No.  **Pit 2** | | | Depth (m) | |  | 2.0 m |
| Total weight of sample (g) | |  | Weight passing No.40(0.425mm | | | | ) sieve |  |
| Soil/water curing time(hr) | |  | %passing No.4 0 (0.425mm) sie | | | | ve |  |
| Test | | Plastic Limits | | | Liquid limit | |  | |
| Number of Can/No .of blows | |  |  |  |  |  |  |  |
| Weight of Can + wet soil g | |  |  |  |  |  |  |  |
| Weight of Can + Dry soil g | |  |  |  |  |  |  |  |
| Weight of moisture g | |  |  |  |  |  |  |  |
| Wt. of container g | |  |  |  |  |  |  |  |
| Weight of dry soil g | |  |  |  |  |  |  |  |
| Wt of moisture % | |  |  |  |  |  |  |  |
| Average % | |  | |  |  | |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| Liquid limit (LL) % |  | Linear shrinkage LS =(L1-L2/ L1 ) x 100 |  |
| Plastic limit (PL) % |  | L1= Initial length of specimen (mm) | **140** |
| Plastic Index(PI) % |  | L2= Final length of specimen (mm) |  |
| Liquid Index(LI) % |  |  |  |
| Linear Shrinkage (LS) % |  |  |  |

**Ajoh Engr. Boloko A. K**



**NON PLASTIC**

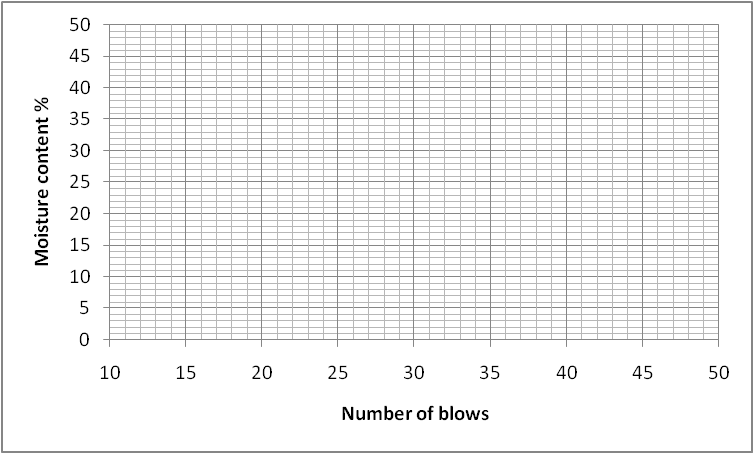
Project: **Proposed Food Technology and Innovation Complex**

Client: **Benue State University, Makurdi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borehole No: |  | Sample No.  **Pit 3** | | | Depth (m) | |  | 2.0 m |
| Total weight of sample (g) | |  | Weight passing No.40(0.425mm | | | | ) sieve |  |
| Soil/water curing time(hr) | |  | %passing No.4 0 (0.425mm) sie | | | | ve |  |
| Test | | Plastic Limits | | | Liquid limit | |  | |
| Number of Can/No .of blows | |  |  |  |  |  |  |  |
| Weight of Can + wet soil g | |  |  |  |  |  |  |  |
| Weight of Can + Dry soil g | |  |  |  |  |  |  |  |
| Weight of moisture g | |  |  |  |  |  |  |  |
| Wt. of container g | |  |  |  |  |  |  |  |
| Weight of dry soil g | |  |  |  |  |  |  |  |
| Wt of moisture % | |  |  |  |  |  |  |  |
| Average % | |  | |  |  | |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| Liquid limit (LL) % |  | Linear shrinkage LS =(L1-L2/ L1 ) x 100 |  |
| Plastic limit (PL) % |  | L1= Initial length of specimen (mm) | **140** |
| Plastic Index(PI) % |  | L2= Final length of specimen (mm) |  |
| Liquid Index(LI) % |  |  |  |
| Linear Shrinkage (LS) % |  |  |  |

**Ajoh Engr. Boloko A. K**

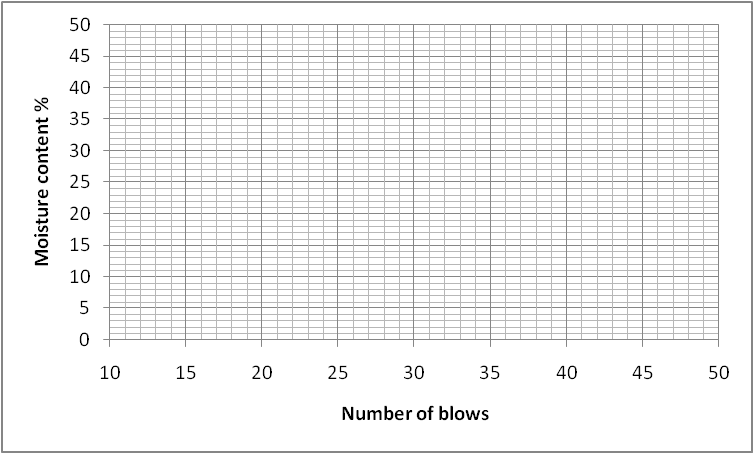


**NON PLASTIC**

Project: **Proposed Food Technology and Innovation Complex**

Client: **Benue State University, Makurdi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borehole No: |  | Sample No.  **Pit 4** | | | Depth (m) | | | 2.0 m |
| Total weight of sample (g) | |  | Weight passing No.40(0.425mm) sieve | | | | |  |
| Soil/water curing time(hr) | |  | %passing No.40 (0.425mm) sieve | | | | |  |
| Test | | Plastic Limits | | | Liquid limit | | |  |
| Number of Can/No .of blows | |  |  |  |  |  |  |  |
| Weight of Can + wet soil g | |  |  |  |  |  |  |  |
| Weight of Can + Dry soil g | |  |  |  |  |  |  |  |
| Weight of moisture g | |  |  |  |  |  |  |  |
| Wt. of container g | |  |  |  |  |  |  |  |
| Weight of dry soil g | |  |  |  |  |  |  |  |
| Wt of moisture % | |  |  |  |  |  |  |  |
| Average % | |  | |  |  | | |  |



**NON PLASTIC**

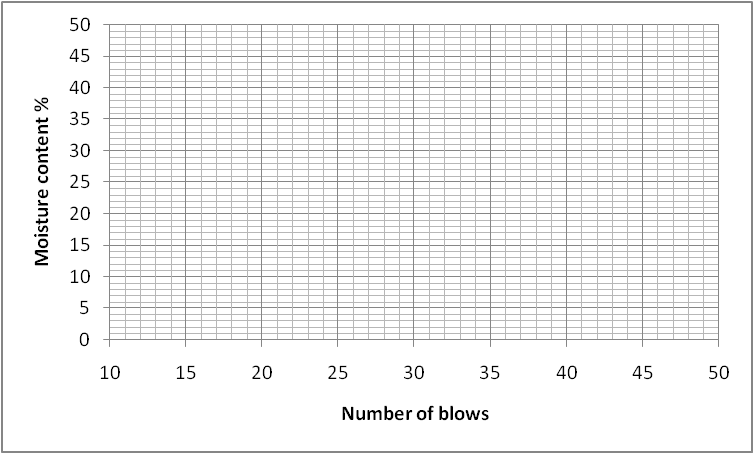
|  |  |  |  |
| --- | --- | --- | --- |
| Liquid limit (LL) % |  | Linear shrinkage LS =(L1-L2/ L1 ) x 100 |  |
| Plastic limit (PL) % |  | L1= Initial length of specimen (mm) | **140** |
| Plastic Index(PI) % |  | L2= Final length of specimen (mm) |  |
| Liquid Index(LI) % |  |  |  |
| Linear Shrinkage (LS) % |  |  |  |

**Operator: Ajoh Checked: Engr. Boloko A. K Date:** 18/07/22

Project: **Proposed Food Technology and Innovation Complex**

Client: **Benue State University, Makurdi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borehole No: |  | Sample No.  **Pit 5** | | | Depth (m) | |  | 2.0 m |
| Total weight of sample (g) | |  | Weight passing No.40(0.425mm | | | | ) sieve |  |
| Soil/water curing time(hr) | |  | %passing No.4 0 (0.425mm) sie | | | | ve |  |
| Test | | Plastic Limits | | | Liquid limit | |  | |
| Number of Can/No .of blows | |  |  |  |  |  |  |  |
| Weight of Can + wet soil g | |  |  |  |  |  |  |  |
| Weight of Can + Dry soil g | |  |  |  |  |  |  |  |
| Weight of moisture g | |  |  |  |  |  |  |  |
| Wt. of container g | |  |  |  |  |  |  |  |
| Weight of dry soil g | |  |  |  |  |  |  |  |
| Wt of moisture % | |  |  |  |  |  |  |  |
| Average % | |  | |  |  | |  | |



**NON PLASTIC**

|  |  |  |  |
| --- | --- | --- | --- |
| Liquid limit (LL) % |  | Linear shrinkage LS =(L1-L2/ L1 ) x 100 |  |
| Plastic limit (PL) % |  | L1= Initial length of specimen (mm) | **140** |
| Plastic Index(PI) % |  | L2= Final length of specimen (mm) |  |
| Liquid Index(LI) % |  |  |  |
| Linear Shrinkage (LS) % |  |  |  |

**Operator: Ajoh Checked: Engr. Boloko A. K Date:** 18/07/22

**Benue State University**

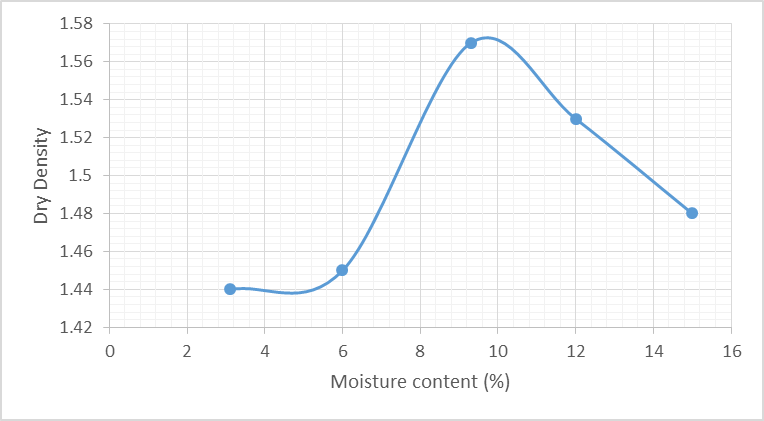
Description: (Pit 1) Date: 27/07/22

No. of layers: 3 No. of blows: 27

Wt. of mould: 3342 g Vol. of mould (v): 1000

**3% 6% 9% 12% 15%**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **1. Test No.** | 1 | 2 | 3 | 4 | 5 |
| **2. Container No.** | 133 | 120 | 2 | 15 | 28 |
| **3. Wt. of Container + Wet Soil** | 76.1 | 92.8 | 95.7 | 100.6 | 108.1 |
| **4. Wt. of Container + Dry Soil** | 74.3 | 76.2 | 89.2 | 91.3 | 96.1 |
| **5. Wt. of Container** | 16.4 | 16.3 | 16.3 | 16.0 | 16.2 |
| **6. Wt. of Moisture** | 1.8 | 3.6 | 5.5 | 9.3 | 12.0 |
| **7. Wt. of Dry Soil** | 57.9 | 59.9 | 59 | 75.3 | 79.9 |
| **8. Moisture Content (m %)** | 3.1 | 6.0 | 9.3 | 12.0 | 15.0 |
| **9. Wt. of Mould + wet Soil ( )** | 5005 | 5060 | 5240 | 5226 | 5220 |
| **10. Wt. of Wet Soil (w)** | 1480 | 1540 | 1720 | 1706 | 1700 |
| **11. Bulk Density Dw=** | 1.48 | 1.54 | 1.72 | 1.71 | 1.70 |
| **12. Dry Density=** | 1.44 | 1.45 | 1.57 | 1.53 | 1.48 |



**Form S5** MAX. DRY DENSITY: 1.57 Kg. /Cum OPTIMUM M/C: 9.3 %

**Operator: K.A Boloko Checked: Engr. K. A. Boloko Date:** 27/07/22

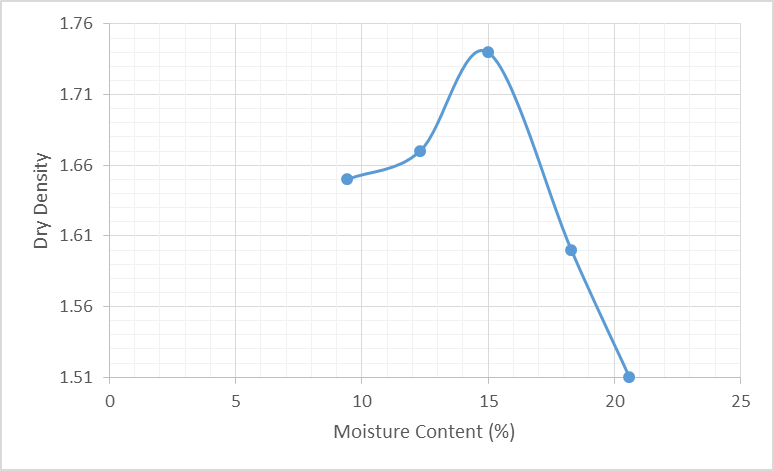
Description: (Pit 2)

No. of layers: 3 No. of blows: 27

Wt. of mould: 3342 g Vol. of mould (v): 1000

**9% 12% 15% 18% 21%**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **1. Test No.** | 1 | 2 | 3 | 4 | 5 |
| **2. Container No.** | 28 | 63 | 83 | 133 | 90 |
| **3. Wt. of Container + Wet Soil** | 62.8 | 63.4 | 92.8 | 84.2 | 85.8 |
| **4. Wt. of Container + Dry Soil** | 58.8 | 58.3 | 82.4 | 73.7 | 71.8 |
| **5. Wt. of Container** | 16.2 | 16.8 | 16.5 | 16.4 | 17.0 |
| **6. Wt. of Moisture** | 4.0 | 5.1 | 9.9 | 10.5 | 14.0 |
| **7. Wt. of Dry Soil** | 42.6 | 41.5 | 65.9 | 57.3 | 68.0 |
| **8. Moisture Content (m %)** | 9.4 | 12.3 | 15.0 | 18.3 | 20.6 |
| **9. Wt. of Mould + wet Soil ( )** | 5152 | 5222 | 5346 | 5225 | 5161 |
| **10. Wt. of Wet Soil (w)** | 1810 | 1880 | 2004 | 1883 | 1820 |
| **11. Bulk Density Dw=** | 1.81 | 1.88 | 2.00 | 1.88 | 1.82 |
| **12. Dry Density=** | 1.65 | 1.67 | 1.74 | 1.60 | 1.51 |



**Form S5** MAX. DRY DENSITY: 1.78 Kg. /Cum OPTIMUM M/C: 15.3 %

**Operator: K.A Boloko Checked: Engr. K. A. Boloko Date:** 27/07/2022

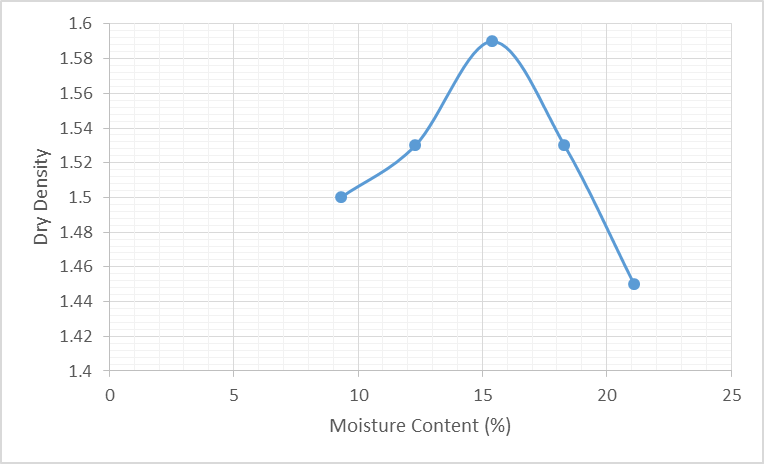
Description: (Pit 3)

No. of layers: 3 No. of blows: 27

Wt. of mould: 3500 g Vol. of mould (v): 1000

**9 % 12 % 15% 18% 21 %**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **1. Test No.** | 1 | 2 | 3 | 4 | 5 |
| **2. Container No.** | 37 | 55 | 107 | 2 | 133 |
| **3. Wt. of Container + Wet Soil** | 54.3 | 66.0 | 78.3 | 56.7 | 59.1 |
| **4. Wt. of Container + Dry Soil** | 50.9 | 60.4 | 70.1 | 50.1 | 51.2 |
| **5. Wt. of Container** | 14.5 | 14.7 | 16.7 | 14.0 | 13.7 |
| **6. Wt. of Moisture** | 3.4 | 5.6 | 8.2 | 6.6 | 7.9 |
| **7. Wt. of Dry Soil** | 36.4 | 45.7 | 53.4 | 36.1 | 37.5 |
| **8. Moisture Content (m %)** | 9.3 | 12.3 | 15.4 | 18.3 | 21.1 |
| **9. Wt. of Mould + wet Soil ( )** | 5068 | 5149 | 5271 | 5239 | 5192 |
| **10. Wt. of Wet Soil (w)** | 1637 | 1718 | 1840 | 1808 | 1761 |
| **11. Bulk Density Dw=** | 1.64 | 1.72 | 1.84 | 1.81 | 1.76 |
| **12. Dry Density=** | 1.50 | 1.53 | 1.59 | 1.53 | 1.45 |



**Form S5** MAX. DRY DENSITY: 1.59 Kg. /Cum OPTIMUM M/C: 15.5 %

**Operator: K.A Boloko Checked: Engr. K. A. Boloko Date:** 27/07/2022

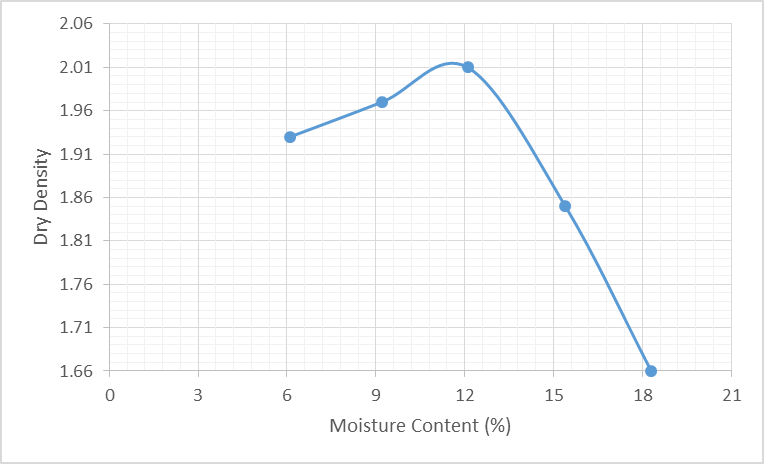
Description: (Pit 4)

No. of layers: 3 No. of blows: 27

Wt. of mould: 3609 g Vol. of mould (v): 1000

**6% 9% 12% 15% 18%**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **1. Test No.** | 1 | 2 | 3 | 4 | 5 |
| **2. Container No.** | 04 | 03 | 16 | 07 | 39 |
| **3. Wt. of Container + Wet Soil** | 40.0 | 47.6 | 49.6 | 50.5 | 51.1 |
| **4. Wt. of Container + Dry Soil** | 38.5 | 44.8 | 45.8 | 45.6 | 46.0 |
| **5. Wt. of Container** | 14.1 | 14.5 | 14.5 | 13.7 | 18.1 |
| **6. Wt. of Moisture** | 1.5 | 2.8 | 3.8 | 4.9 | 5.1 |
| **7. Wt. of Dry Soil** | 24.4 | 30.3 | 31.3 | 31.9 | 27.9 |
| **8. Moisture Content (m %)** | 6.1 | 9.2 | 12.1 | 15.4 | 18.3 |
| **9. Wt. of Mould + wet Soil ( )** | 5080 | 5184 | 5282 | 5178 | 4993 |
| **10. Wt. of Wet Soil (w)** | 2046 | 2150 | 2248 | 2144 | 1959 |
| **11. Bulk Density Dw=** | 2.05 | 2.15 | 2.25 | 2.14 | 1.96 |
| **12. Dry Density=** | 1.93 | 1.97 | 2.01 | 1.85 | 1.66 |



**Form S5** MAX. DRY DENSITY: 2.01 Kg. /Cum OPTIMUM M/C: 12.1 %

**Operator: K.A Boloko Checked: Engr. K. A. Boloko Date:** 27/07/2022

Location: **Benue State University, Makurdi** Operator: ……..

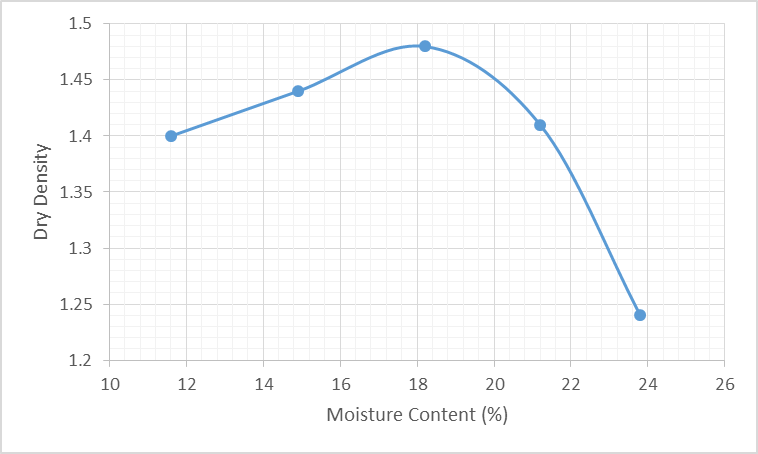
Description: (Pit 5) Date: 27/07/22

No. of layers: 3 No. of blows: 27

Wt. of mould: 3609 g Vol. of mould (v): 1000

**12% 15% 18% 21% 24%**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **13. Test No.** | 1 | 2 | 3 | 4 | 5 |
| **14. Container No.** | 60 | 30 | 10 | 101 | 81 |
| **15. Wt. of Container + Wet Soil** | 84.7 | 102.4 | 110.3 | 111.7 | 113.8 |
| **16. Wt. of Container + Dry Soil** | 77.6 | 91.2 | 95.0 | 95.8 | 95.0 |
| **17. Wt. of Container** | 16.5 | 16.0 | 16.0 | 16.0 | 16.0 |
| **18. Wt. of Moisture** | 7.1 | 11.2 | 14.5 | 16.7 | 18.8 |
| **19. Wt. of Dry Soil** | 61.1 | 75.2 | 79.8 | 78.9 | 79.0 |
| **20. Moisture Content (m %)** | 11.6 | 14.9 | 18.2 | 21.2 | 23.8 |
| **21. Wt. of Mould + wet Soil ( )** | 5115 | 5475 | 5268 | 5225 | 5055 |
| **22. Wt. of Wet Soil (w)** | 1595 | 1655 | 1748 | 1705 | 1535 |
| **23. Bulk Density Dw=** | 1.60 | 1.66 | 1.75 | 1.71 | 1.54 |
| **24. Dry Density=** | 1.40 | 1.44 | 1.48 | 1.41 | 1.24 |

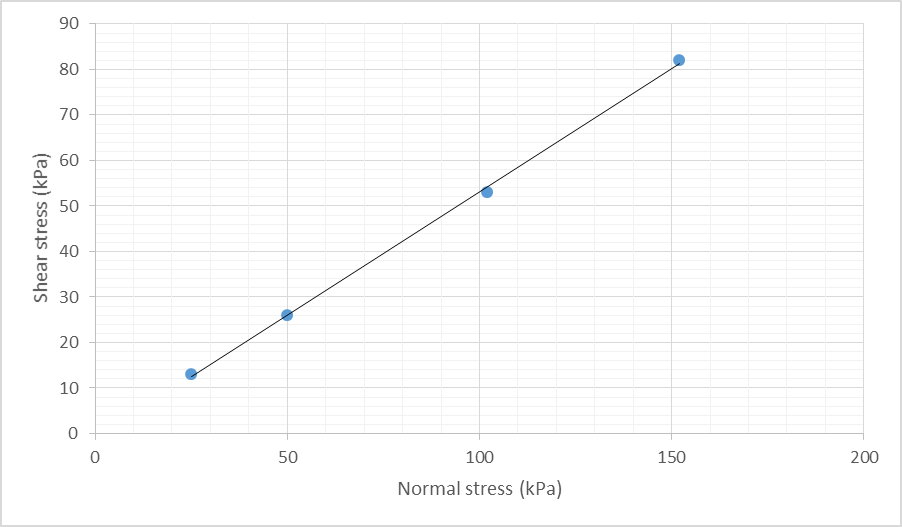


**Form S5** MAX. DRY DENSITY: 1.48 Kg. /Cum OPTIMUM M/C: 18.2 %

**Operator: K.A Boloko Checked: Engr. K. A. Boloko Date:** 27/07/2022 Undrained shear box test for PIT 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test No Total normal stress (kPa) Total stress at failure (kPa) | | | | | | |
|  | 1 |  | 25 |  | 13 |  |
|  | 2  3  4 |  | 50 |  | 26 |  |
| 102 | 53 |
| 152 | 82 |
|  |  |  |

Correlation coefficient = 0.999606

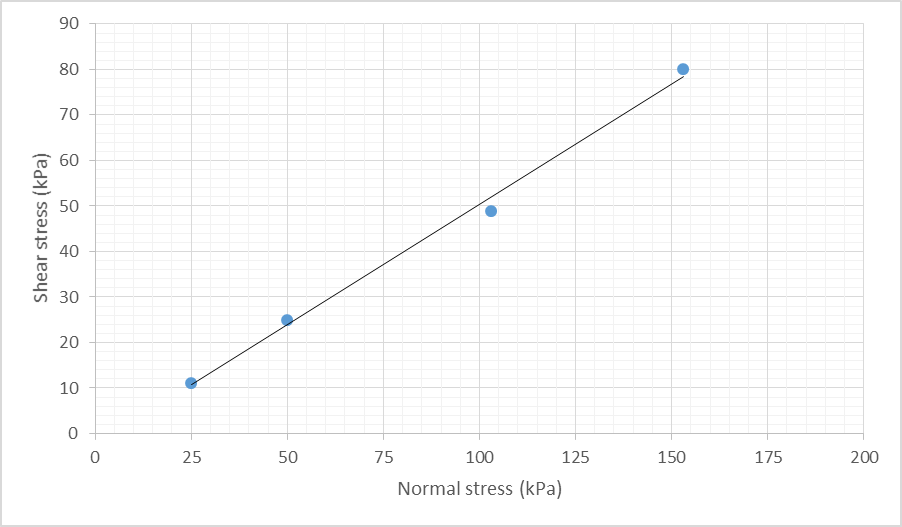


|  |  |  |
| --- | --- | --- |
|  | | |
| Cohesion = | 0 | kPa  o |
| Angle of friction = | 27 |
|  |

Undrained shear box test for PIT 2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test No Total normal stress (kPa) Total stress at failure (kPa) | | | | | | |
|  | 1 |  | 25 |  | 11 |  |
|  | 2  3  4 |  | 50 |  | 25 |  |
| 103 | 49 |
| 153 | 80 |
|  |  |  |

Correlation coefficient = 0.99771

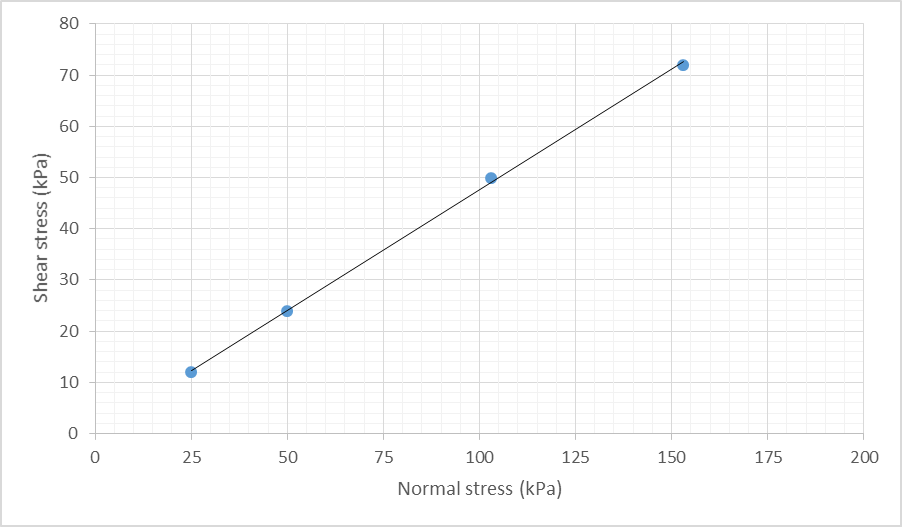


|  |  |  |
| --- | --- | --- |
|  | | |
| Cohesion = | 0 | kPa  o |
| Angle of friction = | 26 |
|  |

Undrained shear box test for PIT 3

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test No Total normal stress (kPa) Total stress at failure (kPa) | | | | | | |
|  | 1 |  | 25 |  | 12 |  |
|  | 2  3  4 |  | 50 |  | 24 |  |
| 103 | 50 |
| 153 | 72 |
|  |  |  |

Correlation coefficient = 0.999684

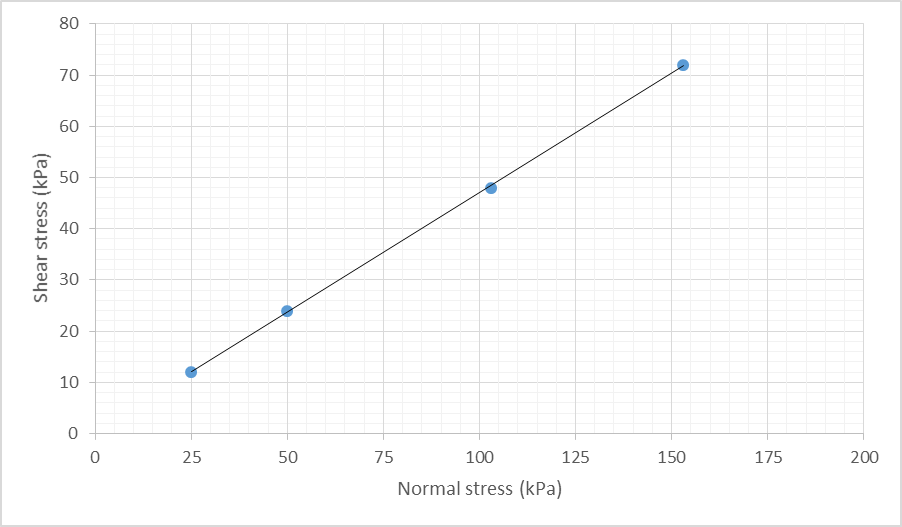


|  |  |  |
| --- | --- | --- |
|  | | |
| Cohesion = | 0 | kPa  o |
| Angle of friction = | 26 |
|  |

Undrained shear box test for PIT 4

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test No Total normal stress (kPa) Total stress at failure (kPa) | | | | | | |
|  | 1 |  | 25 |  | 12 |  |
|  | 2  3  4 |  | 50 |  | 24 |  |
| 103 | 48 |
| 153 | 72 |
|  |  |  |

Correlation coefficient = 0.999665

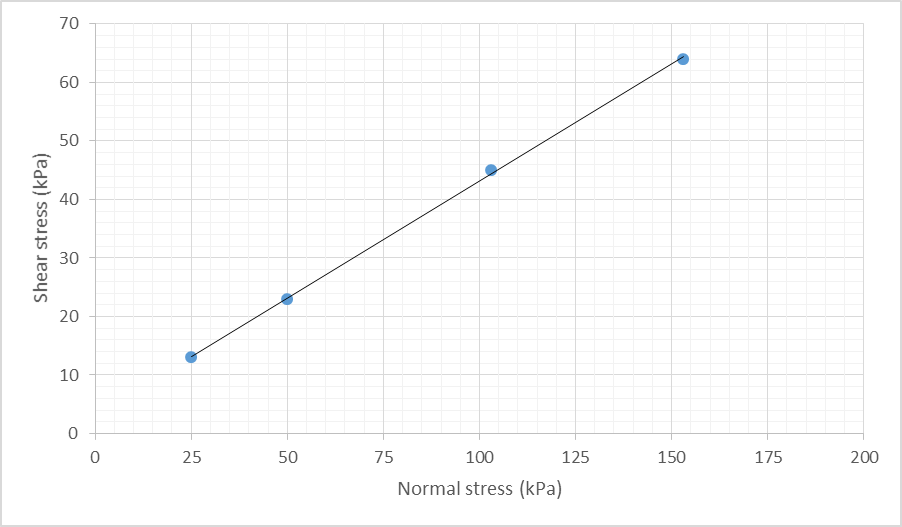


|  |  |  |
| --- | --- | --- |
|  | | |
| Cohesion = | 0 | kPa  o |
| Angle of friction = | 25 |
|  |

Undrained shear box test for PIT 5

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test No Total normal stress (kPa) Total stress at failure (kPa) | | | | | | |
|  | 1 |  | 25 |  | 13 |  |
|  | 2  3  4 |  | 50 |  | 23 |  |
| 103 | 45 |
| 153 | 64 |
|  |  |  |

Correlation coefficient = 0.999164



|  |  |  |
| --- | --- | --- |
|  | | |
| Cohesion = | 0 | kPa  o |
| Angle of friction = | 28 |
|  |