GEOTECHNICAL INVESTIGATION

PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1 ON MERU MUNICIPALITY PARCEL NO. BLOCK 1/357, MERU COUNTY.

Prepared for: National Housing Corporation,
P.O Box 30257-00100,
Nairobi.

Attention: Eng. Wilfred Makutha and Eng. Judith G. Limungi

2 copies - National Housing Corporation
1 copy - Terraconsult Kenya Limited, Nairobi

Distribution: File No. 3-19-10

18 March 2019

TABLE OF CONTENTS

1. INTRODUCTION

Terraconsult was retained by National Housing Corporation to carry out a detailed geotechnical investigation and provide design advice for Proposed Meru Ntutu Mixed Development Phase 1 on Meru Municipality Parcel No. Block 1/357, Meru County.

Engineers Wilfred Makutha and G. Limungi provided all communication on the proposed scope of the subsurface investigation.

This report presents the findings of geotechnical survey carried out at the proposed project site. It primarily contains results from field borehole drilling, insitu tests and laboratory tests. It also includes analysis of the test results, field observations and presentation of factual geotechnical findings.

All the fieldwork was carried out according to BS 5930: 2015 (code of practice for site investigations). Laboratory tests were done as stipulated in the British Standards (BS 1377); the American Society for Testing Materials (ASTM) designated D 2938-79 and D 2845-00. Design recommendations are in adherence to the Manual for the Geotechnical Design of Structures to Euro code 7(2013) and BS 8004.

2. SITE AND PROJECT DESCRIPTION

The subject property is located on Meru-Nairobi Highway, Meru. A topographic map of the area is subsequently appended as Figure 1.

According to GPS data, the project site is at an elevation of approximately 1686.5m above sea level.

The project entailed rotary drilling of geotechnical boreholes to obtain core samples for analysis.

3. FIELD AND LABORATORY PROCEDURE

The fieldwork for this investigation was conducted from 10th to 23rd February 2019. It consisted of drilling and sampling six (6) exploratory boreholes to a maximum depth of 25m below existing grade.

The drilling equipment consisted of a rotary drilling rig (GY-150) equipped with conventional soil sampling and testing tools.

The supervising technician logged the borings and examined the samples as they were obtained. The samples were properly identified by visual inspection, catalogued in wooden core boxes/sealed sample containers and transferred to the laboratory for testing. A geotechnical engineer later reviewed the samples for consistency of description. The photographs of the samples are presented in Appendix B of this report.

Water level measurements were conducted in the open borehole upon completion of drilling. The water was allowed to equilibrate for about 30 minutes before taking the final measurement. The final water rest level is

recorded in the borehole logs (Appendix A). It should be noted that the ground water conditions reported above may not necessarily represent stabilized conditions or conditions expected during construction. In addition, assistive drilling water contributes to the level observed in boreholes.

The recovered intact core samples, representative samples from the anticipated foundation depths and the zone of influence of the foundation loadings, were soaked in water for four (4) days to achieve saturation, trimmed to specifications before either uniaxial compressive strength (UCS), point load tests (PLT) or ultrasonic pulse velocity tests were carried out. The test results are appended to this report. They include computed bearing capacity values from rock cores irrespective of any settlement obtained by use of R. E. Goodman's Formula (Goodman, R.E., 1989) and are applicable at the respective depths indicated.

4. SUBSURFACE CONDITIONS

The borehole elevations and coordinates are provided relative to geodetic datum. The datum for all heights in Kenya is the mean sea level referred to a tide gauge at Kilindini harbour in Mombasa. The horizontal coordinates are reported relative to the Universal Transverse Mercator geographic coordinate system (UTM WGS84). The boreholes were surveyed for horizontal coordinates and geodetic elevations with a hand-held Garmin navigator connected to the Global Navigation Satellite System.

The subsurface soil, rock and ground water conditions encountered in the boreholes are presented on the attached Log of Borehole sheets. The stratigraphic boundaries indicated on the Log of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil or rock type to another. These boundaries should not be interpreted to represent exact planes of geological change. The subsurface conditions have been confirmed in a series of widely spaced boreholes, and will vary between and beyond the borehole locations. The discussion has been simplified in terms of the major soil and rock strata for the purposes of geotechnical design.

4.1Stratigraphy

The following stratigraphy is based on the borehole findings, as well as the geotechnical laboratory testing conducted on selected representative soil samples.

All boreholes encountered a surficial layer of clay soils that extends to depths of 6 to 20 meters below existing grade (Elev. 1675 ± m to 1665.0 ± m). The native soils generally consist of clayey silt some sand with traces of gravel, reddish brown, dark brown, whitish brown to yellowish brown, wet to dry, medium to low plasticity.

Underlying the native deposits all boreholes encountered layers of trachyte of different colors ranging from light grey to reddish grey, highly weathered to moderately weathered at different depths. These trachyte's extend to different thickness and depths in all boreholes. The trachyte extends approximately 2.5 to 15 m

below grade (Elev. 1665 ±m1675 ± m). These trachyte layers are underlain by layers of pale grey, relatively hard phonolites of different degrees of weathering which extend up to the final depth of the investigation.

4.2 Ground Water

The stabilized ground water table was reported at about 13-14 m below grade.

Borehole	Depth of Boring	Ground Water Table (m) After drilling
Bh 101	25	13.13
Bh 102	25	14.1
Bh 103	25	13.1
Bh 104	25	*
Bh 105	25	13.3
Bh 106	25	13.14

Table 1 Ground water table levels

* No water

It should be noted that the ground water levels may fluctuate seasonally depending on the amount of precipitation and surface runoff. The depth of unsterilized ground water and caving were measured in each of Boreholes after the drilling work was completed. The apparent ground water level for Bh 104 was not recorded because there was a broken water pipe that was leaking into the borehole.

4.3 Geotechnical Laboratory Test Results

4.3.1 Clayey Silt

The geotechnical laboratory testing consisted of sieve and hydrometer analysis, Atterberg Limits, permeability, triaxial and consolidation tests on selected native soil samples.

A summary of the results and estimated permeability of the samples analyzed is presented below.

Test	**Samples**	**Results**
Sieve and hydrometer analysis and Atterberg	Bh 101(6.0-7.5)m	Clayey SILT with some sand and traces of gravel with medium plasticity

limits	Bh 101 (13.5-15.0)m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 103(3.0-4.5)m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 104(4.5-6.0) m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 104(9.0-13.5) m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 105(1.5-3.0) m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 106(0.0-1.5) m	Clayey SILT with some sand and traces of gravel with medium plasticity
	Bh 106(13.5-15.0) m	Clayey SILT with some sand and traces of gravel with medium plasticity
Permeability	Bh 101(1.5-3.0) m	$2.217*10^{-4}$ cm/sec
	Bh 101(5.5-6.0) m	$8.220*10^{-5}$ cm/sec
	Bh 102(4.0-4.5) m	$3.759*10^{-4}$ cm/sec
	Bh 103(4.5-6.0) m	$5.271*10^{-4}$ cm/sec
	Bh 105(1.0-1.5) m	$6.926*10^{-5}$ cm/sec
	Bh 106(7.5-9.0) m	$2.218*10^{-4}$ cm/sec
Triaxial and Consolidation	Bh 101(2.0-2.5) m	$\Phi = 15.07°$ $c = 0.20 kg/cm^2$ $m_v=2.6345 \times 10^{-4} m^2/kN$
	Bh 102(1.0-1.5) m	$\Phi = 15.99°$ $c = 0.20 kg/cm^2$

		m_v=2.7495 x 10^{-4} m^2/kN
	Bh 102(5.5-6.0) m	Φ = 11.84° c = 0.30kg/cm^2 m_v=2.9292 x 10^{-4} m^2/kN
	Bh 103(4.0-4.5) m	Φ = 12.51° c = 0.20kg/cm^2 m_v=1.7830 x 10^{-4} m^2/kN
	Bh 105(2.5-3.0) m	Φ = 13.40° c = 0.20kg/cm^2 m_v=3.0553 x 10^{-4} m^2/kN
	Bh 106(4.0-4.5) m	Φ = 10.53° c = 0.20kg/cm^2 m_v=2.8520 x 10^{-4} m^2/kN

Table 2 Summary of Clayey Silt Tests

4.3.2 Trachytes

The laboratory tests done on trachyte was only point load test since the samples could not achieve a length to diameter ratio of two (2).

4.3.3 Phonolites

The tests carried out for phonolites were uniaxial compressive strength (UCS), modulus and ultrasonic pulse velocity.

5. DISCUSSION AND RECOMMENDATIONS

The following are based on the factual data obtained from this investigation and are intended for use of National Housing Corporation and their consultants. Contractors bidding or providing services on this project should review the factual data and determine their own conclusions regarding construction methods and scheduling.

This report is provided based on these terms of reference and on the assumption that the design features relevant to the geotechnical analysis will be in accordance with applicable codes, standards and guidelines of practice.

5.1 Foundations

Laboratory results are subsequently appended in the report. Atterberg's limits portray the clay soils as of low to medium plasticity. The permeability results show the clay soils to have a low degree of permeability.

Depending on the depth where the foundation will be founded, the bearing pressure can be computed using either the equations by Terzaghi for the native soils or the Goodman (1989) formula for the rocks.

5.1.1 Foundation on Native Soils

The Standard Penetration test results ('N' Values) obtained weathered/disturbed soil zone varied from about 6 to 26 blows per 300 mm of penetration indicating a firm to very stiff consistency at a depth of 2 to 12 m.

If the foundation will be founded between depths of 2.0m to 6.0m, then using the foundation dimensions (width, B, and length, L) and the foundation depth, D_f, the ultimate bearing capacity, q_u, for various footing shapes can be calculated using the equations below:

Strip footings: $q_u = cN_c + \gamma D_f N_q + 0.5\gamma B N_\gamma$

Square foundations: $q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$

Circular foundations: $q_u = 1.3cN_c + \gamma D_f N_q + 0.3\gamma B N_\gamma$

Rectangular foundations: $q_u = cN_c(1 + 0.3\frac{B}{L}) + \gamma D_f N_q + 0.5\gamma B N_\gamma(1 - 0.2\frac{B}{L})$

Where,

c = Cohesion (19.61 kN/m^2)

$\emptyset°$ = Angle of internal friction (13.40º, see appended triaxial test results).

γ = Effective unit weight of soil (16.28 kN/m^3)

N_c, N_q, N_γ = Terzaghi' s bearing capacity factors for general shear failure (Appendix D)

A minimum factor of safety of 3 (F = 3) is recommended to obtain the safe bearing pressure from the computed ultimate bearing capacity using the equation below;

$$q_s = \frac{q_u}{F}$$

where,

q_s = Safe bearing capacity and,

F = Factor of safety

For a typical 2.5 x 2.5 m spread foundation at 4.0m depth and, the allowable safe bearing capacity will be 100kN/m^2 using a factor of safety of 3.

5.1.2 Foundations on Rock

Bearing Capacities where computed from the Uniaxial Compressive Strength (UCS) using the Goodman (1989) formula. The maximum allowable bearing capacity of trachyte is 250kN/m^2 while that of phonolite is 800kN/m^2.

$$q_a = q_{ur}(N\emptyset + 1)$$

Where $$N\emptyset = tan^2(45 + \frac{\emptyset}{2})$$

q_a is the allowable bearing capacity;

q_{ur} is the UCS value of the rock;

$\emptyset$ is the angle of internal friction

The UCS, point load index (Is $_{(50)}$) and bearing capacity values at various depths of the boreholes are presented in Appendix C.

A summary of properties with respect to the bedrock below the native soils is presented below.

	Point Load Index Is $_{(50)}$ (MPa)	**Uniaxial Compressive Strength (MPa)**	**Dynamic Modulus (GPa)**	**Poisson's Ratio**
	Trachyte	Phonolite	Phonolite	Phonolite
Average	0.074	138.05	56.25	0.3469
Range	0.01-0.23	76.39-176.52	49.24-63.81	0.3142-0.3940

Table 3 Summary of Properties - the Bedrock

There is typically a zone of weathering at the contact between the bedrock of the trachyte and the native soil overburden. All foundations should be placed on dry, undisturbed rock which has been cleaned of any topsoil or other deleterious matter, loosened material/debris and with the recommended contact pressure.

5.2 Settlement

5.2.1 Foundations on Native Soil

Settlement of foundations in clay soil can be computed using the coefficient of volume compressibility (m_v) obtained from one dimensional consolidation test. Consolidation settlement of clay due to changes in vertical stress can be computed using the equation below;

$$\rho = \int_0^H m_v \times \Delta\sigma \times H$$

Where,

ρ = Consolidation settlement (m).

m_v = Coefficient of compressibility (m^2/kN). (2.6345 x 10^{-4} m^2/kN).

$\Delta\sigma$ = Change in vertical stress (kN/m^2).

H = Height under stress (m).

5.2.2 Foundations on Rock

A wide range of over-consolidated rocks can be treated as 'elastic' for predicting the total settlement. The magnitude of settlement that will occur when foundation loads are applied to the ground depends on the rigidity of the structure, the type and duration of the loading, and the deformation characteristics of the ground. For footings on rocks, elastic settlement should generally be less than 0.5% of the foundation width.

The settlement of a rigid foundation or average settlement of a flexible foundation at the surface of a homogeneous elastic layer can be computed using the following equation

$$s = \frac{q_a B(1-v^2)l}{E_m}$$

Where

q_a is the average pressure on the rock;

B is the width or diameter of the footing;

v is the Poisson's ratio of the rock mass (see Appendix B)

E_m is the modulus of the rock mass

l is the influence value dependent upon the shape of the footing and the rigidity of the footing relative to the rock mass; typical values are (Lysmer and Duncan 1969):

Shape	**Circular**	**Square**	**Rectangular** L/B		
			2	5	10
Rigid	0.79	0.82	1.1	1.6	2.0
Flexible (mean value)	0.85	0.95	1.3	1.8	2.2

Table 4 Influence factors for various shapes of footings.

5.3 Excavations

5.3.1 Excavations on Native Soils

Excavations slopes in clay soil must be supported using proper shoring systems. Shoring methods depend on the loadings and type of structures in the adjoining plots. Proper design is required to preserve the integrity of the slope and surrounding properties. Temporary slope protection may be necessary to prevent sloughing

of soil materials into the excavation. Direct rainfall on such slopes causes rapid erosion. To prevent slope erosion in rainstorms, spray-on product is recommended to bind the soil particles on the surface. Plastic covering can be used to minimize changes in moisture content on the surface of the slope and maintain stability. It should be noted that excavation in saturated clay will result in heave at the bottom of the excavation due to swelling of the clay. It is always important that care should be taken when working in unsupported excavations extending below any ground.

5.3.2 Excavations on Rocks

Excavation faces in highly weathered rock have a considerable risk of failure due to low shear resistance along the potential slip surface, more so if there is significant surcharge in the adjoining plot. Slightly angled excavations have a reduced risk of failure due to an increased factor of safety against sliding failure. In the event unstable rock wedges are detected on the excavation face, they must be stabilized using designed rock bolts or rock anchors. Loose, weathered rock fragments on the excavated face that susceptible to falling can be temporarily restrained using sprayed concrete to protect the work area. Generally, it is always important that care should be taken when working in unsupported excavations extending below any ground.

5.4 Base Slab on Drainage

The lowest floor slab can be supported on the clayey silt but must be compacted. The concrete floor slab must be provided with a capillary moisture barrier and drainage layer. The capillary moisture barrier can be made by placing the slab on a minimum 200 mm layer of clear 19 mm stone compacted by vibration to a dense state. This stone serves also as the drainage media for the subfloor drainage system, which is required. Any aggregate fill placed beneath the floor slab must be compacted to not less than 98% of Standard Proctor maximum dry density.

5.5 Backfilling

The excavated areas should be backfilled with selected approved hard-core or similar material. Backfill below settlement sensitive areas for purposes of levelling the working area should be compacted in lifts 150 mm thick or less, to at least 95 percent Standard Proctor maximum dry density.

6. LIMITATIONS AND RISK

This geotechnical examination has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraconsult Kenya Limited and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained from this investigation. It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. A comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraconsult Kenya Limited has assumed for the purposes of providing design

parameters and advice, that the conditions that exist proximal to the sampling point are similar to those found at the sample location. These conditions may differ from those that actually exist. It may not be possible to drill sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors and Quantity Surveyors bidding on or undertaking work on this project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities. It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. The design parameters provided and the engineering discussion are based on the factual data obtained from this investigation made at the site by Terraconsult Kenya Ltd and are intended for use by the owner and his retained designers in the design phase of the project. If there are changes to the project scope and development features the interpretations made from the subsurface information, the geotechnical design parameters and comments relating to constructability issues and quality control may not be relevant to the revised project. This report was prepared for the express use of National Housing Corporation and is not for use by others.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you please do not hesitate to contact our offices.

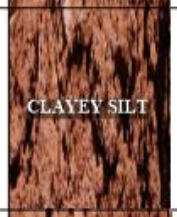
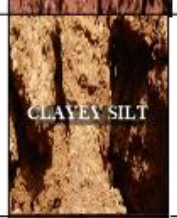
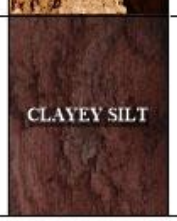
Sincerely,
Terraconsult Kenya Limited

Issa Ismail, PhD.

Geotechnical Engineer

7.APPENDIX A-Borehole Logs and Section

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1685
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349081 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005812
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 1 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 101	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.13 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0												
1	1.5					Dry, fine grained, stiff, reddish brown clayey SILT with some sand and traces of gravel.Has medium plasticity.	VI					
2	1.5					Dry, fine grained, stiff, reddish brown clayey SILT with some sand and traces of gravel.Has medium plasticity.	VI					8
3	1.5					Moist, fine grained, stiff, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					9
4												
5	1.5					Moist, fine grained, stiff, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					8
6	1.5					Moist, fine grained, stiff, light reddish brown clayey SILT with some sand and traces of gravel. Has low plasticity.	VI					
7												
8	1.5					Moist, fine grained, stiff, light reddish brown clayey SILT with some sand and traces of gravel. Has low plasticity.	VI					10

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1685
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349081 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005812
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	Sheet No: 2 of 3	
File No: 3-19-10	Logged By: Winnie Munene	Checked By: Dr. Issa Ismail	
Drilling Method: Rotary	Drill Bit Type: 86-101mm Diamond	Borehole No: 101	
Drill Rig Type: GY 150T	Drilled By: Justus Owino	Depth: 25.00 m	
Apparent Depth of Ground Water: 13.13 m		Inclination From Vertical: 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
9												
10	2.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
11	0.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					7
12	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					6
13	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
14	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
15	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
16	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
17	1.5				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					

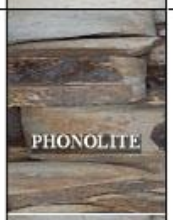
WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

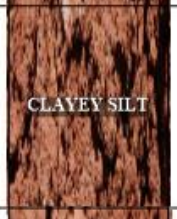
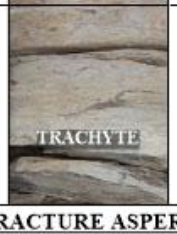
- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1685
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349081 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005812
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 3 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 101	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.13 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
18–19	2					Firm, reddish brown clayey SILT with some sand and trace gravel. Has low plasticity.	VI					
19–20	1.5	66	20	3		Light grey, highly weathered, fine grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	>20	VP	
20–21	2	60	15	3		Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
21–22	1	51	14	3		Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
22–23	0.5	30	30	8		Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	0	P	

WEATHERING GRADES	**FRACTURE ASPERITIES**	**ROCK MASS QUALITY**	
I: Fresh & Hard	**RI**: Rough and Irregular	**E**: Excellent	**TCR:** Total Core Recovery Ratio
II: Slightly Weathered	**RU**: Rough and Undulating	**G**: Good	**RQD:** Rock Quality Designation
III: Moderately Weathered		**Fa**: Fair	**RMR:** Rock Mass Rating after Bieniawski (1989)
IV: Highly Weathered		**P**: Poor	
V: Completely Weathered		**VP**: Very Poor	
VI: Residual/Soil			

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1681
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349116 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005818
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 1 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 102	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 14.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0 – 1	1.5					Dry, stiff, dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
2	1.5					Dry, stiff, dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					9
3	1.5					Moist, stiff, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					10
4 – 5	1.5					Dry, stiff, reddish brown to dark brown clayey SILT with some sand and traces of gravel. Is slightly plasticity.	VI					13
6 – 7	1.5	27	0	3		Light grey, highly weathered, fine grained, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces. Rubbled.	IV	1	RI	RUBBLED	VP	12
8	2	34	0	3		light Grey, fine grained, non-vesicular, highly weathered, highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	9

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1681
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349116 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005818
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 2 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 102	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 14.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
9												
10	3.5					Light Grey, fine grained, non-vesicular, highly weathered, highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI	DECOMPOSED	VP	
11												
12												
13	2	35	0	3		light Grey, fine grained, non-vesicular, highly weathered, highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
14												
15	2	23	0	3		light Grey, fine grained, non-vesicular, highly weathered, highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Cobbled.	IV	1	RI	COBBLED	VP	
16												
17						light Grey, fine grained, non-vesicular, highly weathered,				COB		

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

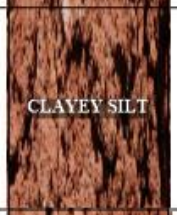
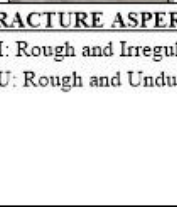
- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1681
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349116 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005818
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 3 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 102	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 14.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
18	2	30	0	3		highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Cobbled.	IV	1	RI	BLE D	VP	
19												
20	2	25	0	3		light Grey, fine grained, non-vesicular, highly weathered, highly fractured, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUB BLE D	VP	
21												
22	1.5	66	0	3		Pale Grey, fine grained, non-vesicular, moderately weathered, highly fractured, hard PHONOLITE. Characterised by both vertical and horizontal open fractures. Rubbled.	III	3	RI	RUB BLE D	VP	
23	1.5	30	0	3		Pale Grey, fine grained, moderately weathered, highly fractured, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	RUB BLE D	VP	
24	1	28	10	3		Pale Grey, fine grained, vesicular, moderately weathered, highly fractured, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
25												

WEATHERING GRADES	**FRACTURE ASPERITIES**	**ROCK MASS QUALITY**	
I: Fresh & Hard	**RI**: Rough and Irregular	**E**: Excellent	**TCR:** Total Core Recovery Ratio
II: Slightly Weathered	**RU**: Rough and Undulating	**G**: Good	**RQD:** Rock Quality Designation
III: Moderately Weathered		**Fa**: Fair	**RMR:** Rock Mass Rating after Bieniawski (1989)
IV: Highly Weathered		**P**: Poor	
V: Completely Weathered		**VP**: Very Poor	
VI: Residual/Soil			

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1 **LOCATION:** MERU. **CLIENT:** NATIONAL HOUSING CORPORATION.	TERRACONSULT KENYA LIMITED	**ELEVATION (m):** 1682 **COORDINATES (UTM-WGS84):** E 0349129, N 0005855, ZONE 37 N **DATE(S):** START 10/02/19, END 23/02/19	
	BOREHOLE LOG	**Sheet No:** 1 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 103	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0 – 1	1.5					Dry, stiff, dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
1 – 2	1.5					Moist, firm, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					8
2 – 3												
3 – 4	1.5					Moist, firm, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					12
4 – 5	1.5					Moist, firm, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					Refusal
5 – 6	1.5					Moist, firm, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
6 – 7	1.5					Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			
7 – 8	2					Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1682
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349129 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005855
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 2 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 103	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
9												
10	2				TRACHYTE	Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			
11												
12	2				TRACHYTE	Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			
13												
14	1.5				TRACHYTE	Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			
15												
16	1.5				TRACHYTE	Light Grey, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI			
17	2	50	25	3	PHONOLITE	Pale Grey, fine grained, highly weathered, highly fractured, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	IV	1	RI	>20	VP	

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1682
LOCATION: MERU.		COORDINATES (UTM-WGS84) E	0349129 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.		COORDINATES (UTM-WGS84) N	0005855
		DATE(S) START	10/02/19
		DATE(S) END	23/02/19
	BOREHOLE LOG	**Sheet No:** 3 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 103	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.10 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
18												
19	2	50	10	3	 PHONOLITE	Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
20												
21	1	100	100	20	 PHONOLITE	Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	1	E	
22	1.5	25	0	3	 PHONOLITE	Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
23												
24	2	25	0	3	 PHONOLITE	Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
25												

WEATHERING GRADES	**FRACTURE ASPERITIES**	**ROCK MASS QUALITY**	
I: Fresh & Hard	**RI**: Rough and Irregular	**E**: Excellent	**TCR:** Total Core Recovery Ratio
II: Slightly Weathered	**RU**: Rough and Undulating	**G**: Good	**RQD:** Rock Quality Designation
III: Moderately Weathered		**Fa**: Fair	**RMR:** Rock Mass Rating after Bieniawski (1989)
IV: Highly Weathered		**P**: Poor	
V: Completely Weathered		**VP**: Very Poor	
VI: Residual/Soil			

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1691		
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E	0349087	ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N	0005886	
		DATE(S)	START	10/02/19	
			END	23/02/19	
	BOREHOLE LOG	**Sheet No:** 1 of 3			
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail			
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 104			
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m			
		Inclination From Vertical: 0°			

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0 – 1	1.5				CLAYEY SILT	Moist, firm, fine grained, reddish brown clayey SILT wth some sand and traces of gravel. Has medium plasticity.						
2	1.5				CLAYEY SILT	Moist, firm, fine grained, reddish brown clayey SILT wth some sand and traces of gravel. Has medium plasticity.	VI					7
3 – 4	1.5				CLAYEY SILT	Moist, firm, fine grained, reddish brown clayey SILT wth some sand and traces of gravel. Has medium plasticity.	VI					11
5	1.5				CLAYEY SILT	Moist, firm, fine grained, reddish brown clayey SILT wth some sand and traces of gravel. Has medium plasticity.	VI					
6 – 7	1.5				CLAYEY SILT	Dry, stiff, fine grained, reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
8	1.5				CLAYEY SILT	Firm, dry, Dark brownish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					

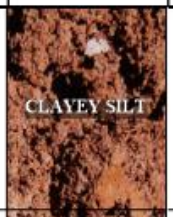
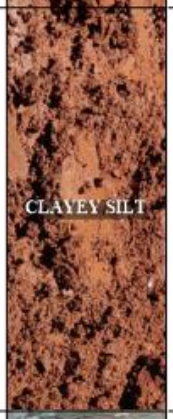
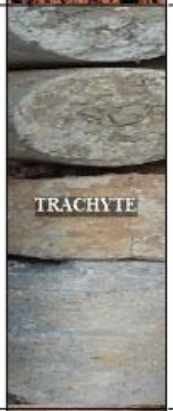
WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1691		
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E	0349087	ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N	0005886	
		DATE(S)	START	10/02/19	
			END	23/02/19	
	BOREHOLE LOG	**Sheet No:** 2 of 3			
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail			
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 104			
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m			
		Inclination From Vertical: 0°			

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
9 – 10	1.5					Firm, dry, Dark brownish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
11 – 12 – 13	3					Firm, dry, Dark brownish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
14 – 15 – 16	3	25	14	3		Light grey, highly weathered, fine grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	>20	VP	
17	1.5	33	0	3		Reddish grey, highly weathered, fine to coarse grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	RUBBLED	VP	

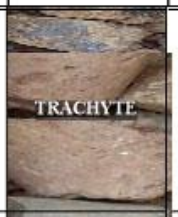
WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1691
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349087 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005886
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 3 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 104	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
		Inclination From Vertical: 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
18–19	1.5	66	15	3		Reddish grey, highly weathered, fine to coarse grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	>20	VP	
20–21	1.5	80	75	17		Reddish grey, highly weathered, fine to coarse grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	8	G	
21–22	1.5	100	80	17		Greenish grey, highly weathered, fine grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces.	IV	1	RI	5	G	
23	1	80	65	13		Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	7	Fa	
24–25	1.5	66	60	13		Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	7	Fa	

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1693
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349111 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005918
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 1 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 105	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.30 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0 – 1	1.5				CLAYEY SILT	Moist, fine grained, stiff dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
2	1.5				CLAYEY SILT	Moist, fine grained, stiff dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					9
3 – 4	1.5				CLAYEY SILT	Moist, fine grained, stiff dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					10
5	1.5				CLAYEY SILT	Moist, fine grained, stiff dark reddish brown clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					13
6 – 7	2				CLAYEY SILT	Firm, reddish brown clayey SILT with some sand and trace gravels. Has medium plasticity.	VI					
8 – 9	1.5	30	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Completely decomposed to soil.	IV	1	RI	RUBBLED	VP	

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1693
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349111 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005918
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 2 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 105	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.30 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
10	1.5	25	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures.	IV	1	RI	RUBBLED	VP	
11	1.5	36	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
12	1.5	21	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
13	1.5	30	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
14	1.5	36	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
15	1.5	24	0		TRACHYTE	Light Brown, fine grained, non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
16						Light Brown, fine grained,						
17												
18												
19												

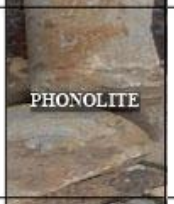
WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1693
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E 0349111 ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N 0005918
		DATE(S)	START 10/02/19
			END 23/02/19
	BOREHOLE LOG	**Sheet No:** 3 of 3	
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail	
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 105	
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m	
Apparent Depth of Ground Water: 13.30 m		**Inclination From Vertical:** 0°	

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
20	1.5	53	0			non-vesicular, highly weathered, relatively soft TRACHYTE. Characterised by both vertical and horizontal open fractures. Rubbled.	IV	1	RI	RUBBLED	VP	
21	1.5	33	0			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	RUBBLED	VP	
22	1.5	33	25			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
23	1.5	27	13			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
24	0.5	27	13			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
25												

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1687		
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E	0349146	ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N	0005902	
		DATE(S)	START	10/02/19	
			END	23/02/19	
	BOREHOLE LOG	**Sheet No:** 1 of 3			
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail			
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 106			
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m			
Apparent Depth of Ground Water: 13.14 m		**Inclination From Vertical:** 0°			

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
0 – 1	1.5				CLAYEY SILT	Moist, stiff, fine grained, reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
2	1.5				CLAYEY SILT	Moist, stiff, fine grained, reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					10
3 – 4	1.5				CLAYEY SILT	Moist, stiff, fine grained, reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					12
5	1.5				CLAYEY SILT	Moist, stiff, fine grained, darkish brown to reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					12
6 – 7	1.5				CLAYEY SILT	Moist, stiff, fine grained, darkish brown to reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					15
8	1.5				CLAYEY SILT	Moist, stiff, fine grained, darkish brown to reddish brown, clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					16

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1687		
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E	0349146	ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N	0005902	
		DATE(S)	START	10/02/19	
			END	23/02/19	
	BOREHOLE LOG	Sheet No: 2 of 3			
File No: 3-19-10	Logged By: Winnie Munene	Checked By: Dr. Issa Ismail			
Drilling Method: Rotary	Drill Bit Type: 86-101mm Diamond	Borehole No: 106			
Drill Rig Type: GY 150T	Drilled By: Justus Owino	Depth: 25.00 m			
Apparent Depth of Ground Water: 13.14 m		Inclination From Vertical: 0°			

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
9												
	1.5				CLAYEY SILT	Firm, dark brown to blackish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					13
10												
	1.5				CLAYEY SILT	Firm, dark brown to blackish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					13
11												
12												
	3				CLAYEY SILT	Firm, dark brown to blackish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					26
13												
14												
15												
	3				CLAYEY SILT	Firm, dark brown to blackish clayey SILT with some sand and traces of gravel. Has medium plasticity.	VI					
16												
17												

WEATHERING GRADES
- **I**: Fresh & Hard
- **II**: Slightly Weathered
- **III**: Moderately Weathered
- **IV**: Highly Weathered
- **V**: Completely Weathered
- **VI**: Residual/Soil

FRACTURE ASPERITIES
- **RI**: Rough and Irregular
- **RU**: Rough and Undulating

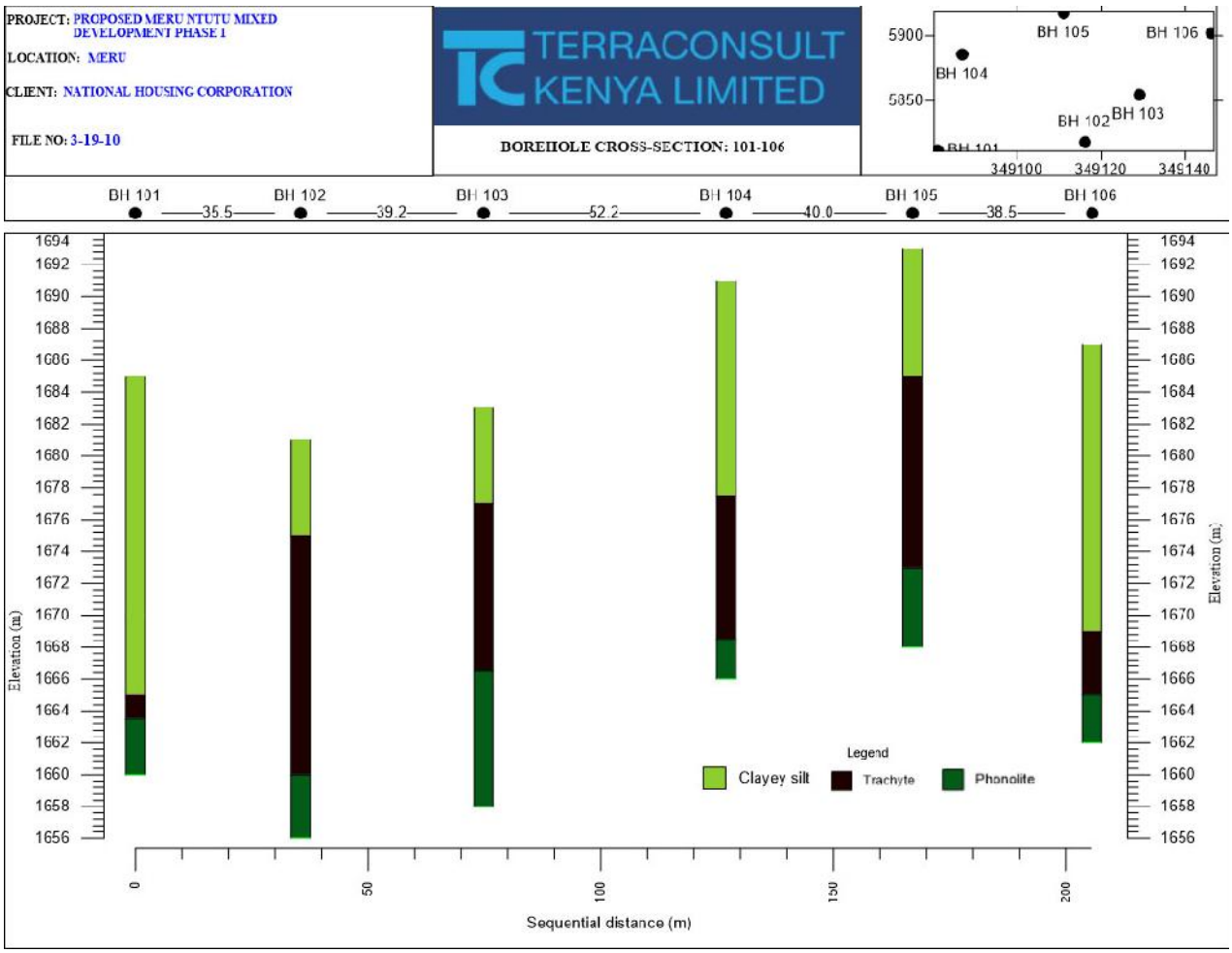
ROCK MASS QUALITY
- **E**: Excellent
- **G**: Good
- **Fa**: Fair
- **P**: Poor
- **VP**: Very Poor

- **TCR:** Total Core Recovery Ratio
- **RQD:** Rock Quality Designation
- **RMR:** Rock Mass Rating after Bieniawski (1989)

PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1	TERRACONSULT KENYA LIMITED	ELEVATION (m)	1687		
LOCATION: MERU.		COORDINATES (UTM-WGS84)	E	0349146	ZONE 37 N
CLIENT: NATIONAL HOUSING CORPORATION.			N	0005902	
		DATE(S)	START	10/02/19	
			END	23/02/19	
	BOREHOLE LOG	**Sheet No:** 3 of 3			
File No: 3-19-10	**Logged By:** Winnie Munene	**Checked By:** Dr. Issa Ismail			
Drilling Method: Rotary	**Drill Bit Type:** 86-101mm Diamond	**Borehole No:** 106			
Drill Rig Type: GY 150T	**Drilled By:** Justus Owino	**Depth:** 25.00 m			
Apparent Depth of Ground Water: 13.14 m		**Inclination From Vertical:** 0°			

Depth (m)	ROCK CORE: Run (m)	TCR (%)	RQD (%)	RMR (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION	Weathering Grade	RMR (Weathering Grade)	Fracture Asperities	Fracture Frequency	Rock Mass Quality	SPT (N-Value)
18 – 22	4	40	0			Light grey, highly weathered, fine grained, porphyritic, relatively soft TRACHYTE. Characterised by open, rough and irregular fracture surfaces. Rubbled	IV	1	RI	RUBBLED	VP	
22 – 24	2	47	20			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	>20	VP	
24 – 25	1	70	40			Pale Grey, fine grained, moderately weathered, hard PHONOLITE. Characterised by both vertical and horizontal open fractures.	III	3	RI	9	P	

WEATHERING GRADES	**FRACTURE ASPERITIES**	**ROCK MASS QUALITY**	
I: Fresh & Hard	**RI**: Rough and Irregular	**E**: Excellent	**TCR:** Total Core Recovery Ratio
II: Slightly Weathered	**RU**: Rough and Undulating	**G**: Good	**RQD:** Rock Quality Designation
III: Moderately Weathered		**Fa**: Fair	**RMR:** Rock Mass Rating after Bieniawski (1989)
IV: Highly Weathered		**P**: Poor	
V: Completely Weathered		**VP**: Very Poor	
VI: Residual/Soil			


PROJECT: PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
LOCATION: MERU
CLIENT: NATIONAL HOUSING CORPORATION
FILE NO: 3-19-10
TERRACONSULT KENYA LIMITED
BOREHOLE CROSS-SECTION: 101-106
BH 101
BH 102
BH 103
BH 104
BH 105
BH 106
35.5
39.2
52.2
40.0
38.5
Elevation (m)
Sequential distance (m)
Legend
Clayey silt
Trachyte
Phonolite

8. APPENDIX B-Sample Photographs

Typical U100 (undisturbed) Samples

Borehole 101: 1.00-1.50m

Borehole 102: 3.00-3.50m

Borehole 103: 5.50-6.00m

Borehole 106: 8.50-9.00m

DRY SAMPLES

Borehole 101: 20.00-25.00m

Borehole 102: 6.00-25.00m

Borehole 103: 6.00-18.50m

Borehole 103: 18.50-25.00m

Borehole 104: 13.50-23.50m

Borehole 104: 23.50-25.00m

Borehole 105: 8.00-20.00m

Borehole 105: 20.00-25.50m

Borehole 106: 18.00-24.50m

WET SAMPLES

Borehole 101: 20.00-25.00m

Borehole 102: 6.00-25.00m

Borehole 103: 6.00-18.50m

Borehole 103: 18.50-25.00m

Borehole 104: 13.50-23.50m

Borehole 104: 23.50-25.00m

Borehole 105: 6.00-20.00m

Borehole 105: 20.00-25.50m

Borehole 106: 18.00-24.50m

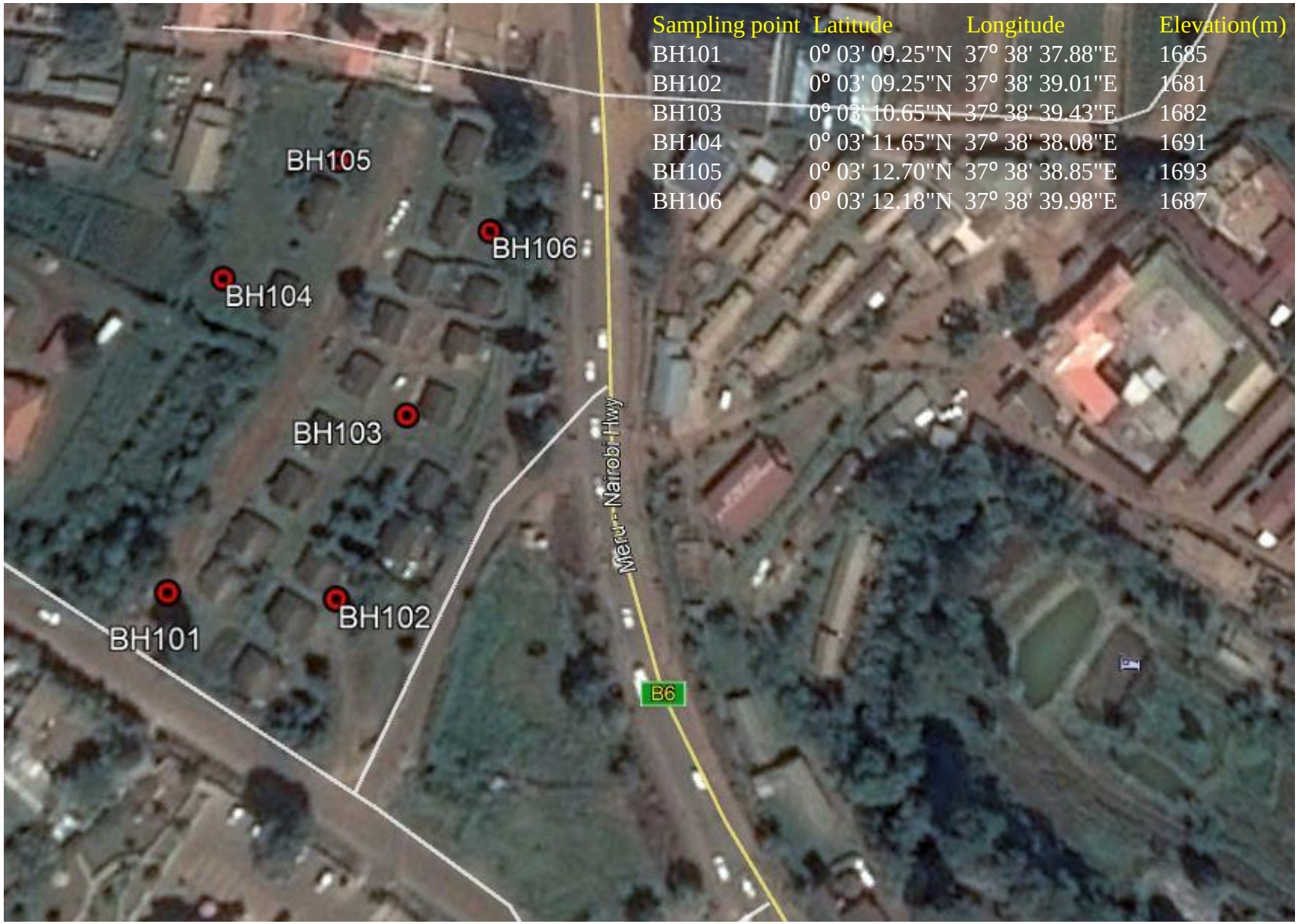


Figure B-1 Topographic map indicating site location

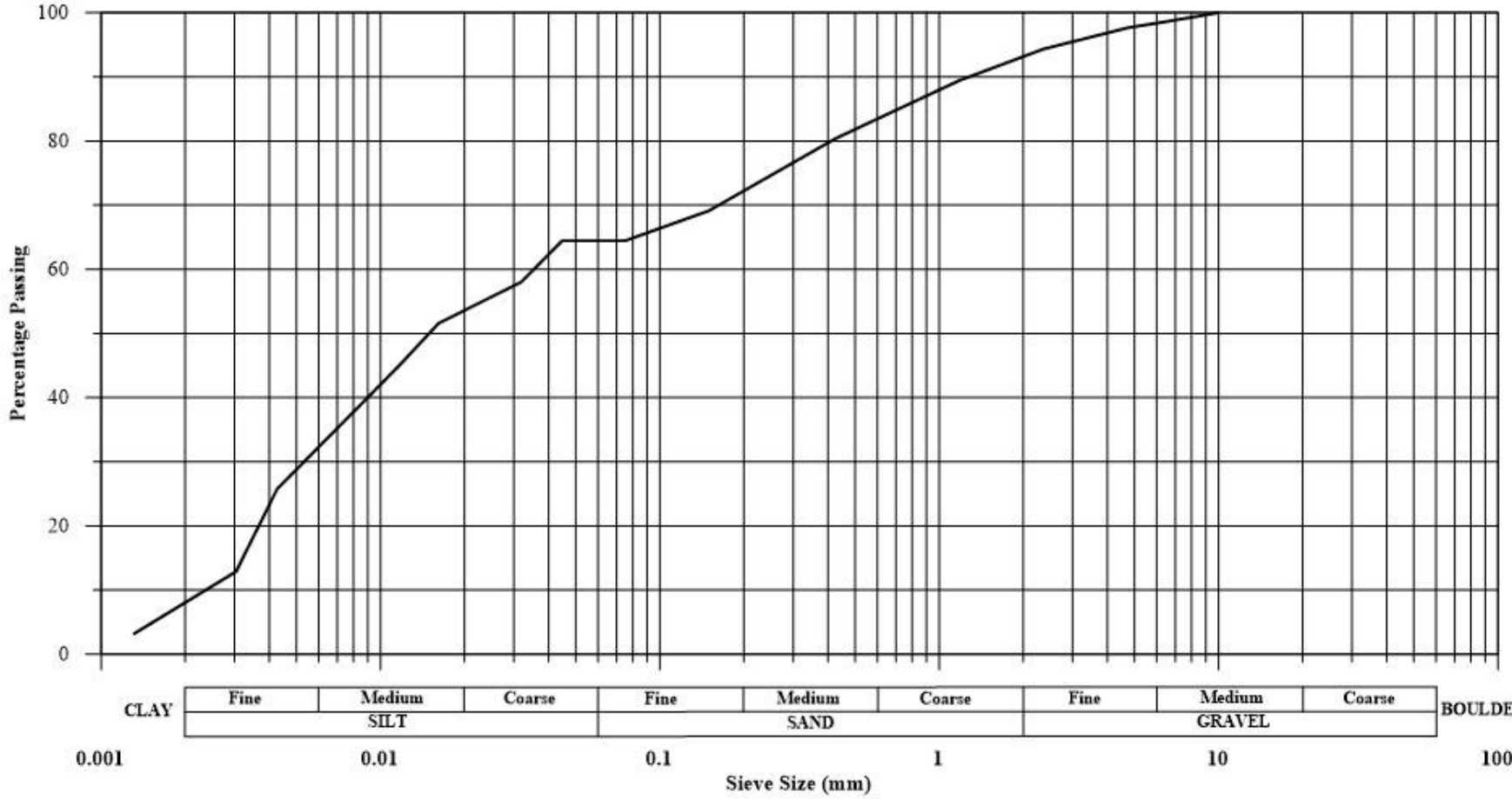
9. APPENDIX C- Laboratory Results

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 101
Depth (m): 6.0 to 7.5
Fines: 64.46 %



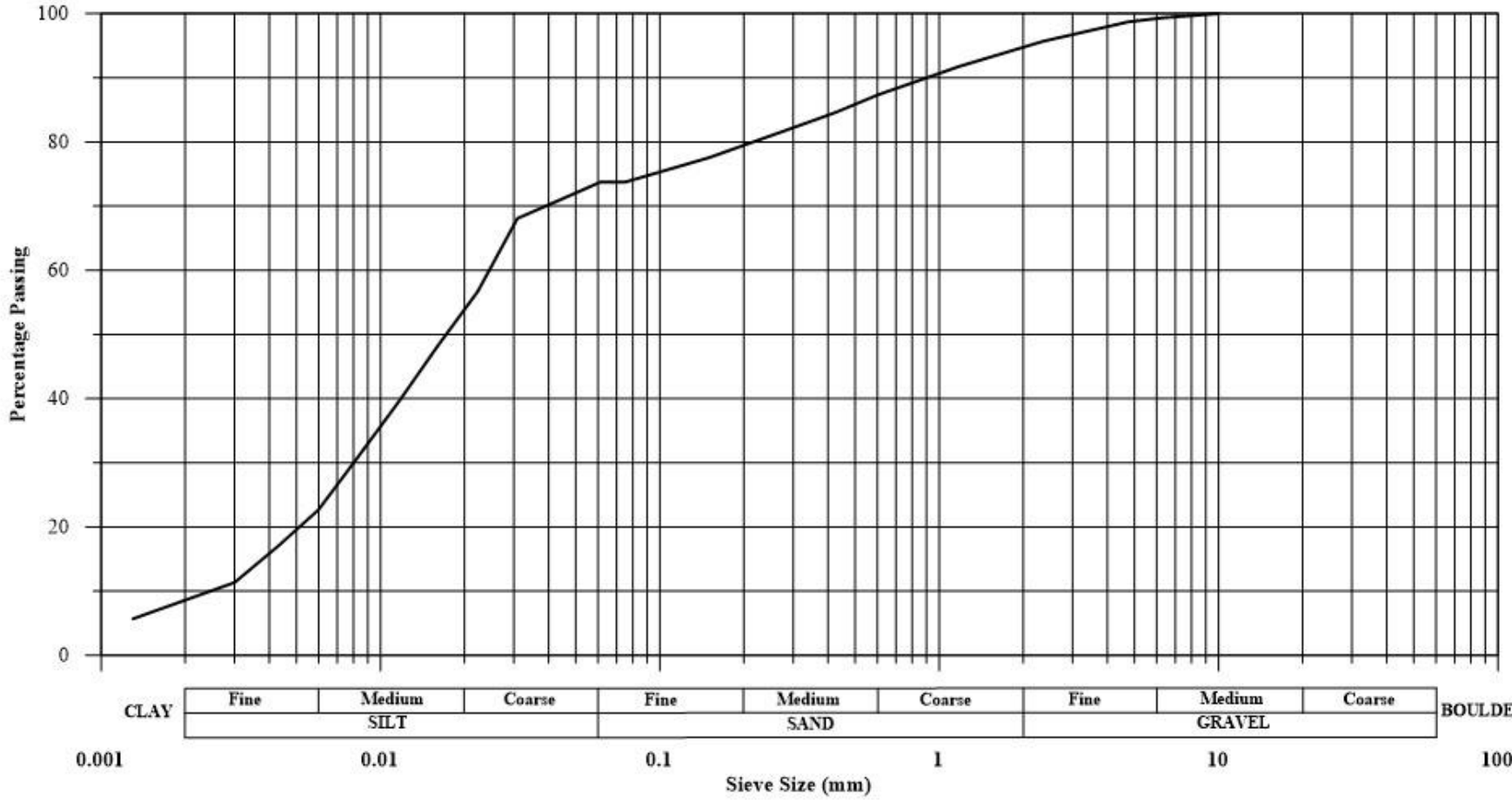
Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 101
Depth (m): 13.5 to 15.0
Fines: 73.74 %



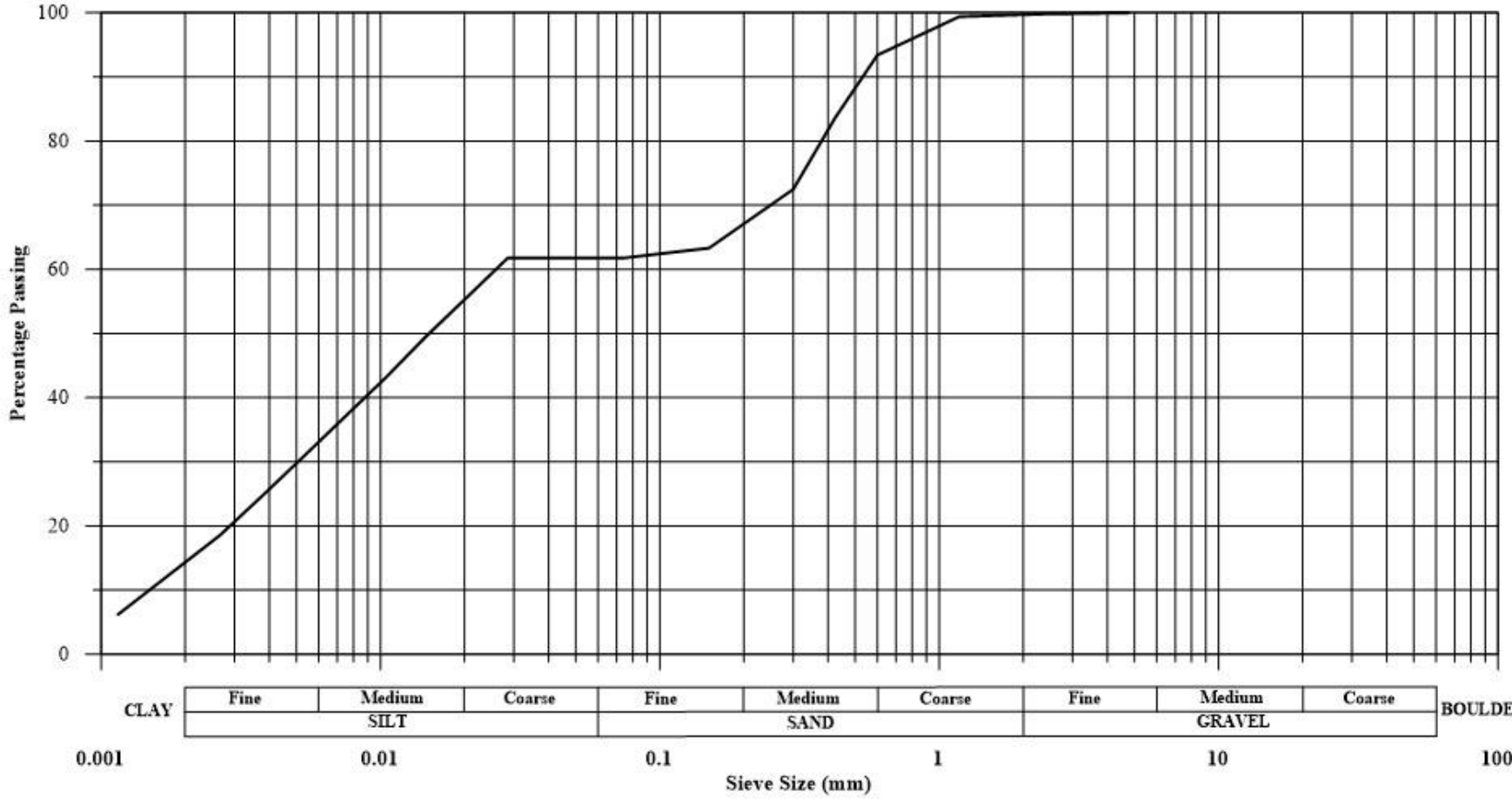
Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 103
Depth (m): 3.0 to 4.5
Fines: 61.78 %



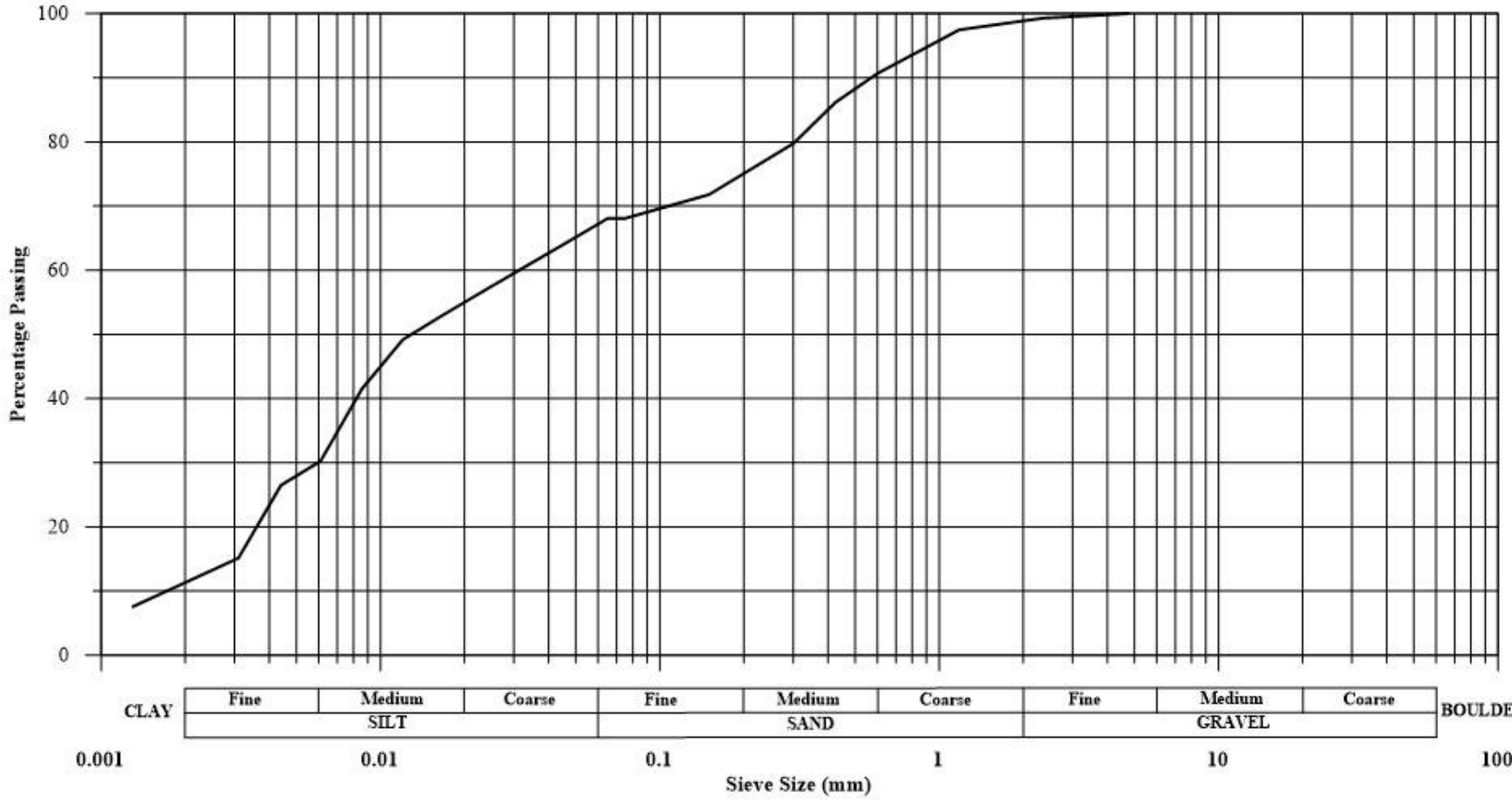
Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 104
Depth (m): 4.5 to 6.0
Fines: 68.07 %



Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

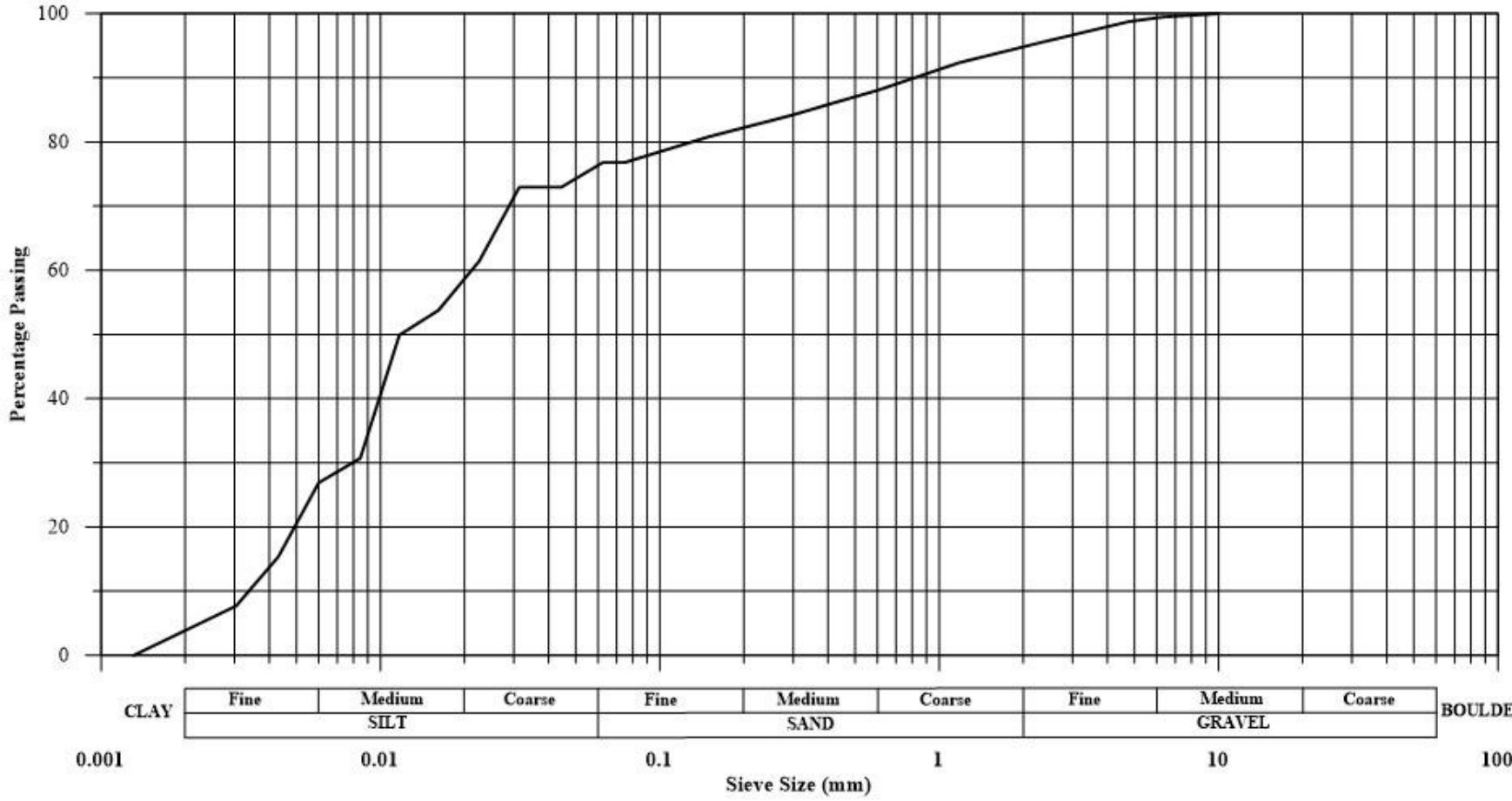
GEOISSA ENGINEERS LTD

Consulting Engineers & Material Testing Laboratories

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 104
Depth (m): 9.0 to 13.5
Fines: 76.80 %



Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

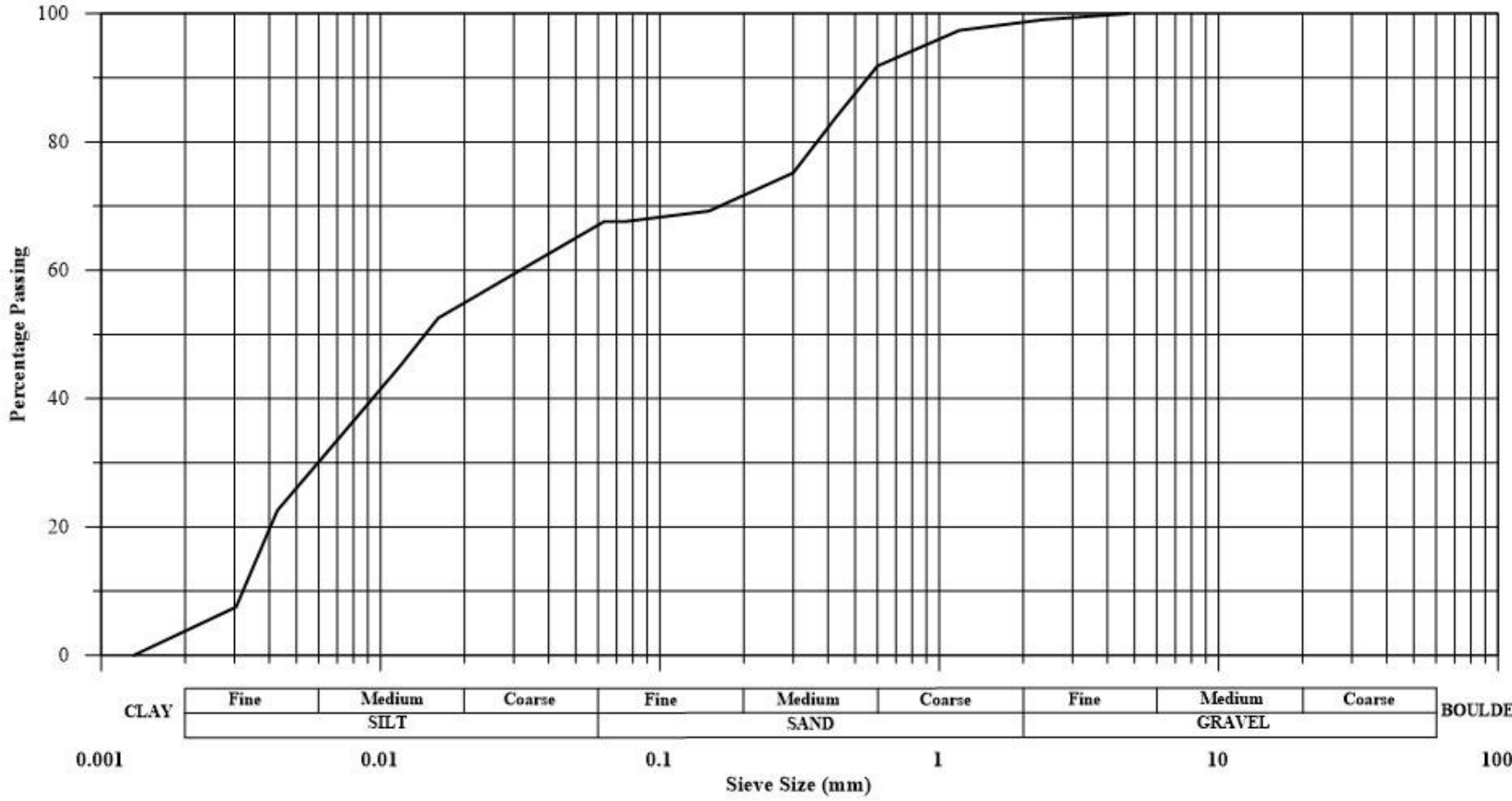
GEOISSA ENGINEERS LTD

Consulting Engineers & Material Testing Laboratories

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 105
Depth (m): 1.5 to 3.0
Fines: 67.60 %



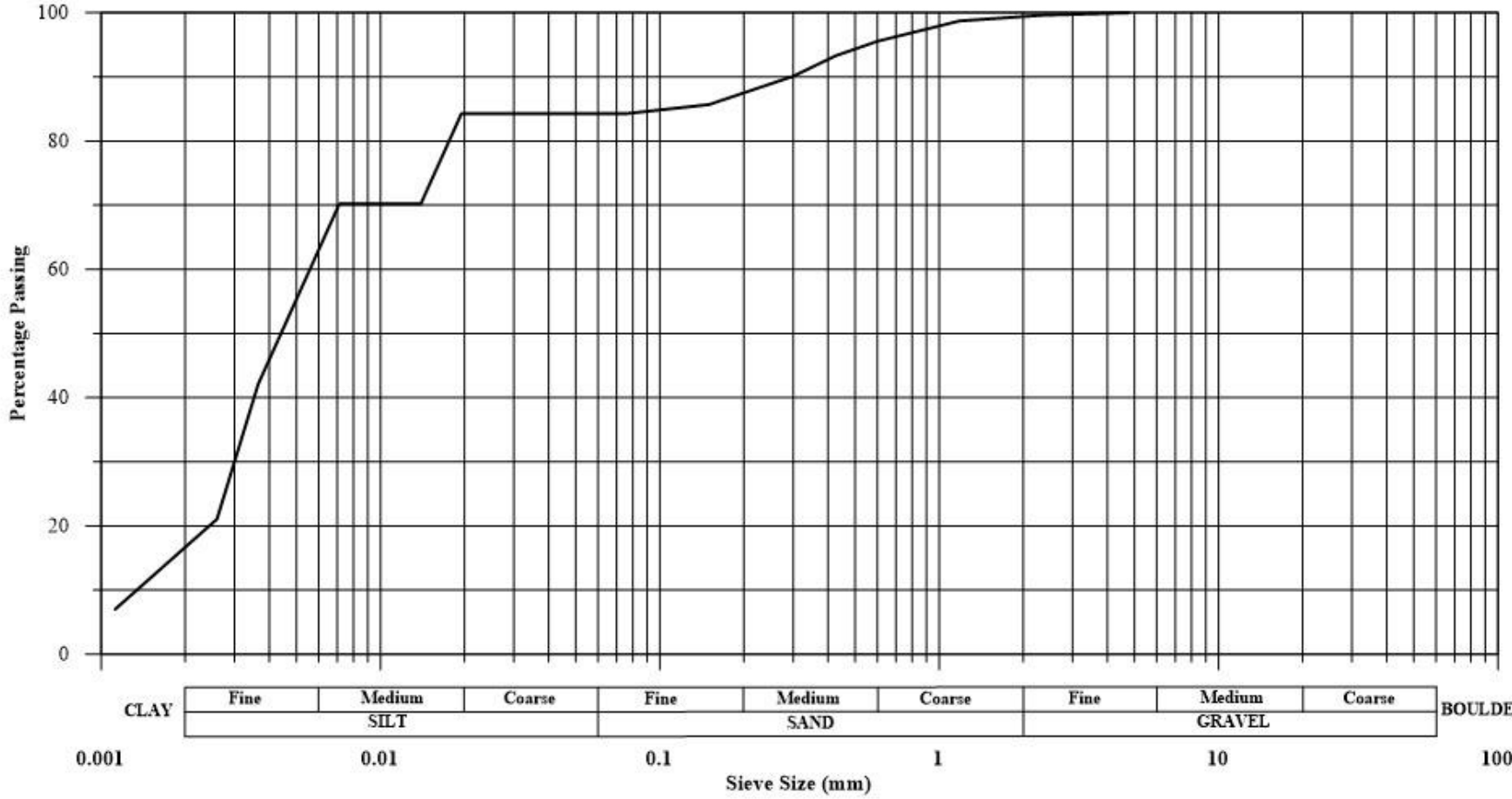
Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 106
Depth (m): 0.0 to 1.5
Fines: 84.25 %



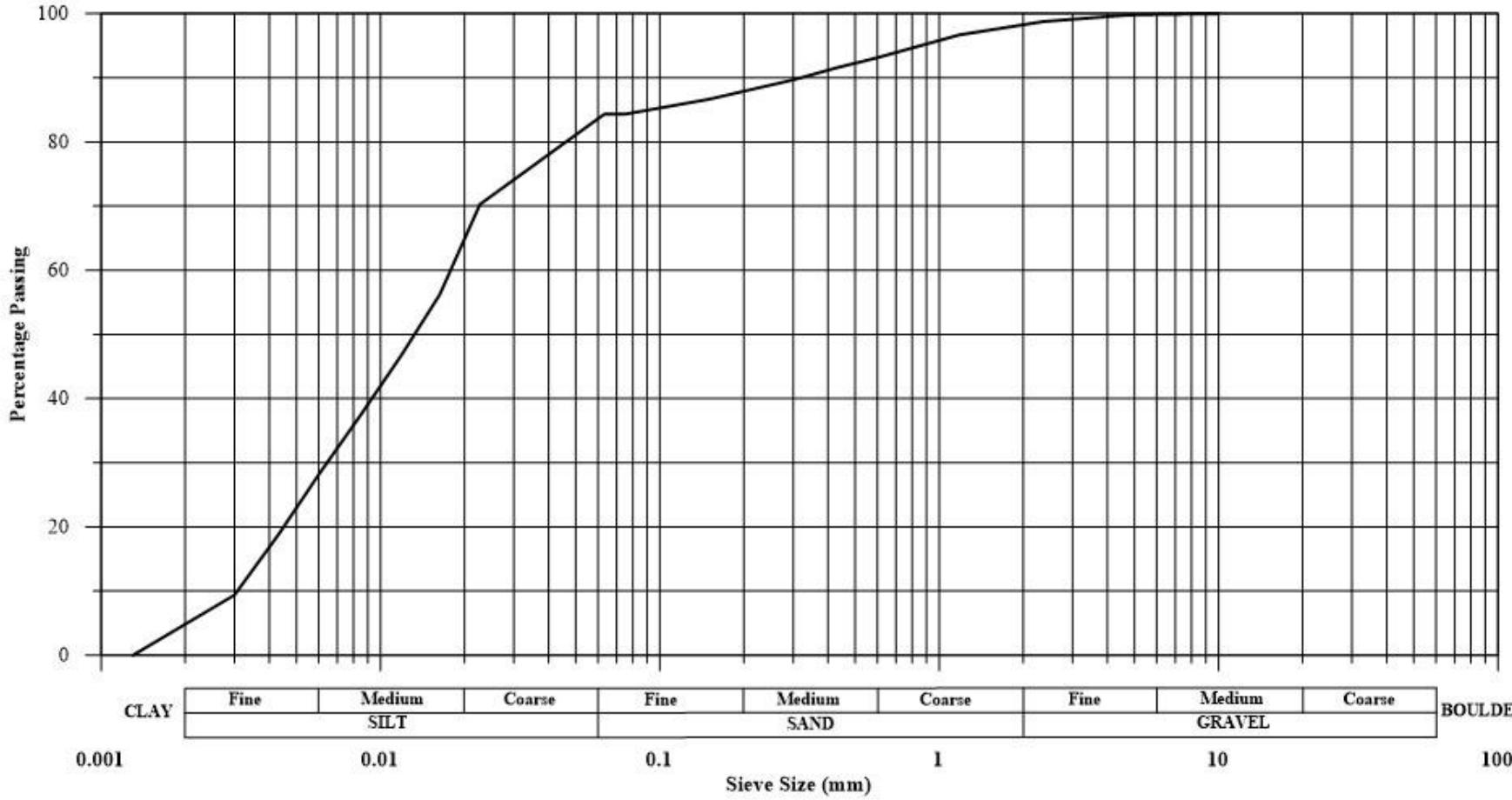
Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories
Likoni Lane
P. O. Box 35305 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

PARTICLE SIZE ANALYSIS

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION

Borehole No. : BH 106
Depth (m): 13.5 to 15.0
Fines: 84.33 %



Date : 01-03-2019 Tested by : ERIC JUMA Reported by : CLEMENT MURIITHI Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 27-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 101 (6.0-7.5)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	19.95	21.16	23.18	
Container No.	**H**	**T2**	**M**	
Container weight (gm)	14.2	14.2	14.5	
Wet soil + container (gm)	65.2	62.4	66.5	
Wet soil (gm). W_w	51.0	48.2	52.0	
Dry soil + container (gm)	48.5	46.3	49.0	
Dry soil (gm), W_d	34.3	32.1	34.6	
Moisture loss (gm), $W_w - W_d$	16.7	16.1	17.5	
Moisture content (%), $(W_w - W_d)/W_d$	**48.72**	**50.19**	**50.52**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**B8**	**T8**
Container weight (gm)	14.3	14.4
Wet soil + container (gm)	43.9	39.6
Wet soil (gm), *Ww*	29.6	25.2
Dry soil + container (gm)	35.2	32.1
Dry soil (gm), *Wd*	20.9	17.8
Moisture loss (gm), *Ww - Wd*	8.7	7.5
Moisture content (%), *(Ww - Wd)/Wd*	41.8	41.9
Average moisture content (%)	**41.9**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**49**
Plastic Limit (%)	**42**
Plasticity Index, PI = LL - PL	**7**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 27-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 101 (13.5-15.0)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	18.16	20.36	22.81	
Container No.	**B7**	**GE07**	**T9**	
Container weight (gm)	14.1	14.2	14.2	
Wet soil + container (gm)	66.7	72.0	61.2	
Wet soil (gm). W_w	52.6	57.9	47.0	
Dry soil + container (gm)	52.1	55.6	47.5	
Dry soil (gm), W_d	38.0	41.5	33.3	
Moisture loss (gm), W_w - W_d	14.6	16.4	13.7	
Moisture content (%), $(W_w - W_d)/W_d$	**38.34**	**39.50**	**41.22**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**I**	**II**
Container weight (gm)	14.2	14.3
Wet soil + container (gm)	38.1	37.8
Wet soil (gm), *Ww*	23.9	23.5
Dry soil + container (gm)	32.2	32.0
Dry soil (gm), *Wd*	18.0	17.7
Moisture loss (gm), *Ww - Wd*	5.9	5.8
Moisture content (%), *(Ww - Wd)/Wd*	32.9	33.0
Average moisture content (%)	**32.9**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**39**
Plastic Limit (%)	**33**
Plasticity Index, PI = LL - PL	**6**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 27-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 103 (3.0-4.5)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	18.10	20.11	22.36	
Container No.	**GE03**	**K**	**GE05**	
Container weight (gm)	14.5	14.1	14.2	
Wet soil + container (gm)	56.8	59.2	63.7	
Wet soil (gm). W_w	42.3	45.1	49.5	
Dry soil + container (gm)	41.0	41.9	44.4	
Dry soil (gm), W_d	26.5	27.8	30.2	
Moisture loss (gm), W_w - W_d	15.8	17.3	19.3	
Moisture content (%), $(W_w - W_d)/W_d$	**59.58**	**62.11**	**64.03**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**V**	**G2**
Container weight (gm)	14.2	14.2
Wet soil + container (gm)	35.2	33.1
Wet soil (gm), *Ww*	21.1	18.9
Dry soil + container (gm)	28.2	26.8
Dry soil (gm), *Wd*	14.0	12.5
Moisture loss (gm), *Ww - Wd*	7.0	6.3
Moisture content (%), *(Ww - Wd)/Wd*	50.1	50.5
Average moisture content (%)	**50.3**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**62**
Plastic Limit (%)	**50**
Plasticity Index, PI = LL - PL	**12**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 26-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 104 (4.5-6.0)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	16.17	18.14	20.17	
Container No.	**T65**	**G9**	**B10**	
Container weight (gm)	14.3	14.3	14.1	
Wet soil + container (gm)	68.2	65.1	68.3	
Wet soil (gm). W_w	53.9	50.8	54.2	
Dry soil + container (gm)	50.8	48.5	50.1	
Dry soil (gm), W_d	36.5	34.2	36.0	
Moisture loss (gm), $W_w - W_d$	17.4	16.6	18.2	
Moisture content (%), $(W_w - W_d)/W_d$	**47.65**	**48.65**	**50.53**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**B6**	**GE03**
Container weight (gm)	14.3	14.2
Wet soil + container (gm)	38.9	40.9
Wet soil (gm), *Ww*	24.6	26.7
Dry soil + container (gm)	31.9	33.3
Dry soil (gm), *Wd*	17.7	19.1
Moisture loss (gm), *Ww - Wd*	7.0	7.6
Moisture content (%), *(Ww - Wd)/Wd*	39.6	39.6
Average moisture content (%)	**39.6**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**50**
Plastic Limit (%)	**40**
Plasticity Index, PI = LL - PL	**11**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 26-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 104 (9.0-13.5)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	19.45	21.32	23.11	
Container No.	**4**	**D**	**5**	
Container weight (gm)	14.2	14.2	14.0	
Wet soil + container (gm)	64.5	67.7	58.7	
Wet soil (gm). W_w	50.3	53.5	44.7	
Dry soil + container (gm)	47.8	49.5	43.1	
Dry soil (gm), W_d	33.6	35.3	29.1	
Moisture loss (gm), W_w - W_d	16.7	18.2	15.6	
Moisture content (%), $(W_w - W_d)/W_d$	**49.63**	**51.59**	**53.66**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**T4**	**G1**
Container weight (gm)	14.4	14.1
Wet soil + container (gm)	35.3	32.9
Wet soil (gm), *Ww*	20.9	18.8
Dry soil + container (gm)	29.6	27.7
Dry soil (gm), *Wd*	15.2	13.7
Moisture loss (gm), *Ww - Wd*	5.7	5.2
Moisture content (%), *(Ww - Wd)/Wd*	37.6	37.9
Average moisture content (%)	**37.8**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**50**
Plastic Limit (%)	**38**
Plasticity Index, PI = LL - PL	**13**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 27-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 105 (1.5-3.0)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	18.43	20.13	22.36	
Container No.	**GE08**	**B8**	**T6**	
Container weight (gm)	14.1	13.9	14.1	
Wet soil + container (gm)	64.8	60.9	61.9	
Wet soil (gm). W_w	50.6	47.0	47.8	
Dry soil + container (gm)	47.3	44.3	44.3	
Dry soil (gm), W_d	33.2	30.4	30.2	
Moisture loss (gm), W_w - W_d	17.4	16.6	17.7	
Moisture content (%), $(W_w - W_d)/W_d$	**52.53**	**54.70**	**58.64**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**R**	**A**
Container weight (gm)	14.2	14.3
Wet soil + container (gm)	38.9	38.7
Wet soil (gm), *Ww*	24.7	24.4
Dry soil + container (gm)	31.8	31.7
Dry soil (gm), *Wd*	17.7	17.4
Moisture loss (gm), *Ww - Wd*	7.1	6.9
Moisture content (%), *(Ww - Wd)/Wd*	39.9	39.8
Average moisture content (%)	**39.9**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**55**
Plastic Limit (%)	**40**
Plasticity Index, PI = LL - PL	**15**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD

Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 27-Feb-2019

Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**

Sample Description : **BH 106 (0.0-1.5)M**

Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	18.26	20.18	22.17	
Container No.	**T7**	**T5**	**E**	
Container weight (gm)	14.0	14.2	14.0	
Wet soil + container (gm)	54.8	53.0	50.0	
Wet soil (gm). W_w	40.8	38.8	36.0	
Dry soil + container (gm)	40.8	39.4	37.0	
Dry soil (gm), W_d	26.8	25.2	23.0	
Moisture loss (gm), W_w - W_d	14.0	13.6	13.0	
Moisture content (%), $(W_w - W_d)/W_d$	**52.41**	**54.07**	**56.48**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**100**	**5**
Container weight (gm)	14.0	14.1
Wet soil + container (gm)	34.8	33.4
Wet soil (gm), *Ww*	20.8	19.3
Dry soil + container (gm)	28.5	27.5
Dry soil (gm), *Wd*	14.5	13.4
Moisture loss (gm), *Ww - Wd*	6.4	5.9
Moisture content (%), *(Ww - Wd)/Wd*	43.9	43.7
Average moisture content (%)	**43.8**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**54**
Plastic Limit (%)	**44**
Plasticity Index, PI = LL - PL	**10**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

LIQUID LIMIT (CONE PENETROMETER) AND PLASTIC LIMIT TEST RESULTS

Client: **NATIONAL HOUSING CORPORATION** Date tested: 26-Feb-2019
Project: **PROPOSED MERU NTUTU DEVELOPMENT PHASE 1**
Sample Description : **BH 106 (13.5-15.0)M**
Test Method: BS1377-2: 1990

LIQUID LIMIT

TEST NUMBER	1	2	3	4
Cone penetration (mm)	18.75	20.45	22.17	
Container No.	**V**	**B9**	**GEOJ**	
Container weight (gm)	14.2	14.3	14.2	
Wet soil + container (gm)	62.4	61.8	70.0	
Wet soil (gm). W_w	48.3	47.5	55.8	
Dry soil + container (gm)	46.5	45.8	51.0	
Dry soil (gm), W_d	32.3	31.6	36.7	
Moisture loss (gm), W_w - W_d	15.9	15.9	19.0	
Moisture content (%), $(W_w - W_d)/W_d$	**49.23**	**50.46**	**51.82**	

PLASTIC LIMIT:

TEST NUMBER	1	2
Container No.	**B4**	**GE01**
Container weight (gm)	14.0	14.1
Wet soil + container (gm)	37.6	36.4
Wet soil (gm), *Ww*	23.6	22.3
Dry soil + container (gm)	31.4	30.5
Dry soil (gm), *Wd*	17.4	16.4
Moisture loss (gm), *Ww - Wd*	6.2	5.9
Moisture content (%), *(Ww - Wd)/Wd*	35.6	35.7
Average moisture content (%)	**35.7**	

SHRINKAGE LIMIT:

SAMPLE DESCRIPTION		
Initial Length, L_o	mm	
Oven-dried Length, L_D	mm	
Clause 6.5.5 Linear Shrinkage = $\left(1 - \frac{L_D}{L_o}\right) x\ 100$	%	

SUMMARY:

Moisture Content at 20mm Penetration (%)	**50**
Plastic Limit (%)	**36**
Plasticity Index, PI = LL - PL	**14**

PI	DESCRIPTION
0	Non-plastic
1 - 5	Slightly plastic
5 - 10	Low plasticity
10 - 20	Medium plasticity
20 - 40	High plasticity
> 40	Very high plasticity

Tested by: GRACE MAINA

Checked by: DR. ISSA ISMAIL

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 101 (1.5-3.0)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	89.0	85.3	15.4	29.725	0.950	90	2.319E-04
2	84.0	81.7	15.4	29.725	0.950	60	2.275E-04
3	75.1	73.7	15.4	29.725	0.950	45	2.056E-04
						Average	**2.217E-04**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 101 (5.5-6.0)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	89.0	86.5	15.4	29.725	0.950	165	8.489E-05
2	86.0	84.7	15.4	29.725	0.950	90	8.320E-05
3	84.1	82.5	15.4	29.725	0.950	120	7.869E-05
						Average	**8.226E-05**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 102 (4.0-4.5)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	89.0	88.4	15.4	29.725	0.950	90	3.695E-05
2	88.0	87.2	15.4	29.725	0.950	120	3.741E-05
3	85.5	85.2	15.4	29.725	0.950	45	3.840E-05
						Average	**3.759E-05**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 103 (4.5-6.0)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	89.0	83.3	15.4	29.725	0.950	60	5.423E-04
2	89.0	84.9	15.4	29.725	0.950	45	5.152E-04
3	89.0	86.2	15.4	29.725	0.950	30	5.238E-04
						Average	**5.271E-04**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 105 (1.0-1.5)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	87.9	86.8	15.4	29.725	0.950	92	6.729E-05
2	86.2	84.7	15.4	29.725	0.950	120	7.192E-05
3	84.0	83.3	15.4	29.725	0.950	60	6.857E-05
						Average	**6.926E-05**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA
ENGINEERS LIMITED
INDEPENDENT MATERIAL TESTING LABORATORIES

Likoni Lane off Dennis Pritt Road
P. O. Box 35035 - 00100 Nairobi,Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel:+254-020-2635002,Cell:254-729-818 418

FALLING HEAD PERMEABILITY TEST

Project: **PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1**

Client: **NATIONAL HOUSING CORPORATION**

Sample: **BH 106 (7.5-9.0)M**

Test	Standpipe readings (cm)		Length of soil sample (cm), L	Cross-section area of the soil sample (cm^2), A	Cross-section area of stand pipe (cm^2), a	Time (sec), t	Permeability (cm/sec), k
	h_0	h_1					
1	89.0	86.5	15.4	29.725	0.950	60	2.335E-04
2	88.0	84.4	15.4	29.725	0.950	90	2.282E-04
3	85.5	83.4	15.4	29.725	0.950	60	2.038E-04
						Average	**2.218E-04**

Tested by: Clement Muriithi

Approved by : Dr Issa Ismail

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 101 (2.5-3.0)M**
Test date: **26-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							77.98	g
MASS OF RING + TRAY + SPECIMEN							1612.7	g
MASS OF RING							58.37	g
MASS OF TRAY							1483.11	g
MASS OF DRY SPECIMEN (ms)							57.16	g
MASS OF MOISTURE							20.82	g
MOISTURE CONTENT (m)							48.5	%
BULK DENSITY (ρ)							1.76	g/cm³
DRY DENSITY (ρd)							1.18	g/cm³
INITIAL VOID RATIO (e_o)							1.28	
DEGREE OF SATURATION (Sr)	m /(ρw/ρd - 1/Gs)						102.3	%
DENSITY OF SOIL PARTICLES ASSUMED	Gs ρw						2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)	(ms x 1000)/(Gs ρw x A)						8.9	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	11.39	1.279
25	0.634	19.67	96.88	10.76	1.208
50	0.321	19.35	95.30	10.44	1.172
100	0.663	18.68	92.03	9.78	1.098
200	0.918	17.76	87.51	8.86	0.995
FLOODED 200	0.029	17.74	87.36	8.83	0.991
400	0.907	16.83	82.90	7.92	0.889

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 102 (1.0-1.5)M**
Test date: **26-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							76.2	g
MASS OF RING + TRAY + SPECIMEN							1602.1	g
MASS OF RING							59.93	g
MASS OF TRAY							1471.45	g
MASS OF DRY SPECIMEN (ms)							55.91	g
MASS OF MOISTURE							20.29	g
MOISTURE CONTENT (m)							48.7	%
BULK DENSITY (ρ)							1.75	g/cm³
DRY DENSITY (ρd)							1.17	g/cm³
INITIAL VOID RATIO (e_o)							1.30	
DEGREE OF SATURATION (Sr)			m /(ρw/ρd - 1/Gs)				101.2	%
DENSITY OF SOIL PARTICLES ASSUMED			Gs ρw				2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)			(ms x 1000)/(Gs ρw x A)				8.8	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	11.47	1.298
25	1.053	19.25	94.81	10.41	1.179
50	0.342	18.91	93.13	10.07	1.140
100	0.626	18.28	90.04	9.44	1.069
200	0.876	17.40	85.73	8.57	0.970
FLOODED 200	0.018	17.39	85.64	8.55	0.968
400	0.939	16.45	81.01	7.61	0.862

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 102 (5.5-6.0)M**
Test date: **27-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							74.41	g
MASS OF RING + TRAY + SPECIMEN							1618.8	g
MASS OF RING							59.94	g
MASS OF TRAY							1489.83	g
MASS OF DRY SPECIMEN (ms)							55.55	g
MASS OF MOISTURE							18.86	g
MOISTURE CONTENT (m)							45.6	%
BULK DENSITY (ρ)							1.70	g/cm³
DRY DENSITY (ρd)							1.17	g/cm³
INITIAL VOID RATIO (e_o)							1.31	
DEGREE OF SATURATION (Sr)			m /(ρw/ρd - 1/Gs)				94.2	%
DENSITY OF SOIL PARTICLES ASSUMED			Gs ρw				2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)			(ms x 1000)/(Gs ρw x A)				8.8	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	11.50	1.307
25	0.567	19.73	97.21	10.93	1.243
50	0.274	19.46	95.86	10.66	1.211
100	0.589	18.87	92.96	10.07	1.145
200	0.93	17.94	88.37	9.14	1.039
FLOODED 200	0.026	17.91	88.25	9.11	1.036
400	1.025	16.89	83.20	8.09	0.919

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 103 (4.0-4.5)M**
Test date: **26-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							78.69	g
MASS OF RING + TRAY + SPECIMEN							1620.1	g
MASS OF RING							58.7	g
MASS OF TRAY							1487.01	g
MASS OF DRY SPECIMEN (ms)							61.12	g
MASS OF MOISTURE							17.57	g
MOISTURE CONTENT (m)							37.5	%
BULK DENSITY (ρ)							1.84	g/cm³
DRY DENSITY (ρd)							1.34	g/cm³
INITIAL VOID RATIO (e_o)							1.02	
DEGREE OF SATURATION (Sr)			m /(ρw/ρd - 1/Gs)				99.0	%
DENSITY OF SOIL PARTICLES ASSUMED			Gs ρw				2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)			(ms x 1000)/(Gs ρw x A)				10.0	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	10.26	1.022
25	0.79	19.51	96.11	9.47	0.943
50	0.322	19.19	94.52	9.15	0.911
100	0.316	18.87	92.97	8.83	0.879
200	1.093	17.78	87.58	7.74	0.771
FLOODED 200	0.041	17.74	87.38	7.70	0.766
400	0.593	17.15	84.46	7.10	0.707

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 105 (2.5-3.0)M**
Test date: **27-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							75.34	g
MASS OF RING + TRAY + SPECIMEN							1613.6	g
MASS OF RING							58.41	g
MASS OF TRAY							1487.98	g
MASS OF DRY SPECIMEN (ms)							54.95	g
MASS OF MOISTURE							20.39	g
MOISTURE CONTENT (m)							50.0	%
BULK DENSITY (ρ)							1.66	g/cm³
DRY DENSITY (ρd)							1.11	g/cm³
INITIAL VOID RATIO (e_o)							1.44	
DEGREE OF SATURATION (Sr)	m /(ρw/ρd - 1/Gs)						93.8	%
DENSITY OF SOIL PARTICLES ASSUMED	Gs ρw						2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)	(ms x 1000)/(Gs ρw x A)						8.3	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	11.98	1.441
25	0.278	20.02	98.63	11.71	1.407
50	0.188	19.83	97.70	11.52	1.385
100	0.438	19.40	95.55	11.08	1.332
200	0.92	18.48	91.01	10.16	1.222
FLOODED 200	0.008	18.47	90.98	10.15	1.221
400	1.121	17.35	85.45	9.03	1.086

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

ONE DIMENSIONAL CONSOLIDATION TEST

CLIENT: **NATIONAL HOUSING CORPORATION**
PROJECT: **MERU NTUTU MIXED DEVELOPMENT PHASE 1**
Sample: **BH 106 (4.0-4.5)M**
Test date: **27-Feb-19**
Specification **According to BS 1377:1990.**

DIA OF RING	50.4	mm	HEIGHT OF RING	20.3	mm	AREA (A)	19.953	cm²
STAGE - AFTER TEST								
MEASURED THICKNESS OF SPECIMEN (H1)							20.3	mm
WET SPECIMEN							74.41	g
MASS OF RING + TRAY + SPECIMEN							1613.0	g
MASS OF RING							58.69	g
MASS OF TRAY							1486.44	g
MASS OF DRY SPECIMEN (ms)							54.32	g
MASS OF MOISTURE							20.09	g
MOISTURE CONTENT (m)							50.1	%
BULK DENSITY (ρ)							1.67	g/cm³
DRY DENSITY (ρd)							1.12	g/cm³
INITIAL VOID RATIO (e_o)							1.42	
DEGREE OF SATURATION (Sr)			m /(ρw/ρd - 1/Gs)				95.2	%
DENSITY OF SOIL PARTICLES ASSUMED			Gs ρw				2.7	g/cm³
HEIGHT OF SOIL PARTICLES (H0)			(ms x 1000)/(Gs ρw x A)				8.4	mm

APPLIED PRESSURE	TOTAL DEFLECTION D	THICKNESS OF SPECIMEN,H (H1-D)	PERCENTAGE THICKNESS H/H1 X 100	HEIGHT OF VOIDS (H-H0)	VOIDS RATIO H-H0/H0
kN/m²	mm	mm		mm	
0	0	20.30	100.00	11.91	1.420
25	0.44	19.86	97.83	11.47	1.368
50	0.162	19.70	97.03	11.31	1.349
100	0.416	19.28	94.99	10.89	1.299
200	0.839	18.44	90.85	10.06	1.199
FLOODED 200	0.001	18.44	90.85	10.05	1.199
400	1.051	17.39	85.67	9.00	1.074

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

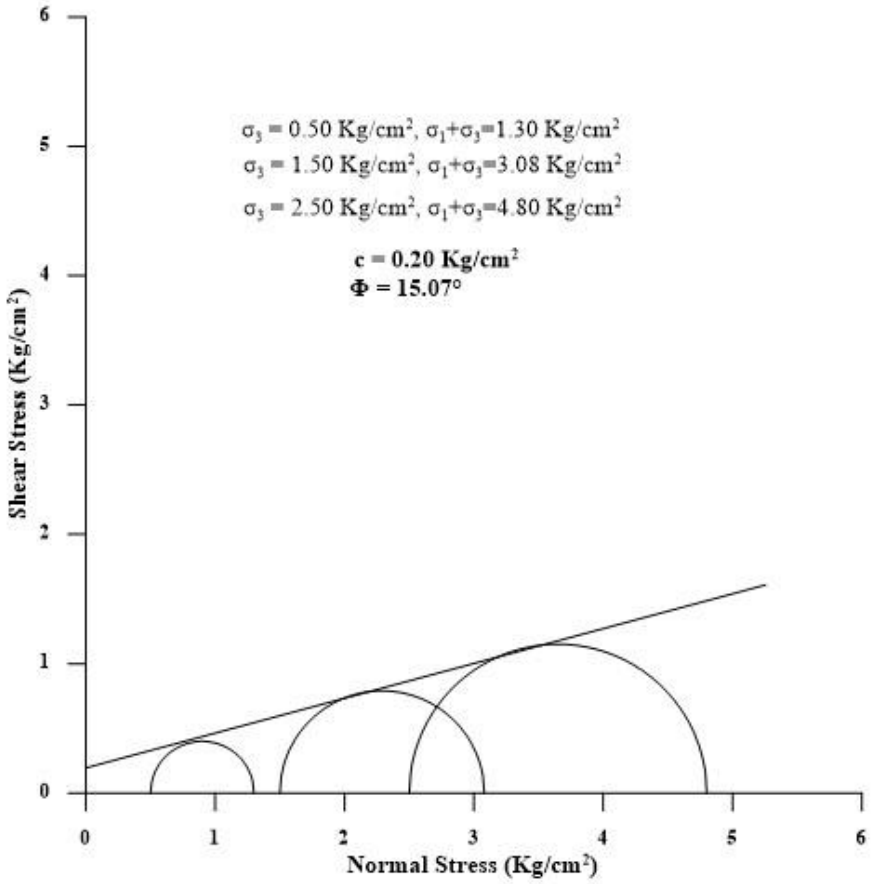
GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 101
Depth (m) : 2.0 to 2.5



Date : 26-02-2019

Reported by : CLEMENT MURIITHI

Checked by : DR. ISSA ISMAIL

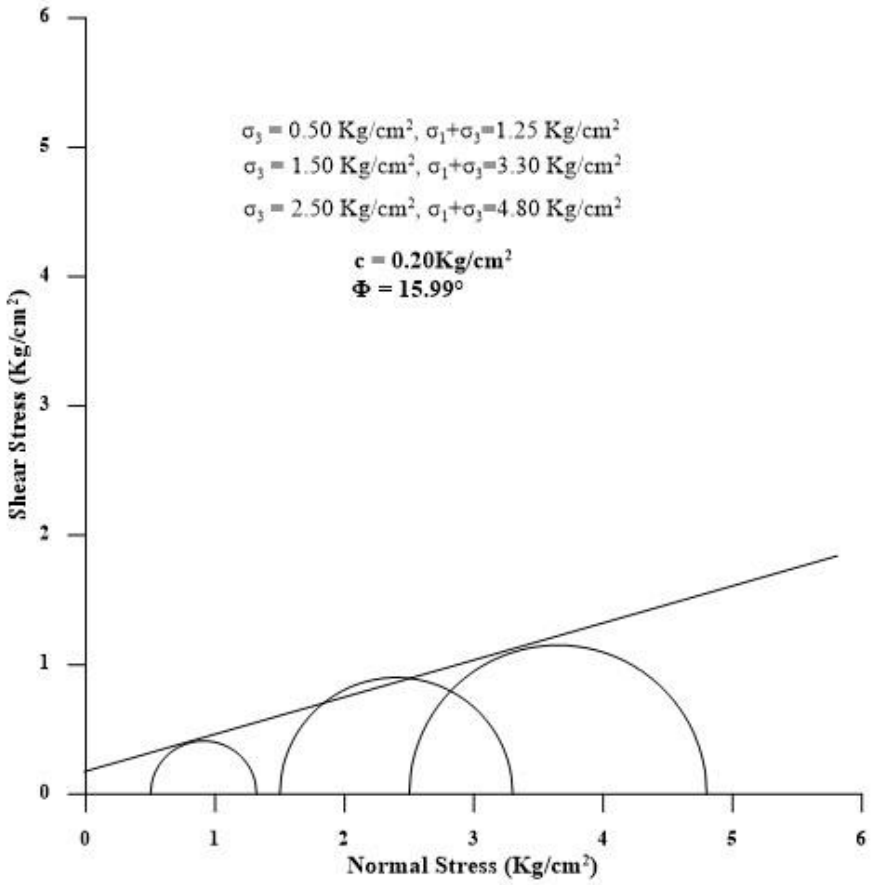
GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 102
Depth (m) : 1.0 to 1.5



Date : 27-02-2019

Reported by : CLEMENT MURIITHI

Checked by : DR. ISSA ISMAIL

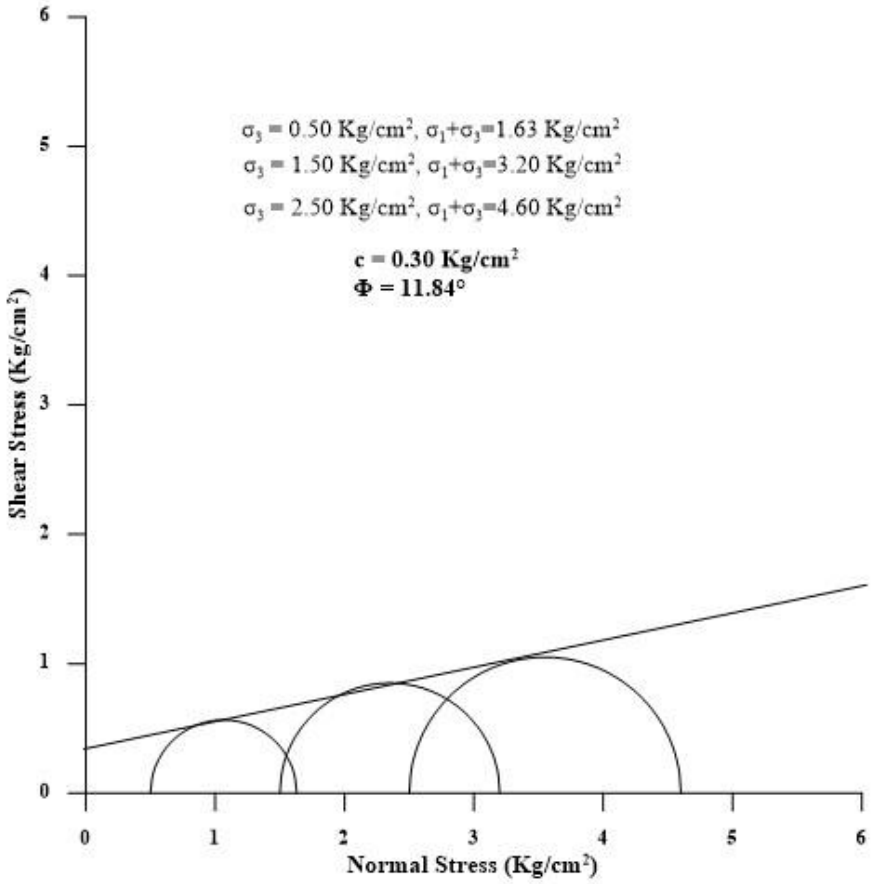
GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 102
Depth (m) : 5.5 to 6.0



Date : 27-02-2019
Reported by : CLEMENT MURIITHI
Checked by : DR. ISSA ISMAIL

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

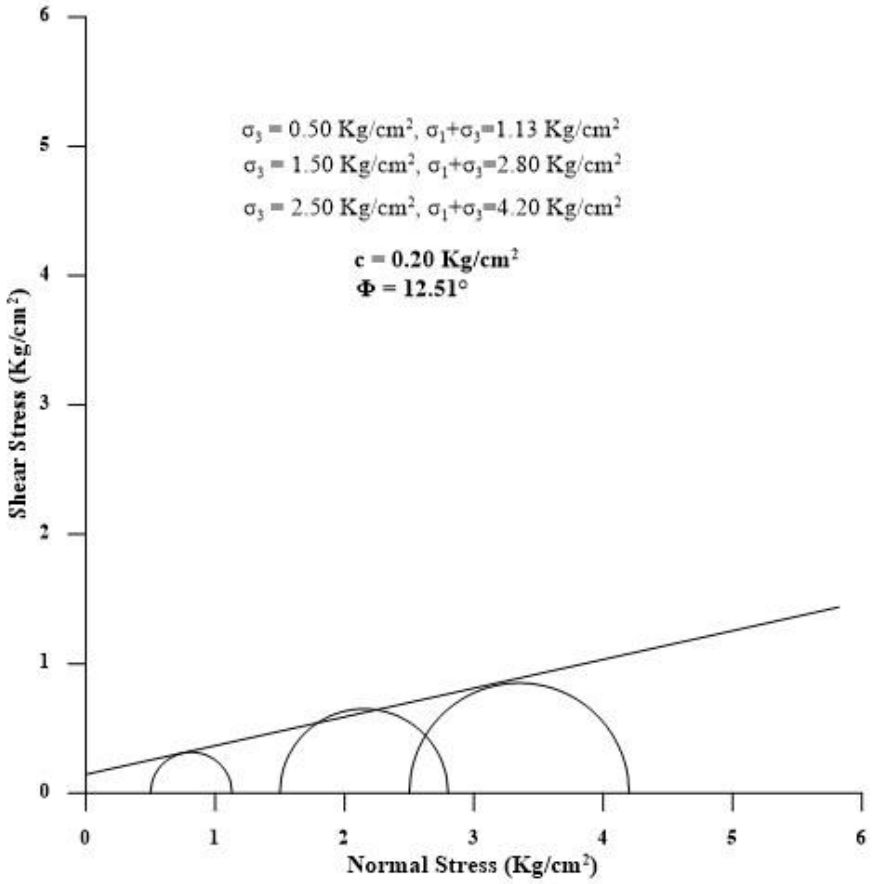
GEOISSA ENGINEERS LTD

Consulting Engineers & Material Testing Laboratories

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 103
Depth (m) : 4.0 to 4.5



Date : 26-02-2019

Reported by : CLEMENT MURIITHI

Checked by : DR. ISSA ISMAIL

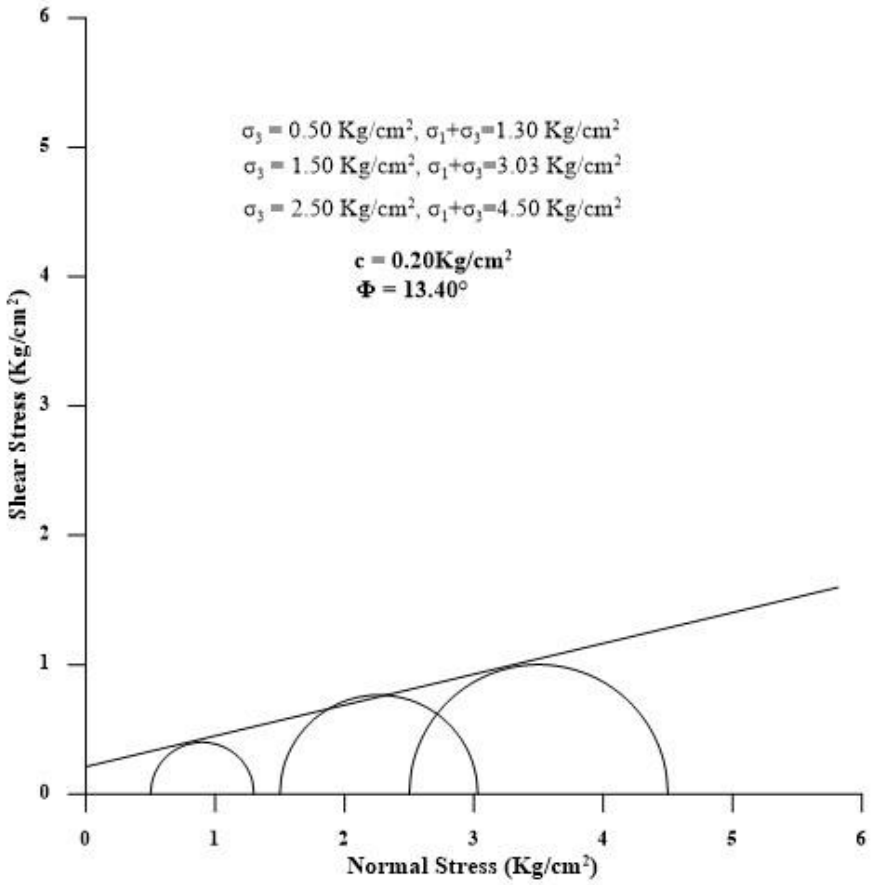
GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 105
Depth (m) : 2.5 to 3.0



Date : 27-02-2019

Reported by : CLEMENT MURIITHI

Checked by : DR. ISSA ISMAIL

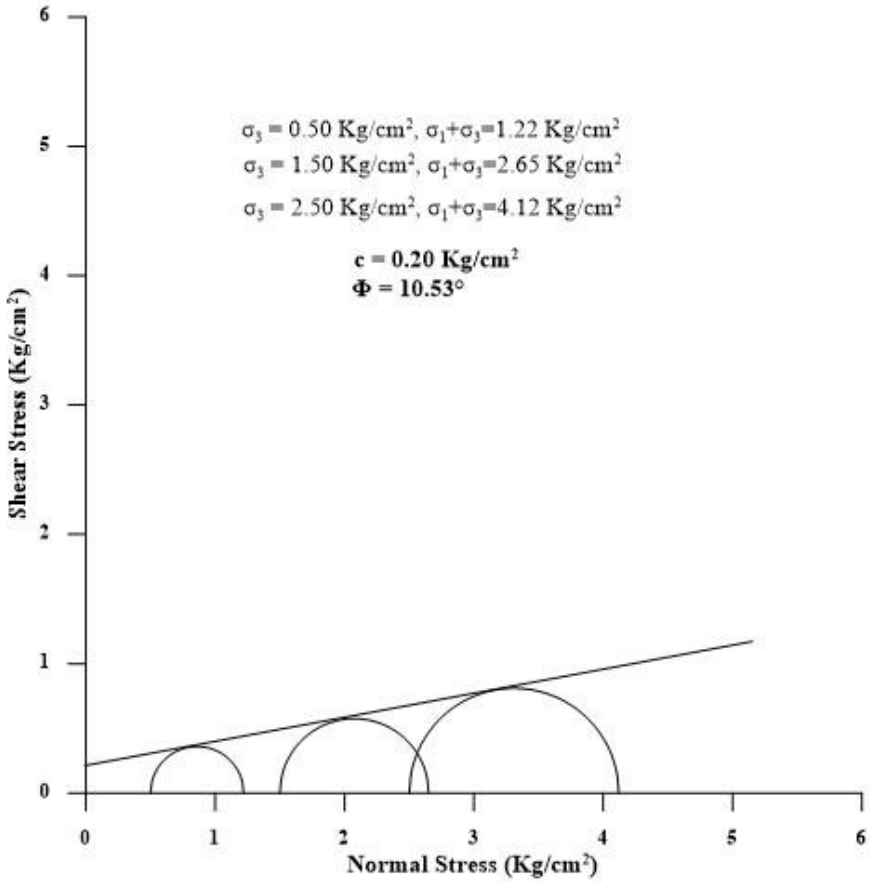
GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION

Borehole No. : 106
Depth (m) : 4.0 to 4.5



Date : 28-02-2019

Reported by : CLEMENT MURIITHI

Checked by : DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD

Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

UNCONFINED COMPRESSION TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT PHASE 1
Client : NATIONAL HOUSING CORPORATION
Location : MERU

Standard : ASTM D 7012
Date received : 23/2/19
Date tested 1/3/19

Sample No.	Borehole No	Depth (m)		Sample Condition	Diameter (mm)	Length (mm)	L/D	Weight (gms)	Density (Kg/m^3)	Failure Load (kN)	Corrected UCS (MPa)	Failure Mode	RMR Rating (UCS)	Bearing Capacity(Mpa)	Safe Bearing Capacity(Mpa)	Remarks
		From	To													
S1	BH101	23.40	23.60	dry	70	129	1.85	1357.4	2729	362.90	94.35	Multiple Fracturing	7	353.36	17.67	Strong
S2	BH102	24.10	24.30	dry	71	142	1.99	1554.6	2774	686.50	173.48	Multiple Fracturing	12	816.02	40.80	Very Strong
S3	BH103	17.60	17.80	dry	71	141	1.99	1571.1	2846	595.90	151.87	Axial Splitting	12	668.94	33.45	Very Strong
S4	BH103	20.50	21.50	dry	71	143	2.02	1614.0	2868	687.60	176.52	Multiple Fracturing	12	838.22	41.91	Very Strong
S5	BH104	23.10	23.50	dry	71	143	2.03	1558.1	2785	600.90	155.70	Axial Splitting	12	693.73	34.69	Very Strong
S6	BH106	22.50	22.70	dry	71	134	1.90	1426.3	2714	298.90	76.39	Axial Splitting	7	272.93	13.65	Strong

Tested by : CLEMENT MURIITHI **Reported by :** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

GEOISSA ENGINEERS LTD
Consulting Engineers & Material Testing Laboratories

Likoni Lane
P. O. Box 35035 - 00100 Nairobi, Kenya
Email:info@geoissa.co.ke
Website: www.geoissa.co.ke
Tel: +254-020-2635002, Cel: +254-729-818-418

POINT LOAD TEST

File No. : 3-19-10
Project : PROPOSED MERU NTUTU MIXED DEVELOPMENT
Client : NATIONAL HOUSING CORPORATION
Location MERU

Standard : ASTM D5731
Date received : 23/2/19
Date tested : 1/3/19

Sample No.	Borehole No.	Depth (m)		Field Index Strength	Moisture	Test Type	Failure Type	L_d , L_a or D (mm)	D_d W_a or W (mm)	Density (Kg/m^3)	De^2 (mm^2)	De (mm^2)	P (kN)	P/D_d^2 (MPa)	P/De^2 (MPa)	$Is_{(50)}$ (MPa)	RMR ($Is_{(50)}$)	Estimated UCS $Is_{(50)}$*25	Safe Bearing Capacity (Mpa)	Remarks RMR $Is_{(50)}$
		From	To																	
S1	BH101	20.50	20.60	EW	D	A	SP	63.4	69.5	1673	5609.55	74.90	0.060	-	0.01	0.01	0	0.32	0.05	Extremely Weak
S2	BH101	21.20	21.30	W	D	A	SP	63.3	71	1940	5721.58	75.64	0.600	-	0.10	0.13	1	3.16	0.47	Weak
S3	BH102	6.00	6.10	VS	D	A	TP	59	70.3	2531	5280.33	72.67	18.400	-	3.48	4.12	12	103.08	19.76	Very Strong
S4	BH102	18.50	18.60	VW	D	A	AF	63.4	70	2098	5649.90	75.17	0.100	-	0.02	0.02	0	0.53	0.08	Very Weak
S5	BH103	7.10	7.20	VS	D	A	TP	66.7	83.3	2798	7073.34	84.10	30.100	-	4.26	5.38	12	134.43	28.14	Very Strong
S6	BH103	16.50	16.60	W	D	A	SP	71	70	1503	6327.18	79.54	0.800	-	0.13	0.16	1	3.90	0.58	Weak
S7	BH103	17.50	17.60	VW	D	A	SP	65.5	70.3	2479	5862.06	76.56	0.100	-	0.02	0.02	0	0.52	0.08	Very Weak
S8	BH104	14.80	15.00	MW	D	A	SP	55.6	70.3	2284	4976.04	70.54	1.000	-	0.20	0.23	2	5.87	0.88	Moderately Weak
S9	BH104	18.60	18.70	VW	D	A	SP	62.5	61	1473	4853.60	69.67	0.100	-	0.02	0.02	0	0.60	0.09	Very Weak
S10	BH104	19.10	19.20	W	D	A	SP	63.2	70.4	1839	5664.26	75.26	0.500	-	0.09	0.11	1	2.65	0.40	Weak
S11	BH105	10.90	11.00	VW	D	A	SP	80	67.5	1332	6874.60	82.91	0.170	-	0.02	0.03	0	0.78	0.12	Very Weak
S12	BH105	19.00	19.10	EW	D	A	SP	54.2	70.2	1383	4843.84	69.60	0.060	-	0.01	0.01	0	0.36	0.05	Extremely Weak
S13	BH105	19.90	20.00	VS	D	A	TP	54.2	70.3	2848	4850.74	69.65	23.400	-	4.82	5.60	12	140.00	29.77	Very Strong
S14	BH105	24.50	24.60	VS	D	A	SP	57.6	71	2841	5206.37	72.16	26.700	-	5.13	6.05	12	151.22	33.24	Very Strong
S15	BH106	21.40	21.50	VS	D	A	TP	56.2	70.8	2758	5065.51	71.17	19.200	-	3.79	4.44	12	111.08	21.77	Very Strong

KEY: Symbol "-" means "not applicable" or "does not meet criteria"

Moisture
D- Dry
M- Moist
W- Wet

Field Index Strength
EW- Extremely Weak
W- Weak
MW- Moderately Weak
MS- Moderately Strong
S- Strong
VS- Very Strong
ES- Extremely Strong

Test Type
D- Diametral
A- Axial
L- Lump

Sample Dimensions
L_d - Height of Diametral Sample
L_a - Height of Axial sample
D_d- Diameter of Diametral Sample
D- Distance between Platen Contacts for Lump Sample
W_a- Diameter of Axial Sample
W- Smallest Specimen Width for Lump Sample

Failure Type
AF (Oblique/Parallel)- Failures along foliations when foliations are inclined /parallel
SP- Failure along single plane containing line of loading
TP- Triple Plane: Failure along three extensional planes
S - Shear Failure

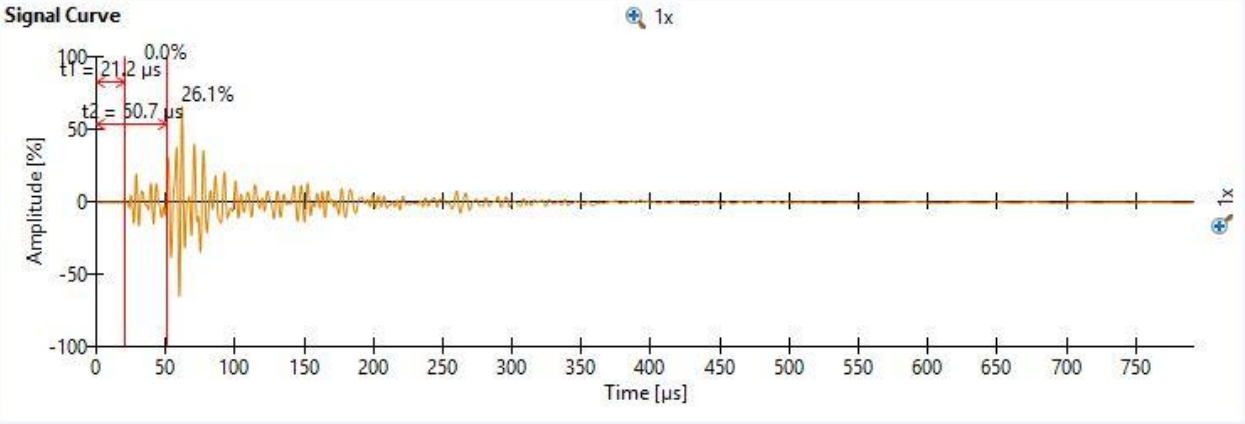
RMR
RMR- Rock mass rating system (Bieniawski, 1989)

$Is_{(50)}$- Point load strength index for the standard core size of 50mm diameter
P- Load

Tested by : CLEMENT MURIITHI **Reported** CLEMENT MURIITHI **Checked by :** DR. ISSA ISMAIL

Meru nhc bh101 (23.4-23.6)	03/01/2019 11:47 AM	E-Modulus	49.24 GPa	0.129 m	--	21.2 µs	1.00

Signal Curve



Settings & Results

Distance:	0.129 m
Density:	2728 kg/m³
Poisson's Ratio:	0.3940
E-Modulus:	49.24 GPa

Device Information

Device Name:	Pundit
Serial Number:	UP01-001-0341
Software Version:	2.0.10
Hardware Revision:	B3

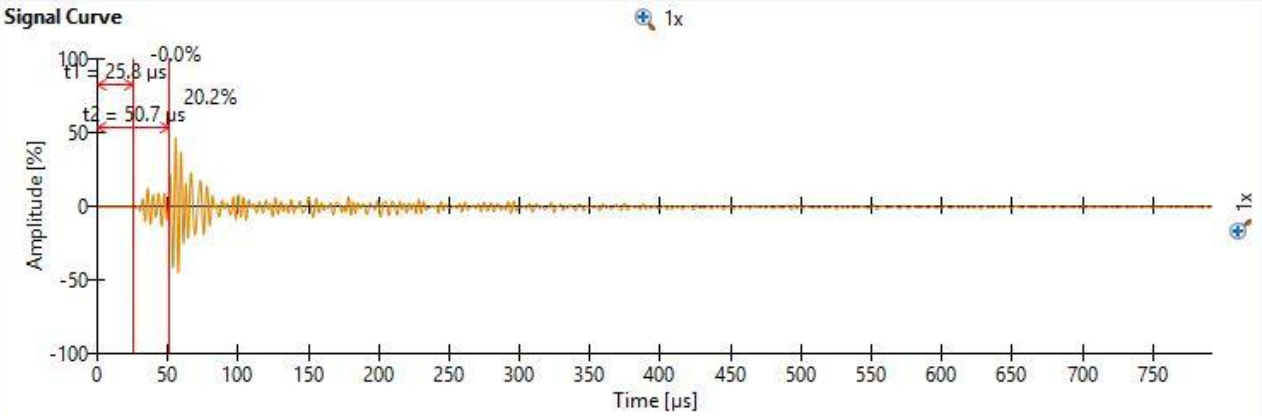
Wave	S	
Time (µs)	21.2	50.7
Velocity (m/s)	6084	2544
Probe Type	Shear Wave	
Probe Freq. (kHz)	250	
Probe Gain (x)	20	
Pulse Voltage (V)	50	
Calib. Time Offset (µs)	-0.9	

Comment

[Add]

Meru nhc bh102 (24.1-24.3)M	03/01/2019 11:49 AM	E-Modulus	57.66 GPa	0.142 m	--	25.8 µs	1.00

Signal Curve



Settings & Results

Distance:	0.142 m
Density:	2773 kg/m³
Poisson's Ratio:	0.3255
E-Modulus:	57.66 GPa

Device Information

Device Name:	Pundit
Serial Number:	UP01-001-0341
Software Version:	2.0.10
Hardware Revision:	B3

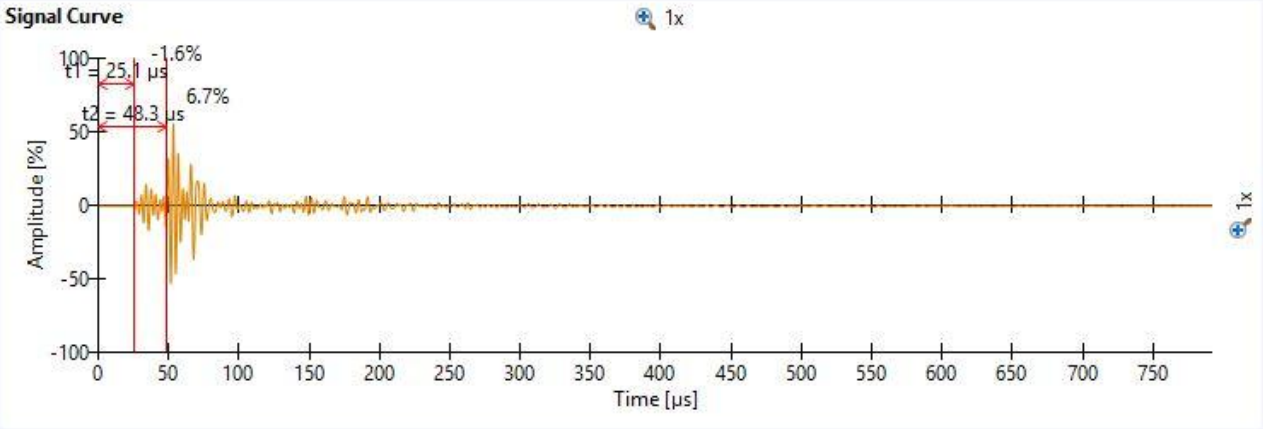
Wave	S	
Time (µs)	25.8	50.7
Velocity (m/s)	5507	2801
Probe Type	Shear Wave	
Probe Freq. (kHz)	250	
Probe Gain (x)	2	
Pulse Voltage (V)	50	
Calib. Time Offset (µs)	-0.9	

Comment

[Add]

Meru nhc bh103 (17.6-17.8)M	03/01/2019 11:50 AM	E-Modulus	63.81 GPa	0.141 m	--	25.1 µs	1.00

Signal Curve



Settings & Results

Distance:	0.141 m
Density:	2844 kg/m³
Poisson's Ratio:	0.3142
E-Modulus:	63.81 GPa

Device Information

Device Name:	Pundit
Serial Number:	UP01-001-0341
Software Version:	2.0.10
Hardware Revision:	B3

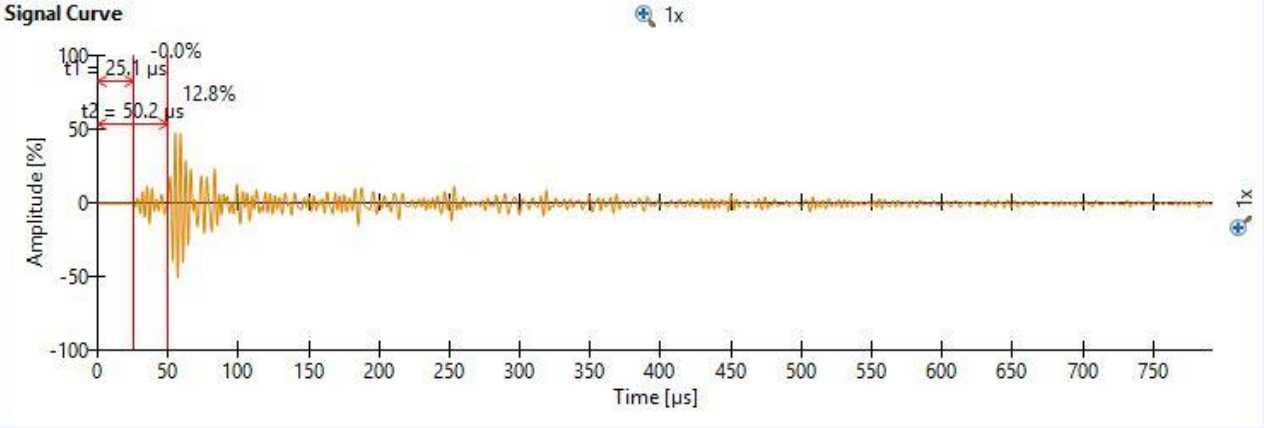
Wave	S	
Time (µs)	25.1	48.3
Velocity (m/s)	5613	2922
Probe Type	Shear Wave	
Probe Freq. (kHz)	250	
Probe Gain (x)	2	
Pulse Voltage (V)	50	
Calib. Time Offset (µs)	-0.9	

Comment

[Add]

Meru nhc bh104 (23.1-23.5)M	03/01/2019 11:51 AM	E-Modulus	60.25 GPa	0.143 m	--	25.1 µs	1.00

Signal Curve



Settings & Results

Distance:	0.143 m
Density:	2783 kg/m³
Poisson's Ratio:	0.3328
E-Modulus:	60.25 GPa

Device Information

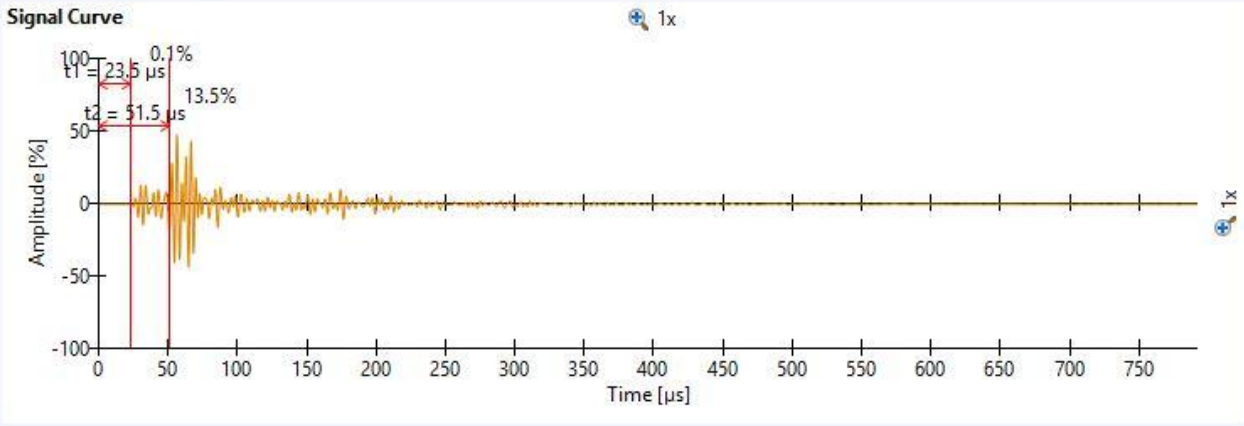
Device Name:	Pundit
Serial Number:	UP01-001-0341
Software Version:	2.0.10
Hardware Revision:	B3

Wave	S	
Time (µs)	25.1	50.2
Velocity (m/s)	5692	2850
Probe Type	Shear Wave	
Probe Freq. (kHz)	250	
Probe Gain (x)	5	
Pulse Voltage (V)	50	
Calib. Time Offset (µs)	-0.9	

Comment

[Add]

Meru nhc bh105 (22.5.22.6)M	03/01/2019 11:54 AM	E-Modulus	50.28 GPa	0.134 m	--	23.5 µs	1.00



Settings & Results

Distance:	0.134 m
Density:	2713 kg/m³
Poisson's Ratio:	0.3680
E-Modulus:	50.28 GPa

Device Information

Device Name:	Pundit
Serial Number:	UP01-001-0341
Software Version:	2.0.10
Hardware Revision:	B3

Wave		S
Time (µs)	23.5	51.5
Velocity (m/s)	5695	2603
Probe Type	Shear Wave	
Probe Freq. (kHz)	250	
Probe Gain (x)	5	
Pulse Voltage (V)	50	
Calib. Time Offset (µs)	-0.9	

Comment

[Add]

Ultrasonic Pulse Velocity Curves

10. APPENDIX D-Relevant Literature

SAMPLING METHOD

SS	split spoon
ST	Shelby tube
AS	auger sample
WS	wash sample
RC	rock core
WH	weight of hammer
PH	pressure, hydraulic

PENETRATION RESISTANCE

Standard Penetration Test (SPT) resistance ('N' values) is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a standard 50 mm (2 in.) diameter split spoon sampler for a distance of 0.3 m (12 in.).

Dynamic Cone Test (DCT) resistance is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a conical steel point of 50 mm (2 in.) diameter and with 60° sides on 'A' size drill rods for a distance of 0.3 m (12 in.).

SOIL DESCRIPTION - COHESIONLESS SOILS

Relative Density	'N' value
very loose	< 4
loose	4 - 10
compact	10 - 30
dense	30 - 50
very dense	> 50

SOIL DESCRIPTION - COHESIVE SOILS

Consistency	Undrained Shear Strength, kPa	'N' value
very soft	< 12	< 2
soft	12 - 25	2 - 4
firm	25 - 50	4 - 8
stiff	50 - 100	8 - 16
very stiff	100 - 200	16 - 32
hard	> 200	> 30

SOIL COMPOSITION

	% by weight
'trace' (e.g. trace silt)	< 10
'some' (e.g. some gravel)	10 - 20
adjective (e.g. sandy)	20 - 35
'and' (e.g. sand and gravel)	35 - 50

TESTS, SYMBOLS

MH	mechanical sieve and hydrometer analysis
w, w_c	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index
k	coefficient of permeability
γ	soil unit weight, bulk
ϕ'	angle of internal friction
c'	cohesion shear strength
C_c	compression index

GENERAL INFORMATION, LIMITATIONS

The conclusions and recommendations provided in this report are based on the factual information obtained from the boreholes and/or test pits. Subsurface conditions between the test holes may vary.

The engineering interpretation and report recommendations are given only for the specific project detailed within, and only for the original client. Any third party decision, reliance, or use of this report is the sole and exclusive responsibility of such third party. The number and siting of boreholes and/or test pits may not be sufficient to determine all factors required for different purposes.

Table D-1 Soil and Insitu Test Description

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

PARAMETER			Range of values // ratings						
1	Strength of intact rock material	Point-load strength index	> 10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range uniaxial compr. strength is preferred		
		Uniaxial com-pressive strength	> 250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
		RATING	**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core quality RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	< 25%		
	RATING		**20**	**17**	**13**	**8**	**5**		
3	Spacing of discontinuities		> 2 m	0.6 - 2 m	200 - 600 mm	60 - 200 mm	< 60 mm		
	RATING		**20**	**15**	**10**	**8**	**5**		
4	Condition of discon-tinuities	Length, persistence	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m		
		Rating	**6**	**4**	**2**	**1**	**0**		
		Separation	none	< 0.1 mm	0.1 - 1 mm	1 - 5 mm	> 5 mm		
		Rating	**6**	**5**	**4**	**1**	**0**		
		Roughness	very rough	rough	slightly rough	smooth	slickensided		
		Rating	**6**	**5**	**3**	**1**	**0**		
		Infilling (gouge)	none	Hard filling		Soft filling			
			-	< 5 mm	> 5 mm	< 5 mm	> 5 mm		
		Rating	**6**	**4**	**2**	**2**	**0**		
		Weathering	unweathered	slightly w.	moderately w.	highly w.	decomposed		
		Rating	**6**	**5**	**3**	**1**	**0**		
5	Ground water	Inflow per 10 m tunnel length	none	< 10 litres/min	10 - 25 litres/min	25 - 125 litres/min	> 125 litres /min		
		$p_w / \sigma 1$	0	0 - 0.1	0.1 - 0.2	0.2 - 0.5	> 0.5		
		General conditions	completely dry	damp	wet	dripping	flowing		
	RATING		**15**	**10**	**7**	**4**	**0**		

p_w = joint water pressure; $\sigma 1$ = major principal stress

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS

		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable
RATINGS	Tunnels	**0**	**-2**	**-5**	**-10**	**-12**
	Foundations	**0**	**-2**	**-7**	**-15**	**-25**
	Slopes	**0**	**-5**	**-25**	**-50**	**-60**

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 - 81	80 - 61	60 - 41	40 - 21	< 20
Class No.	I	II	III	IV	V
Description	VERY GOOD	GOOD	FAIR	POOR	VERY POOR

D. MEANING OF ROCK MASS CLASSES

Class No.	I	II	III	IV	V
Average stand-up time	10 years for 15 m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2.5 m span	30 minutes for 1 m span
Cohesion of the rock mass	> 400 kPa	300 - 400 kPa	200 - 300 kPa	100 - 200 kPa	< 100 kPa
Friction angle of the rock mass	< 45°	35 - 45°	25 - 35°	15 - 25°	< 15°

Table D-2 Rock Mass Rating (RMR) after Bieniawski,1989

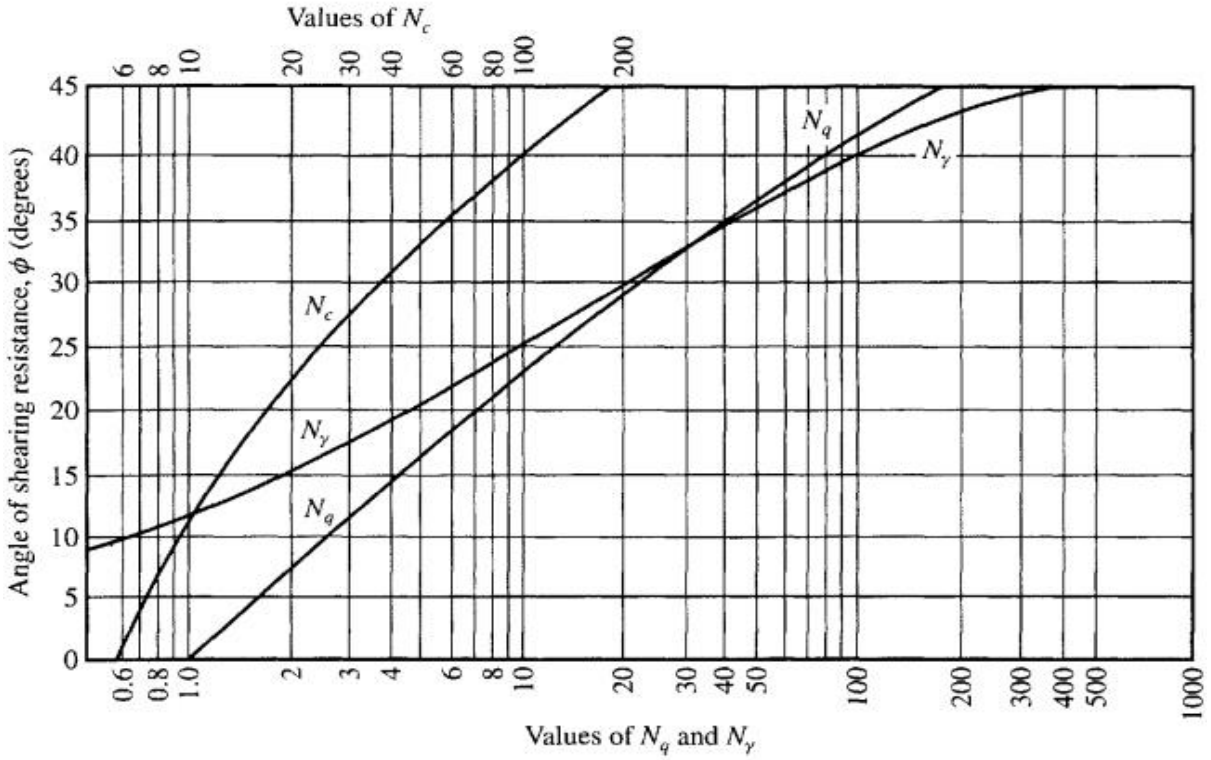


Figure D-1 Terzaghi' s bearing capacity factors

Figure D-2 Site Photo

Figure D-3 Site Photo

11. REFERENCES

1. Bieniawski, Z. T. (1989). *Engineering Rock Mass Classification.* New York: John Wiley & Sons.
2. British Standards Institution. (1999). *BS 5930-1999 Code of Practice for Site Investigations.* London: British Standards Institution.
3. British Standards Institution. (2015). *BS 8004-2015 Code of Practice for Foundations.* London: British Standards Institution.
4. Craig, R. F. (1974). *Craig's Soil Mechanics.* London: Spon Press.
5. Peck, R. B., Hanson, W. E., & Thornburn, T. H. (1974). *Foundation Engineering.* New York: John Wiley & Sons.
6. Terzaghi, K. (1943). *Theoretical Soil Mechanics.* New York: John Wiley & Sons.
7. Terzaghi, K., & Peck, R. (1967). *Soil Mechanics in Engineering Practice* (2nd ed.). New York: John Wiley & Sons.
8. The European Union. (2007). *Eurocode 7-EN 1997-2 Geotechnical Design: Ground Investigation and Testing.* The European Union.
9. Tomlinson, M. J. (2001). *Foundation Design and Construction* (7th ed.). Harlow: Pearson Education Limited.