SOIL AND CONCRETE LABORATORY

STRUCTURAL INTEGRITY INVESTIGATIONS

On

Administration block located on Plot _____, Amuria District Local Government Headquaters

Project No. 0071/AMRT/NOV-INT/2018

Prepared For:

REPUBLIC OF UGANDA

AMURIA DISTRICT

Local Government

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SOIL AND CONCRETE LABORATORY

Department of Civil and Building Engineering

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1.0. EXECUTIVE SUMMARY

This Executive Summary is provided as a brief overview of our laboratory based structural integrity assessment for the project and is not intended to replace more detailed information contained elsewhere in this report.

For the design and analysis of the structural system of the as built structure, sub-soil and materials investigation had to be carried out to provide the design team with the required reliable information. As an overview, this summary inherently omits details that could be very important to the proper application of the provided structural integrity recommendations. Therefore, it should be read and used to its entirety with periodic consultation with the investigating team. Below is a summary of key considerations;

Material assessment of the existing structures was carried out by determining the as built compressive strength of selected structural members using a Schmidt rebound hammer for compressive strength, rebar assessment, visual inspection for defects, structural member dimension assessment, and sub soil investigation to ascertain foundation properties and suitability.

The subsurface exploration program consisted of two test pits (designated as TP 01 through TP 02). Site subsurface conditions generally consisted of blackish clayey fine gravel soils in the surficial layers, underlain by reddish brown clayey gravels. The as built structure was found to be supported on pad and strip foundation systems bearing on soils of maximum allowable bearing **pressure of 180Kpa** at an average depth of 1.40 - 1.50m below ground level.

Visual inspection was also done to check for any concrete surface defects. Some honey combed surfaces were observed and sufficient concrete cover was observed to be provided to the reinforcement. Please note that all main bars in the as-built structure were of **Ribbed type (approx. 500 MPa tensile strength)**

With reference to the seismic hazard map of Uganda, the mean peak ground acceleration (PGA), which is exceeded on average once every 50 years, was calculated. It should be noted that the area in which the structure is located is in zone 3 of the seismic zoning of Uganda and far away from the rift valley regions, it is therefore unlikely for earthquakes to occur with high frequency and magnitude.

The rebound hammer test revealed that the both the assessed buildings had a compressive strength that varies from **26 – 29Mpa**. It is therefore recommended that a maximum compressive strength of **26MPa** be used to assess the existing building for structural stability.

Some slab soffit areas were observed to have some staining, efflorescence, and blistering in, an indication of water penetration and saline conditions. This can easily lead to bar corrosion, later undermining reinforcement strength. We therefore call for immediate application of finishes to the slabs.

There were a few exposed reinforcement bars as a result of insufficient concrete cover, though all the bars were observed to have undergone less corrosion.

Compiled by	Endorsed by
P. Ochieng	**Dr. J. Nyende**
Lab Engineer	HEAD OF DEPARTMENT

2.0 INTRODUCTION

2.0.1 BACKGROUND

Structural integrity investigation is an assessment carried on an existing building to check on limit state requirements as an assessment for suitability of its intended purpose. The design of a structure is always based on the criterion of Safety -strength, stability and robustness, economy and appearance; however, in this case the structure under investigation was partially checked and assessed for the safety criteria.

Amuria District is one of the Local Governments under the Uganda Government decentralization policy, it is approximately 37 kilometers by road North of Soroti District and it is one of the largest towns in the Sub region. It is bordered by Otuke District to the North, Napak and Kapelebyong District to the Northeast, Katakwi District to the East, Soroti District to the South, Kaberemaido District to the Southwest, and Alebtong District to the West. Amuria district made procurement procedure to construct its district local government offices and it commenced with putting up the ground floor under the Works and Technical Services Department. A proposal has been made to add more floor levels to the building and this required to first ascertain the current structural stability conditions of the existing ground floor.

As requested by the district Engineer, a team from the soil and concrete Laboratory of Kyambogo University set out to conduct a Laboratory based Structural Integrity assessment on the existing administrative block, on plot No. _____, Amuria district local government. The structure is currently under management of the district local government. The investigation was commenced on 04th November, 2018.

This report details the engineering characteristics as discovered from the investigation that include hardened concrete strength, rebar assessment details, sub soil investigation details, terrain and some building defects. It describes the general methodology that was used to conduct the investigations, and studies undertaken to assess structural stability and sub soil suitability.

Information obtained from geological maps and available reports was used to set up the geological outline of the project area and determine the foundation suitability for the existing building.

2.1 OBJECTIVES

The main objective of this investigation was as to assess the stability and serviceability of the as-built structure with respect to the design and required standards as specified by the designer and city authority. It should be noted that structural drawings were not availed at the time of the investigation.

2.2 SPECIFIC OBJECTIVES

The investigation comprised of:

I. Carrying out Insitu Non-destructive concrete tests on selected structural members.
II. Visual inspection on the structural masonry and concrete to establish signs of and failure, and fatigue.
III. Carrying out dimension inspections of the different structural members used in construction.
IV. Carrying out a geotechnical/subsoil investigation on the site
V. Assessing the findings in comparison to the availed drawings and attached geotechnical investigation findings.
VI. Compiling and submitting of a technical report.

The positions of members to be tested were predetermined and marked out on the structure for ease of identification during a field reconnaissance with the aid of the availed structural Drawings. The key out puts of the both the laboratory and field activities are clearly stipulated in the following chapters.

2.3 ACTIVITY DETAILS

The table below indicates the planned activities and schedule of works as executed by the investigating team.

S/N	Works/activity	Involved team personnel	Time (days)									
			1	2	3	4	5	6	7	8	9	10
1	Site visit and review	Lab+client+consultant										
2	Field work (sampling)	Lab+consultant										
3	Insitu test	Lab										
4	Laboratory tests	Lab										
5	Analysis and compiling	Lab+consultant										
6	review	Lab+consultant										
7	Submission of report	Lab+client+consultant										

2.4 SCOPE OF SERVICES

The purposes of our involvement on this project were to 1) provide general descriptions of the subsurface soil conditions encountered at the locations explored, 2) provide foundation design recommendations, and 3) comment on other geotechnical aspects of the proposed development. In order to accomplish the above objectives, we undertook the following scope of services:

I. Visited the site to prepare and mark points to be tested, on all selected concrete structural members.

II. Reviewed and summarized readily available information regarding the proposed project and the area.

III. Conduct non - destructive concrete strength test on selected concrete members.

IV. Executed a subsurface exploration consisting of two test pits excavations up to maximum depth of about 2.5 - 3.00m in predetermined positions as required by the design team.

V. Rebar assessment, building defects analysis and dimension checks on the different structural members.

VI. Evaluation and analysis of the findings and prepare a technical report

3.0 STRUCTURAL DESCRIPTION

The building under investigation is an incomplete single storied administrative building at the time of investigation. The structure is a framed reinforced concrete structure having reinforced concrete beams, columns, stair cases, footings and max span suspended slab. The walling infill material was found to be of common burnt clay bricks bonded in cement sand mortar of unknown ration/mix. The existing structure was as seen in the photo plate below.

Photo plate 01: the as built structure under investigation.

4.0 SITE AND SUB SURFACE DESCRIPTION

4.1 SITE DESCRIPTION AND TOPOGRAPHY

The structure under investigation is located in within the district local government premises of Amuria, on plot No. _____, Amuria District as previously stated. The site is topographically located along a gently sloping terrain. The areas in which the site is located is a renown Administrative area with other administrative department building within the vicinity. The site vegetation cover was found to be comprising of short grass cover with mature tropical trees with an on-road orientation.

4.2 PROJECT INFORMATION

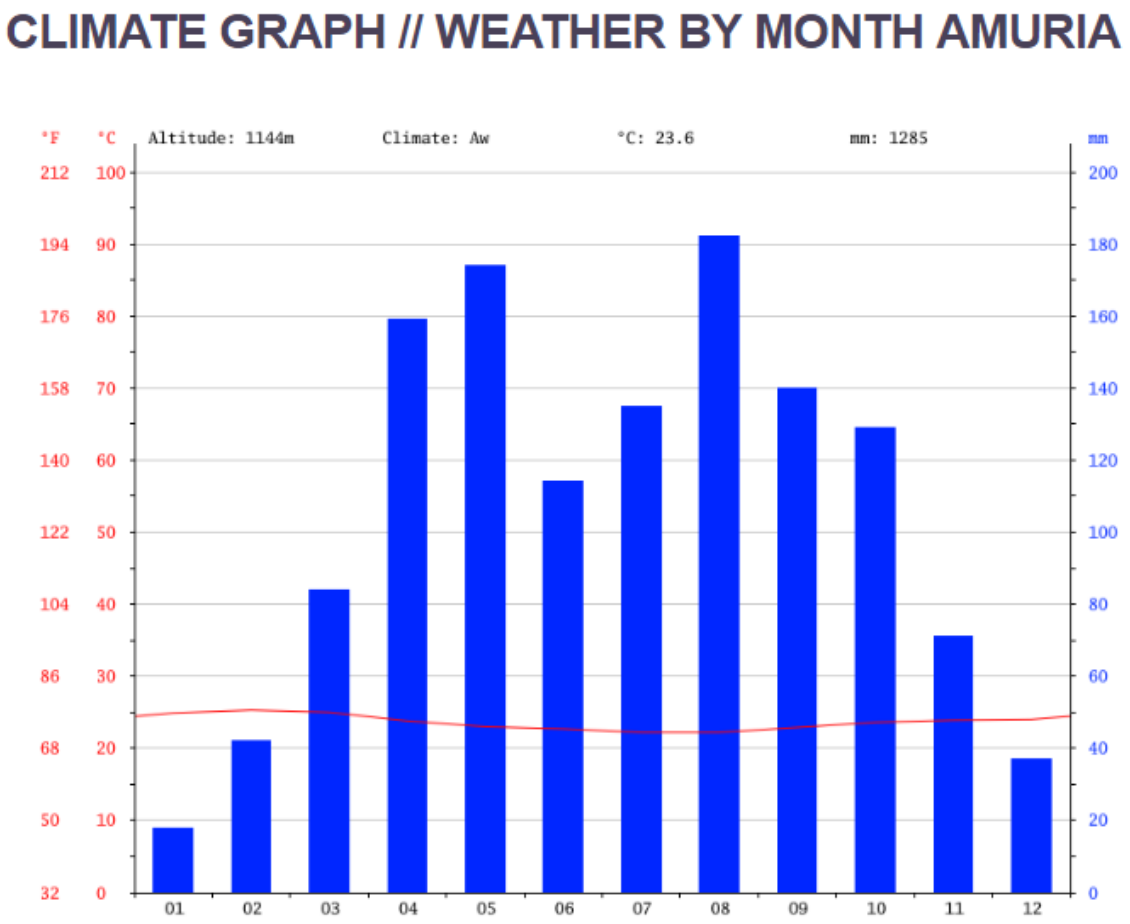
Our understanding of the project is based on information provided by mainly the district Engineer, previous design documents and our experiences with similar projects. This report is therefore purposed to aid in the structural - stability analysis of the existing unfinished administrative building under investigation and preparation of safe structural designs and drawings for submission so as addition construction can safely be commenced.

4.3 PREVIOUS REPORTS AND INFORMATION

There was no integrity or subsurface exploration information availed and therefore it was assumed that this report entails the first ever investigation executed on the proposed structure and site.

4.4 CLIMATIC DESCRIPTION

The rainfall pattern is greatly influenced by the existing relief and the presence of water bodies, vast swamps and the area topography, which generally encourage evaporation and uplifts of winds causing precipitation during most parts of the year without any specified dry and wet seasons. The average annual rainfall is estimated to exceed 1285mm per annum. The temperature here averages 23.6 °C. The average annual rainfall is 1285 mm.



4.5 REGIONAL GEOLOGY

The site is located in an area underlain by partly Proterozoic rocks and Archean plutonic rocks partly reworked during later orogenic events. The soils were largely consisting of laterite gravel material. The soils resulting from in-situ weathering of the rocks, without significant transportation, are called residual soils and these were observed through out the site. The residual soil profile generally grades downward gradually from thin fine grained strata to coarse grained plastic strata up to explored depth as presented in the test pit logs. Some rock out crops were observed within the site and in the neighborhood. Further details about the site geology and geotechnical properties are represented in the attached geotechnical report section.

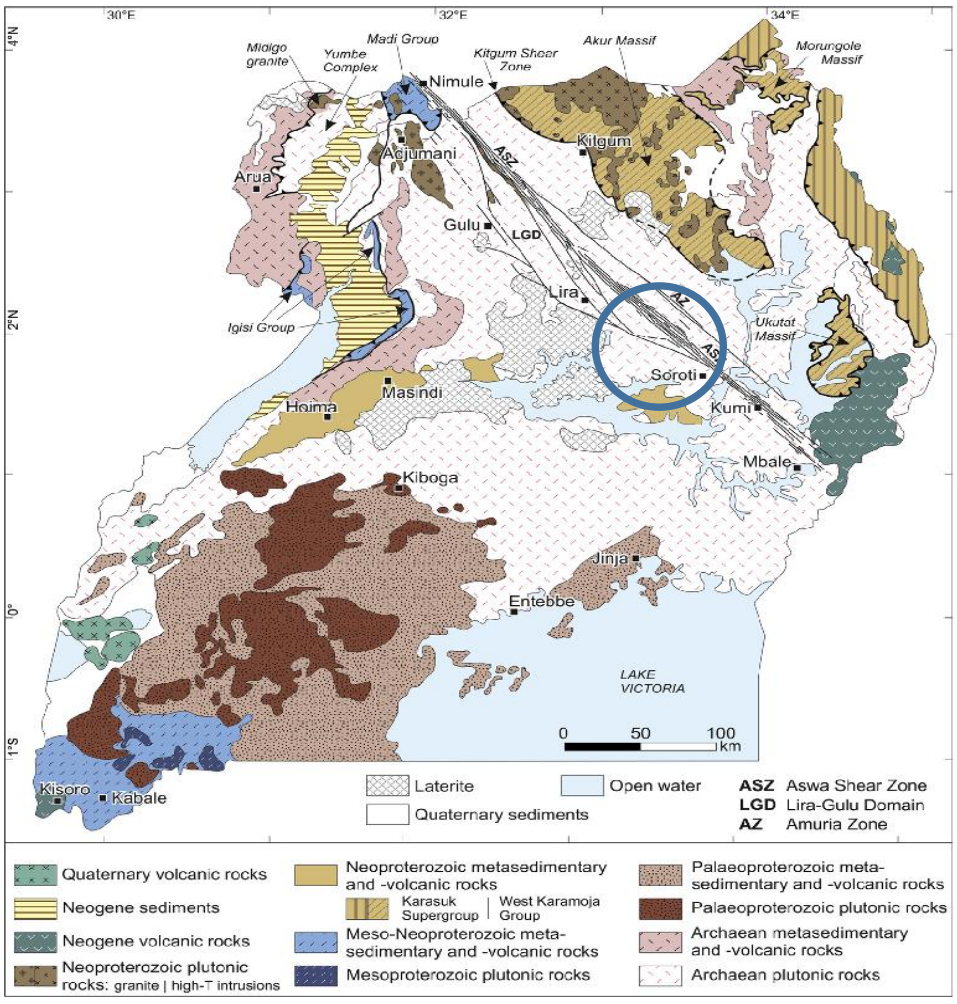
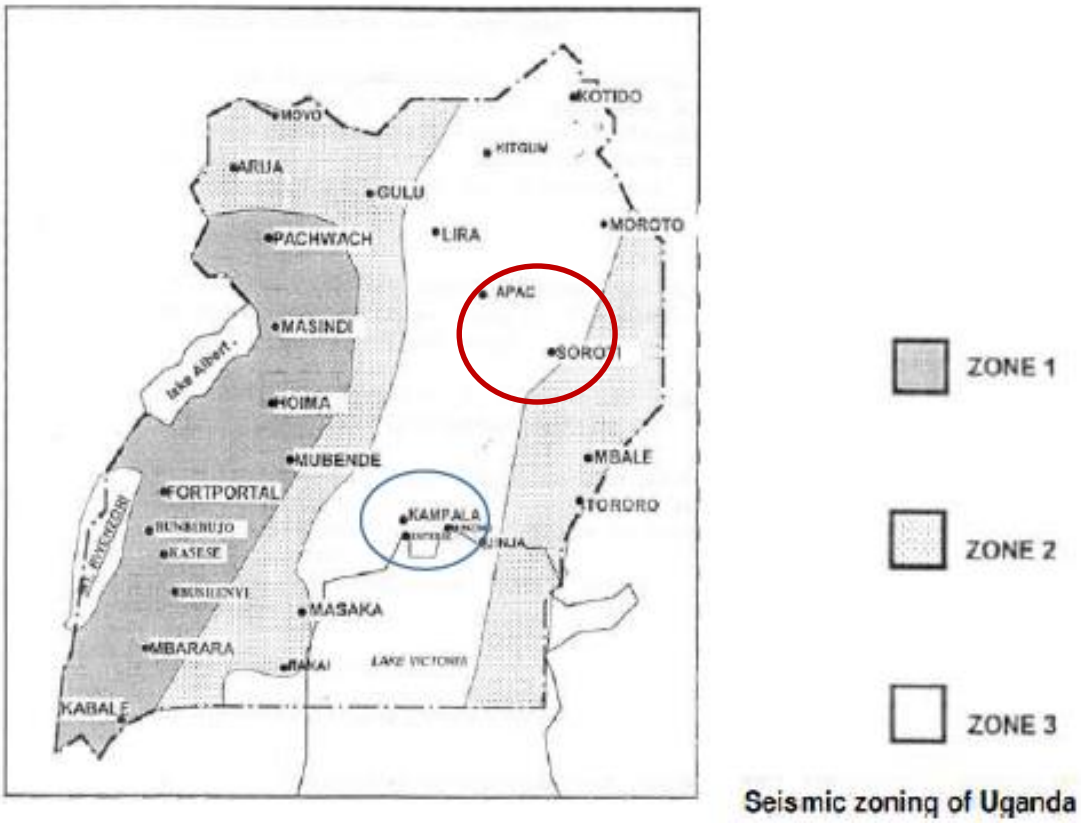


FIGURE 02: GEOLOGICAL MAP OF UGANDA

4.6 SEISMOLOGICAL ASPECTS

The site is located in zone 3 of the seismic zoning of Uganda, implying that there is a slightly low frequency (and magnitude) of earthquake occurrence in the area. (*Seismic Code of practice for Structural Designs; Uganda National Bureau of Standards, First Editions: June 2003*) below is a seismological map of Uganda to justify this information



Seismic zoning of Uganda

4.7 GROUND WATER TABLE (G.W.T)

The standard method of determining GWT was adopted, in which whenever ground water is encountered during excavation or drilling, the pits were covered to allow the water level to stabilize for about 24 hours. The actual level of the static water table is there after measured using a tape measure. In this case, the **ground water was not encountered** in any of the excavated pits as presented in the test pit loggings.

5.0 METHODOLOGY

5.1 STRUCTURAL INSPECTION AND ASSESSMENT METHODS

Building inspection is a general surface examination of those parts of a property which are accessible. In order to carry out the inspection, the engineer required some basic equipment to be used during the survey. In general four types of inspection were distinguishable: these include visual inspection, concealed object inspection, Dampness inspection, stress survey.

5.1.1 Non-Destructive Rebound Hammer Test.

This test was carried out with an N-type Schmidt mechanical rebound hammer. The concrete surface to be tested was first prepared by smoothening with a carborundum stone. Care was taken to avoid honeycombed regions and wet surfaced concrete. At least ten shots of the hammer were taken on each chosen member, and the mean rebound reading of each member was recorded, corrected and used to obtain the average compressive strength. In the case of this building, no chiseling or hacking was required to remove plaster, since most of the members were exposed.

5.1.2. Structural Member Dimensions Assessment

This activity involved ascertaining the dimensions of the different structural members i.e.; the beams, slabs, and foundation footings. A calibrated tape measure was used, and were possible, a Vernier caliper came into play.

5.1.3. Reinforcement detail assessment

This was carried out with the help of hand tools and equipment e.g. chisels mallets, micrometer screw gauge, and a Vernier caliper. Since the buildings under investigation were found complete, a few members were chosen from each of the buildings, such that they can be chiseled to expose the reinforcement for analysis and assessment. After exposure, some of the exposed reinforcements were assessed to check for defects and measured to obtain their individual sizes. The chiseled points were later filled and finished back to original surface finish.

5.2 SUB-SOIL /GEOTECHNICAL INVESTIGATION

The output of the sub-soil investigation is detailed in the geotechnical investigation findings including all activities undertaken by the laboratory to ascertain the geotechnical conditions. All structural foundation stability should be assessed with reference to this section of the report.

5.2.1 SUBSURFACE EXPLORATION PROCEDURES AND METHODS

Following a review and evaluation of existing information regarding soil conditions, survey reports and architectural details for the project, an investigation and testing program has been developed and implemented. Field testing, sampling and laboratory testing has been designed to provide information as follows:

5.2.2 Trial Pits

Two trial pits were sunk at approximate nominal distribution as presented on the site layout plan, each pit attaining a target depth of about 2.5 - 3.0m. Two of the test pits were located at foundation points. The test pitting operations were carried out manually with aid of hand tools such as hoes, spades and pick axes.

The test pits were located in alternate positions of the site as requested by the design team. The aim of the excavation of trial pits was to determine the structure of existing sub soils, the type of underlying soils, including extraction of both disturbed and undisturbed samples. In-situ density tests to determine the actual density of the underlying strata where carried out with aid of the core cutter method.

5.2.4 Sampling:

Bulk samples were taken from each of the test pits at 1.0 – 1.5m depth intervals for laboratory testing. Representative soil samples obtained throughout the exploration program were placed in air tight containers and transported to the laboratory. In the laboratory, the soil samples were classified in general accordance with techniques outlined in the visual-manual identification procedure (ASTM D 2488) and the Unified Soil Classification System.

5.2.3 Dynamic Cone Penetration Test (DCP)

Dynamic Cone Penetrometer (DCP) tests were conducted through the ground below surfacing to provide an estimate of the in-situ bearing capacities of the layers underneath. DCP tests at this stage were performed in the test pits at depth intervals of 1.50m, commencing from ground level as presented in the appendix on the site layout. The program of dynamic cone penetrometer testing was carried out, using the TRL model cone penetrometer with 8kg hammer falling through a shaft of drop height 575mm, which intern forces a 20mm diameter/60 degree cone into the encountered strata.

The TRL DCP is an instrument designed for the rapid in-situ measurement of the structural properties of existing sub soil structure. Correlations have been established between measurements with the DCP, CBR (California Bearing Ratio) and allowable bearing capacity, so that results can be interpreted and presented appropriately for foundation design.

5.2.5 Test pit logging

Test pit layer details were also examined recorded as profiles and are shown in detail in the appendix. The stratigraphy revealed by each pit was carefully logged with special note taken to the thicknesses and conditions of the various layers. The soil descriptions and classifications discussed in this report and shown on the attached test pit logs are generally based on visual observation and should be considered approximate. Copies of the test pit logs are provided and classification procedures are further explained in the Appendix attachments.

5.2.6 LABORATORY SOIL TESTING

Laboratory testing was carried out on samples obtained from the excavated test pits to identify the physical properties of the soils, and obtain parameters for determining their strength and compressibility characteristics. The tests were conducted according to the following standard methods given in table 03:

Table 03; Laboratory tests carried out on samples

Classification Tests		
	Standard Test Method	Sample status
Moisture content	BS 1377: Part 2: 1990	Disturbed
Particle size distribution	BS 1377: Part 2: 1990	"
Liquid Limit	BS 1377: Part 2: 1990	"
Plastic Limit	BS 1377: Part 2: 1990	"
Plasticity Index	BS 1377: Part 2: 1990	"
Specific gravity	BS 1377: Part 2: 1990	"
Chemical tests		
Sulphate tests	BS 1377: Part 3: 1990	Disturbed
Chloride tests	BS 1377: Part 3: 1990	Disturbed
pH tests	BS 1377: Part 3: 1990	Disturbed
Compaction tests		
In situ Density	BS 1377: Part 4: 1990	Undisturbed
Lab Density determination	BS 1377: Part 4: 1990	Disturbed
Strength tests		
Shear strength test	BS 1377: Part 7: 1990	Undisturbed

5.2.6.1 CLASSIFICATION TESTS

Natural Moisture Content

This was carried out in accordance with BS 1377: Part 2: 1990. A specimen was obtained from each of the samples delivered to the laboratory, and its weight taken. The specimen was oven dried at temperatures between 105^0C and 110^0C for 24 hours and the dry weight was also taken. The ratio of moisture loss (wet mass – dry mass) to the mass of the dried soil expressed as a percentage is the moisture content of the specimen.

Particle size distribution determination (sieve analysis)

The standard method of wet sieving which conforms to BS 1377: Part 2: 1990 was adopted. A representative sample was taken from the main sample and oven dried at temperatures between 105^0C and 110^0C for 24 hours. The dried soil was weighed to obtain its dry mass, and after it was washed through a 0.063mm BS test sieve in accordance with the test method.

The retained fraction was again oven dried for 24 hours at temperatures between 105^0C and 110^0C, after which it was sieved through a series of BS test sieves arranges in descending order of aperture sizes to form a nest. Sieving was done. The fraction retained on each sieve was weighed and the percentage passing each sieve was determined.

Plastic Limit (PL)

Plastic limit is the moisture content below which soil is not plastic (non-plastic). This test was also carried out in accordance with BS 1377: Part 2: 1990. The samples used in this test were prepared in the same manner as those for the liquid limit tests. The test consisted of rolling balls of soil pastes between the hands and then into threads between the palm and a glass plate. The plastic limit was the moisture content at which the threads develop transverse cracks when they were about 3mm diameter.

Liquid Limit (LL)

Liquid limit is the moisture content beyond which soil behaves like a viscous fluid. Therefore Liquid limit is a consistency limit of soil. The Liquid limit test was carried out using the BS Cone Penetrometer in accordance with BS 1377: Part 2: 1990. A BS cone Penetrometer fitted with an automatic timing device that ensures 5 second penetration under an 80gm load was used. Air dried representative samples were ground in a mortar and sieved through a 0.425mm BS test sieve. 200g of each of the sieved samples were mixed thoroughly with distilled water and there after the water was allowed to permeate the samples overnight in an air tight container. The soils specimens were then remixed the following day with sufficient water to achieve two penetrations in the range between 15mm and 25mm. After each penetration, the respective moisture contents of the specimens were determined. Moisture content, Penetration curve was plotted for each of the specimens from which the moisture content at 20mm penetration was taken to be the liquid limit.

Plasticity Index (PI)

The Plasticity index was determined in conformity with BS 1377: Part 2: 1990. The Plasticity index is the numerical difference between the LL and PL. (**PI = LL – PL)**

Specific Gravity of soils (Gs)

Specific gravity is in simple terms the relative density of soil, hence the ration of mass of a given soil sample to the mass of an equal volume of water. This test was carried out with accordance to BS 1377: Part 2: 1990. The density bottle method was used in this test were each of the air dried sample were ground with a mortar and pestle, and after sieved through a 2mm BS test sieve. About 50g of each of the sieved samples were placed in respective bottles and there masses taken.

These were treated to procedure complying with BS 1377: Part 2: 1990 to obtain the Specific gravities for each of the samples

5.2.6.2 CHEMICAL TESTS

Chemical tests were also conducted on the extracted soil samples, the sand material found on site and also ground concrete samples from hardened concrete specimens

Sulphate tests

In this test, the gravimetric method was used, in accordance with BS: 1377: Part 3: 1990. It involved obtaining 50gms of air dried samples were placed in extraction bottles and 100ml of distilled water added to each before covering tightly. These were then mounted onto shakers and agitated for 16 hours. The soil suspensions were then filtered into clean and dry flasks. 50ml of the soil suspensions were dissolved in distilled water, after which Barium chloride solution was added to each, to form a precipitate of Barium sulphate, which was collected, dried and weighed. The Sulphate content was then calculated from the mass of water used in the analysis and the mass of Barium sulphate precipitated.

Chloride tests

This was done in accordance with BS: 1377: Part 3: 1990. 5gms of material passing the 0.150mm BS test sieve was put in a beaker of 500ml volume. 50ml of distilled water was added followed by 15mlof concentrated nitric acid. The mixture was then heated to near boiling point, cooled and filtered through coarse graded filter paper.

The residue was washed with distilled water and all the filtrate collected. Silver nitrate was then added to the filtrate from burette until all the chlorides were precipitated.

Titration was done with standard Potassium thio-cynate using ferric alum as an indicator. 3, 5-5 trimethylhexan-1-ol was used to coagulate the precipitate.

pH test

This test was performed in accordance with BS: 1377: Part 3: 1990, in which the Electrometric method was used to determine the pH of the soils. 10gms of an air dried soil/sand/pulverized concrete sample was dissolved in distilled water and introduced into a 100ml beaker and stirred for a few minutes then covered and allowed to stand for 8hrs. Calibration of the Ph meter was done initially using a standard buffer solution. The electrode was then washed with distilled water and immersed in the dissolved sample. The corresponding reading was taken with brief stirring between each reading.

5.2.6.3 SOIL COMPACTION TESTS

In situ Density Determination

This test was carried out in accordance with BS 1377: Part 4: 1990. The Core cutter method was used. This was done to determine the dry density (mass of dry soil per cubic meter) of natural or compacted soil in situ, since density is also an important parameter of strength and a measure of the Degree of Compaction. ***The core cutter*** is a cylindrical metal of known dimension (volume) and weight, and has a cutting sharp edge. The core cutter was driven into the floor of the excavated pit at a suitable depth using a steel dolly. The core cutter was then later carefully extracted out of the pit, and it contained a core of soil. A small portion of soil was also taken and placed in an air tight container for relative moisture content determination. The weight of the core cutter and the sample in it was taken. Calculations were done to obtain the field / insitu density with accordance to BS 1377: Part 4: 1990.

Maximum Dry Density/ Optimum Moisture Content Determination (BS Heavy)

This test was also carried out in accordance with BS 1377: Part 4: 1990, in which each of the samples were air dried and compacted into a BS standard compaction mould with a 4.5kg rammer at different predetermined amounts of water, hence varying moisture contents. The compaction was in a way that the mould was filled in five equal layers, and each layer was compacted with 27 blows by free fall of the 4.5kg rammer. After compaction of each of the samples the mould was trimmed to level with a straight edge and the weights of the samples in the moulds were obtained. Further calculations were made for the five moisture increments, to obtain the respective dry densities, for each of the samples. After which a graph of Dry density against moisture content was plotted and the Maximum dry density (MDD) was taken to be the Dry density in horizontal extrapolation with the peak of the curve, while the Optimum Moisture Content (OMC) was the moisture content value corresponding with the peak of the curve.

5.2.6.4 STRENGTH TESTS

Direct Shear Test

This was performed on the undisturbed sample in conformity to BS 1377: Part 7: 1990. For each of the samples, three specimens of dimensions 60×60×20mm were prepared and tested as follows: the first specimen was given a fixed normal load (stress) close to the respective overburden pressure and was sheared along its horizontal plane through its mid-depth to failure. The same was done on the other two specimens but this time the fixed normal stresses were successively higher. The failure readings were noted. A plot was made between the normal stress as the abscissa and the shear stress as the ordinate. The angle between the graph and the horizontal was taken to be the angle of internal friction **ϕ** and the y-intercept was the cohesion **C.**

Bearing Capacity as derived from Penetration Test Results

The table below shows the bearing capacity variation with depth as derived from the penetration tests, Allowable Bearing Capacity can therefore be calculated from the formula below, as specified for cohesive soils.

Log10 (**CBR**) = *2.48 – 1.057 Log10 (Strength)*

Allowable Bearing Capacity **(KN/m2) = *10 x CBR + γZ***

Where: CBR – Californian Bearing Ratio derived from the DCP test as a Strength parameter

γ - Specific weight (ρg) of the soil as determined from the lab

Z - Depth from Ground level

6.0 PICTORIAL PRESENTATIONS OF THE INVESTIGATION

Photo plate 02: Random view of the site and the building under investigation

Photo plates 03: Manual excavation of test pit at one of the footing points

Photo plates 04: Perspective view of the added ramp

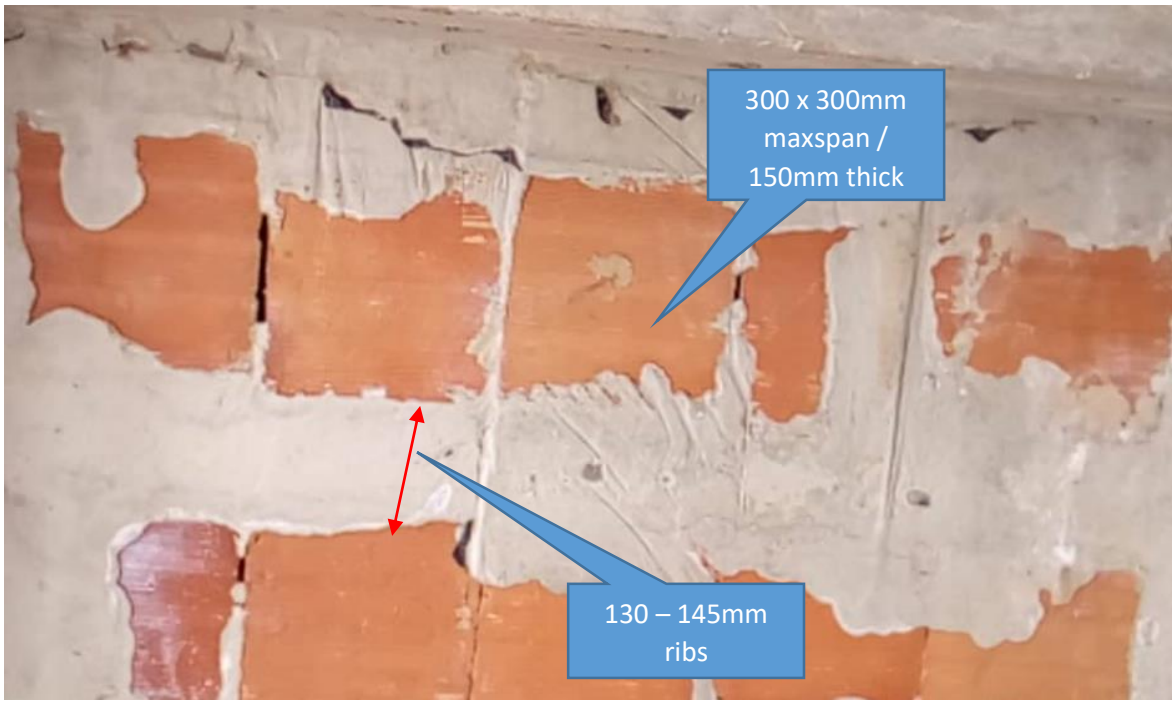


Photo plate 05: view underneath first floor slab.

Photo plate 06: dimension measurement/check of structural members

Photo plate 07: Reinforcement bar details being captured

Photo plate 08: Rebound hammer tests for compressive strength on concrete members

Photo plate 09: walling material used. (common burnt clay brick wall, 200mm thick)

Photo plate 10: Honey combings observed in some area.

7.0 FINDINGS

7.10 STRUCTURAL /BUILDING ASSESSMENT FINDINGS

7.11 Visual inspection findings.

Visual inspections were made on the different walling and concrete surfaces at different random points. The table below shows some of the defects found on the structure with some of the remedies.

Table 02: visual inspection and assessed defects

S/No.	Defects	Remarks / Proposed Remedies
1	Concrete honey combs were observed.	Immediate grouting to stop rebar exposure, which may lead to corrosion and oxidation
2	Some cases of exposed rebar were observed, due to insufficient cover and honey combed surfaces	
4	Small walling cracks of non-structural effect were observed in some areas	Mortar infill in cracks, application of mesh along cracks, re-application of plaster.
5	**Ceiling** All ceiling/slab soffit were observed to be structurally sound though with slight efflorescence.	n/a
6	**Concrete slab floor** Few shrinkage cracks were observed especially on the ground floor slab. It should be noted that though shrinkage cracks are of no structural effect in ground floor slabs, they should be remedied to facilitates proper floor finishes.	

7.1.2. Concrete structural member sizes/dimensions

As previously stated, dimension measurements were taken and below is a table showing the approximate as built member sizes as obtained from the existing building.

Table 03: Table showing the sizes of members on the existing structure.

Member	Dimension details	Remarks
COLUMNS	**Square columns** Most of the columns were square columns with dimensions of 230 x 230mm and a floor to floor height of 3.05 – 3.1m **Circular column** The circular column was observed with 230mm circumference and also about 3050 – 3100mm floor to floor height.	Concrete was visually sound and the cover had good resistance to hacking. All aggregates used for concreting were observed to be of machine crushed type.
BEAMS	All beams were found to have 500mm depth and 230mm wide.	
SLABS	The assessed max span slabs were observed to have 220 – 230mm thickness and a rib of width 130 – 145mm	
STAIR CASE	290 – 300mm treads, 150mm risers and a 150 – 160mm waist	
RAMP	The ramp was found to have a thickness of 200 – 250mm	
FOUNDATION	The foundation pads were of 1500 x 1500mm and a 290 - 300mm thickness	

7.1.3 Concrete reinforcement details

The table that follows gives the details of the finding regarding the reinforcement used in the concrete structural members. All details are as assessed and booked from the as-built structure.

Table 04: Reinforcement details as obtained from the as-built structure

Structural Member	As Built bar/reinforcement details	Remarks
COLUMNS	<u>Square columns</u> All columns were found with six, 16mm ribbed bars, wrapped in 8mm rings at a spacing of 170 - 175mm c/c	All structural analysis designs should be carried out with reference to this data.
	<u>Circular columns (one)</u> All circular columns were found with six 16mm ribbed bars, wrapped in 8mm rings at a spacing of also about 170 - 180mm c/c	
BEAMS	All the beams were found with three 16mm ribbed bars at the top and bottom, wrapped in 8mm rings at a spacing of about 180 - 190mm	
SLABS	The max span slabs were found to have two 12mm rebars in each rib	
STAIR CASE	The stairs had 12mm diameter twisted bars at a spacing of about 170mm in both directions, bottom at the bottom of the waist	
FOUNDATION	The foundation footings were found with 12mm diameter bars at a spacing of 150 - 160mm center to center, in both directions, bottom	

7.14 Concrete strength of members

After carrying out nondestructive rebound hammer tests, details regarding the individual strength of each tested member in building is represented in the attached result certificate below.

Table 05: Compressive Strength Test Results

COMPRESSIVE STRENGTH TEST RESULTS FOR CONCRETE MEMBERS (SCHIMDT HAMMER TEST)				
Age of concrete: Past 28 days		**Test conditions:** Air dry	**Date tested:** 04/11/2018	
STRUCTURAL MEMBER	**STRUCTURAL LEVEL/POSITION**	**REFERENCE GRID MARK**	**ANGLE OF REBOUND SHOT, (DEGREES)**	**AVERAGE COMPRESSIVE STRENGTH (MPA)**
BEAMS	FIRST FLOOR	Along grid B	+90	27
		Along grid A	+90	27
		Along grid 2	0	26
		Along grid 8	0	28
		Along grid 10	0	28
		Along grid 11	+90	27
		Along grid F	+90	28
STAIR CASE A	GROUND FLOOR	STAIR CASE SLAB	0	28
			+45	28
STAIR CASE B			0	27
			0	26
FOUNDATION	5,D	PLINTH COLMN	0	28
		FOOTING	-90	28
COLUMNS	GROUNG FLOOR	2,A	0	29
		5,D	0	28
		1,D	0	27
		2,G	0	27
		10,G	0	28
		2,F	0	28
	FIRST FLOOR	5,A	0	28
		9,F	0	29
		11,B	0	27
		4,B	0	28
SLABS	FIRST FLOOR SLAB	Randomly selected point in slab panels	-90	26
			-90	26
			-90	27
			-90	27
			-90	26
			-90	26
	GROUND FLOOR SLAB		-90	26
			-90	27
			-90	28
			-90	27

7.2. GEOTECHNICAL /SUB-SOIL INVESTIGATION FINDINGS

After carrying out all the necessary soil laboratory tests and analysis, the following pages detail representation of the results as obtained from the laboratory and insitu soil tests.

7.2.1. LABORATORY FINDINGS

7.2.2 Compaction Tests

The In Situ Dry Density test for soils retrieved from the excavated Test pits at suitable depths was carried out using the Core cutter method. The laboratory and In situ densities of the test pits at the specific depths are as given in the test result certificates.

Table 06: Density properties of the site referring to the test pits

PIT No.	Depth (m)	LAB DENSITY PROPERTIES		FIELD DENSITY PROPERTIES	
		MDD (Mg/m^3)	OMC (%)	FDD (Mg/m^3)	NMC (%)
TP 01	1.50	1.87	16.5	1.42	23.6
	2.50	1.90	15.2	1.49	28.4
TP 02	1.00	1.90	17.2	1.45	25.7
	2.50	1.89	15.6	1.47	26.8

7.2.3 Classification test results

Laboratory classification tests were carried out for each of the Disturbed samples recovered from the test pits. The findings revealed that the pits exhibited fairly coarse grained material at the upper layers underlain by clayey coarse gravel material throughout the excavated depths of reddish brown coloration. All the soil classification was carried out using the Unified Soil Classification System as presented in appendix B).

7.2.4 Soil Shear Strength test Results.

For the undisturbed samples extracted from each of the pits, drained shear box test was carried out to establish shear strength parameter. The findings for this test are as given in appendix B. it was observed that test pits exhibited allowable bearing capacities ranging between 208 – 32KPa.

7.2.5 Soil Chemical test results.

Here in, is a table showing the chemical test results as determined in the laboratory by standard methods as previously discussed.

Table 07: Chemical test results

PIT No.	Depth (m)	Sulphate content (%)	Chloride content (%)	pH
TP 01	1.50	0.0025	0.0035	6.05
	2.50	0.0020	0.0040	5.90
TP 02	1.00	0.0035	0.0040	6.00
	2.50	0.0035	0.0045	6.15
Permissible Limits, BS 882: 1992		**0.2 Max**	**0.05 Max**	**4.5 Min**

7.2.6 Bearing Capacity as derived from Penetration Test Results

The table below shows the bearing capacity variation with depth as derived from the penetration tests, Allowable Bearing Capacity can therefore be calculated from the formula below, as specified for cohesive soils.

Table 08: Penetration test results

PIT No.	Start depth (m)	Strata range tested (m)	Depth from ground level, Z (m)	Layer thickness (mm)	Unit weight KN/m³	CBR VALUE (%)	ALLOWABLE BEARING CAPACITY
TP 01	0.00	0.000 – 0.566	0.283	566	17.6	13	135
		0.566 – 0.980	0.773	414		08	94
	1.50	1.500 – 2.037	1.769	537		16	191
		2.037 – 2.472	2.255	435	19.1	13	173
	2.50	2.500 – 2.850	2.675	350		13	181
		2.850 – 3.428	3.139	578		17	230
TP 02	0.00	0.000 – 0.535	0.268	535	18.2	26	265
		0.535 – 0.969	0.752	434		09	104
	1.00	1.000 – 1.350	1.175	350		21	231
		1.350 – 1.948	1.649	598	18.6	15	181
	2.50	2.500 – 2.901	2.701	401		14	190
		2.901 – 3.579	3.240	678		13	190

8.0 CONCLUSIONS AND RECMMENDATIONS

8.1 General

The following evaluations and recommendations are based on our observations at the site, interpretation of the field and laboratory data obtained during this investigation and our experience with similar subsurface conditions and projects.

All these conclusions and recommendations are based on the tests and observations carried out on the structure and the site. Soil penetration data has been used to develop an allowable bearing pressure and estimate associated settlements using established correlations. The structural integrity report should be used in assessment of the building under investigation; however this should be done hand in hand with approved structural designs and calculations to confirm stability of the building.

8.2 Concrete Strength

Based on the rebound hammer test results, compressive strength for concrete members was found varying from 26 – 29MPa, as presented in the findings. Should the building be found unstable under existing moments and stresses, additional bracing should be considered to ensure stability or consider it unstable. It is further recommended that a maximum design compressive strength of **26MPa** (average) be used for concrete design and assessment of the buildings.

8.3 Foundation Design

Based on the structural information and findings in this report, the exiting building was found to be supported on a foundation system bearing on approved undisturbed residual soils with a maximum **allowable bearing pressure of 180KPa**.

8.4 Rebar assessment and dimension of structural members

The assessed concrete members were found to have sound reinforcement bars with no significant corrosive signs and reduction in girth/circumference. Please note that all the reinforcement bars were of twisted type.

8.5 Site Seismic Class Definition

With reference from the updated ground motion prediction equation by Pankow and Pechmann, seismic results for Uganda show that the PGA values for the region in which the site is located falls in the range of 0.152 to 0.162 g, 0.187 to 0.195 g and 0.248 to 0.256 g (where g is the acceleration due to gravity), for return periods of 475, 975 and 2,475 years, respectively. Further, the site is located in zone 3 of the seismic zoning, hence there is less frequency and magnitude of earth quakes.

8.6 Building defects.

It should be noted that the building was found in an incomplete state and pending addition of more floor levels by the client at the time of investigation. Some concrete defects such as efflorescence, shrinkage cracking, honey combings and rebar exposure were observed and require immediate remediation as explained.

8.7 Subsurface Water Conditions

Subsurface water for the purposes of this report is defined as water encountered below the existing ground surface. Based on the subsurface exploration data obtained during our exploration program, we generally confirm that subsurface ***water was not encountered*** in any of the excavated test pits.

8.8 Soil property analysis

The investigation revealed that the site mostly comprised of firm clayey medium coarse gravel of intermediate and low plasticity (according to USCS system of soil classification) in both the A-Horizon and underlying soils.

The soils were of colors that ranged from black brown to reddish brown. Chemical analysis revealed that the sulphate content in the soil ranged from 0.0020 to 0.0035, while the considerable chloride content ranged from 0.0035 to 0.0045 hence no effect of these chemicals' contents to normal strength concrete. The soils were found with a pH range of 5.90 – 6.15, which is also considered to have no effect on normal strength concrete.

8.8 CONTINUATION OF SERVICES

We also recommend that an Engineer from the Soil and concrete laboratory be retained for professional and construction materials testing services during addition construction or remedial works of the project. Our continued involvement on the project helps provide continuity for proper implementation of the recommendations discussed herein.

8.9 LIMITATIONS

This report has been prepared for the exclusive use by the here-in stated client or their agent, for specific application to the structural integrity assessment of the existing single storied administrative building in Amuria, on Plot _____, Amuria district local government premises, in accordance with generally accepted practices. The conclusions and recommendations do not reflect variations in subsurface conditions and structural member characteristics which could exist intermediate of the test point locations or in untested areas of the structure. Should such variations become apparent during addition construction, it will be necessary to re-evaluate our conclusions and recommendations based upon on-site observations of the conditions. Therefore, we assume no responsibility for construction compliance with the design concepts, specifications, or recommendations.

Endorsed by:

_____

DR. J. NYENDE
HEAD OF DEPARTMENT

APPENDIX A

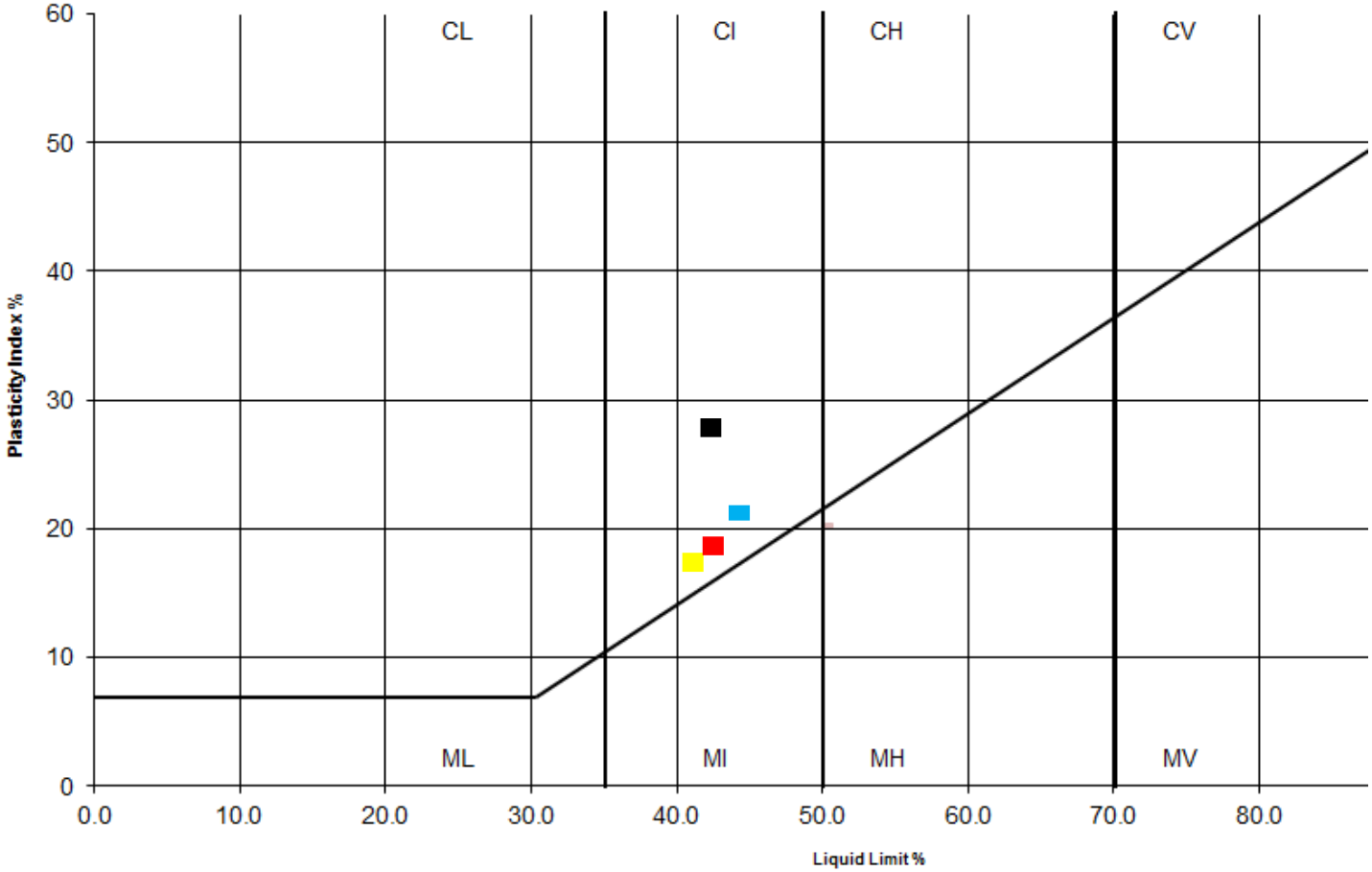
SITE/STRUCTURAL DETAILS

FIGURE SHOWING THE BUILDING PLAN LAYOUT

FIGURE SHOWING THE SITE LAYOUT PLAN SHOWING THE PROPOSED BUILDING AND APPROXIMATE TESTPIT LOCATIONS

APPENDIX B

Test Pit Logs



TP 01 @ 1.50m TP 01 @ 2.50m TP 02 @ 1.00m TP 02 @ 2.50m

SOIL AND CONCRETE LABORATORY

PROJECT: STRUCTURAL INTERGRITY INVESTIGATION ON PLOT _____, AMURIA DISTRICT LOCAL GOVERNMENT BLOCK,

CLIENT; AMURIA DISTRICT LOCAL GOVERNMENT OF P.O. BOX 4, AMURIA

THE CLASSIFICATION TEST DATA FOR DISTURBED SAMPLES COLLECTED FROM SITE

PIT No,	DEPTH (m)	Sample type	Percentage passing (%)												Atterberg limits			NMC (%)	USCS
			Sieve 37.5 mm	Sieve 20 mm	Sieve 10 mm	Sieve 6.3 mm	Sieve 4.75 mm	Sieve 2.0 mm	Sieve 0.600 mm	Sieve 0.425 mm	Sieve 0.300 mm	Sieve 0.212 mm	Sieve 0.150 mm	Sieve 0.075 mm	LL (%)	PL (%)	PI (%)		
TP 01	1.50	D	_	_	100	98	94	89	84	77	72	66	61	57	43	15	28	23.6	CI
	2.50	D	100	98	92	86	82	75	67	61	55	47	42	35	43	24	19	28.4	G-CI
TP 02	1.00	D	100	97	92	85	79	73	65	60	53	47	42	37	45	24	21	25.7	G-CI
	2.50	D	100	98	94	89	81	74	69	64	59	52	44	35	41	23	18	26.8	G-CI

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LAB MANAGER

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DR. J. NYENDE
HEAD OF DEPARTMENT

Unified Soil Classification System

Major Divisions			Group Symbol	Typical Names	Laboratory Criteria		
					Fines (%)	Grading	Plasticity
Course-Grained Soils More than 50% retained on the 0.075 mm (No. 200) sieve	Gravels 50% or more of course fraction retained on the 4.75 mm (No. 4) sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines		$C_u > 4$	
					0-5	$1 < C_c < 3$	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	0-5	Not satisfying GW requirements	
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures	>12		Below A-line or $I_p < 4$
			GC	Clayey gravels, gravel-sand-clay mixtures	>12		Above A-line or $I_p > 7$
	Sands 50% or more of course fraction passes the 4.75 (No. 4) sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_u > 6$	
					0-5	$1 < C_c < 3$	
			SP	Poorly graded sands and gravelly sands, little or no fines	0-5	Not satisfying SW requirements	
		Sands with Fines	SM	Silty sands, sand-silt mixtures	>12		Below A-line or $I_p < 4$
			SC	Clayey sands, sand-clay mixtures	>12		Above A-line or $I_p > 7$
Fine-Grained Soils More than 50% passes the 0.075 mm (No. 200) sieve	Silts and Clays Liquid Limit 50% or less		ML	Inorganic silts, very fine sands, rock four, silty or clayey fine sands	Use plasticity chart		
			CL	Inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays	Use plasticity chart		
			OL	Organic silts and organic silty clays of low plasticity	Use plasticity chart		
	Silts and Clays Liquid Limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	Use plasticity chart		
			CH	Inorganic clays or high plasticity, fat clays	Use plasticity chart		
			OH	Organic clays of medium to high plasticity	Use plasticity chart		
Highly Organic Soils			Pt	Peat, muck, and other highly organic soils			

SOIL AND CONCRETE LABORATORY

PROJECT: STRUCTURAL INTERGRITY INVESTIGATION ON PLOT _____, AMURIA DISTRICT LOCAL GOVERNMENT BLOCK,

CLIENT; AMURIA DISTRICT LOCAL GOVERNMENT OF P.O. BOX 4, AMURIA

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL FROM THE DRAINED –UNCONSOLIDATED SHEAR BOX TEST (GENERAL SHEAR FAILURE)

PIT No.	Depth D (m)	WIDTH B (m)	UNIT WEIGHT γ (KN/m³) x 10	COHESION C (KPa)	ANGLE OF FRICTION Φ (Degrees)	BEARING CAPACITY FACTORS			ULTIMATE BEARING CAPACITY (KPa)	SAFETY FACTOR, F	ALLOWABLE BEARING CAPACITY (KPa)
						N_C	N_q	N_γ			
TP 01	1.50	1	17.6	17	22	18.8	9.2	6.8	623	3	208
	2.50	1	19.1	09	25	24.7	13.6	9.8	965	3	321
TP 02	1.00	1	18.2	15	25	24.7	13.6	9.8	708	3	236
	2.50	1	18.6	10	22	18.8	9.2	6.8	679	3	226

COMPILED BY:

_____

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LAB MANAGER

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_____

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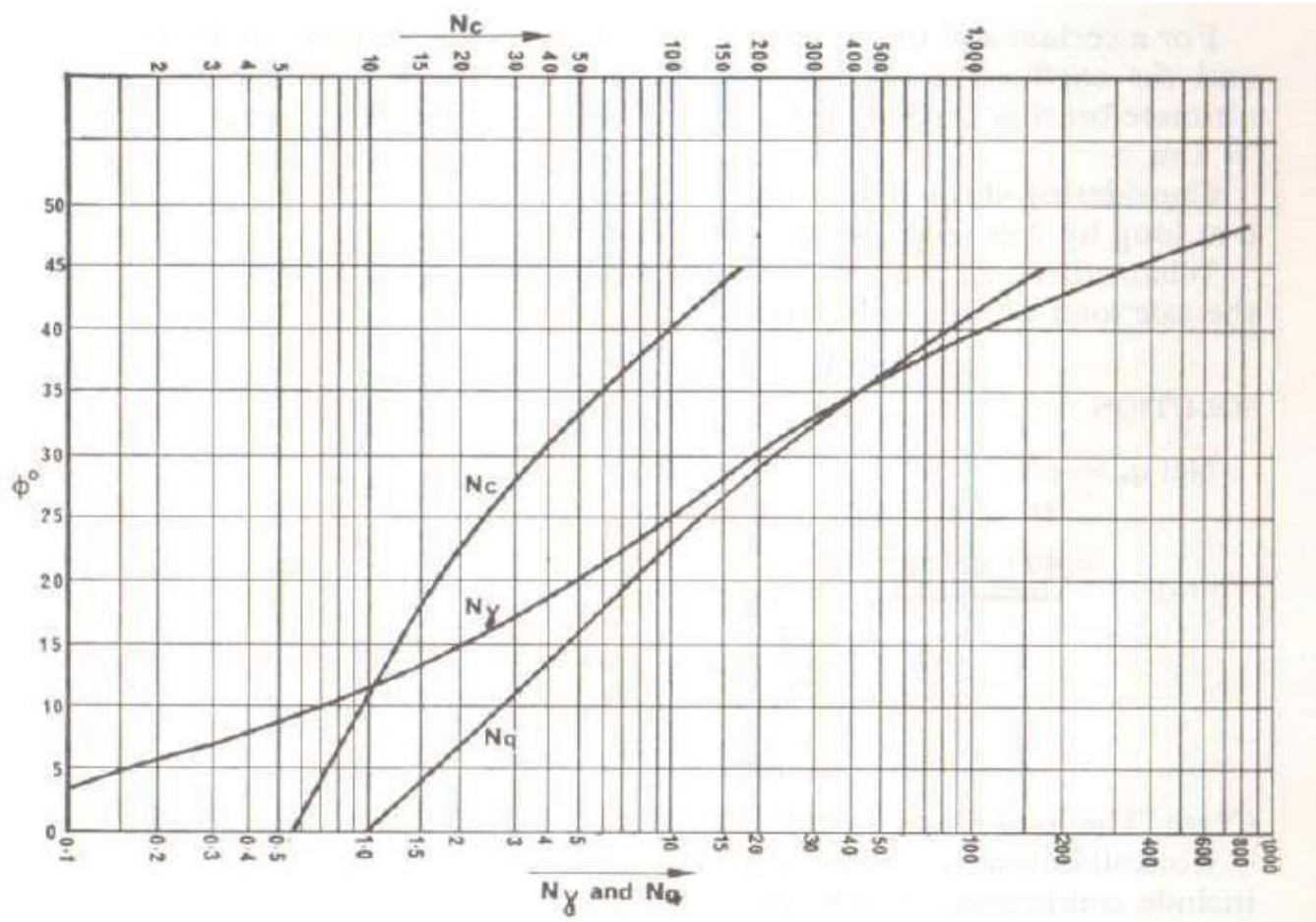
HEAD OF DEPARTMENT



A GRAPH FOR BEARING CAPACITY COEFFICIENTS (source: Soil Mechanics by Smith-pg 155, fig 103)

APPENDIX D

DYNAMIC CONE PENETRATION RESULTS AND ANALYSIS

SOIL AND CONCRETE LABORATORY

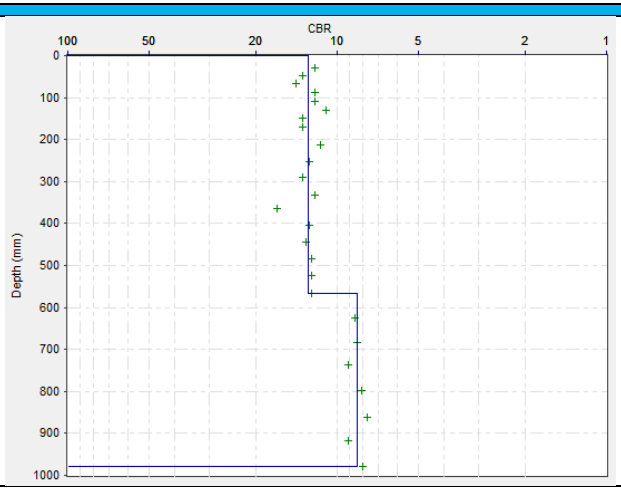
DEPARTMENT OF CIVIL AND BUILDING ENGINEERING

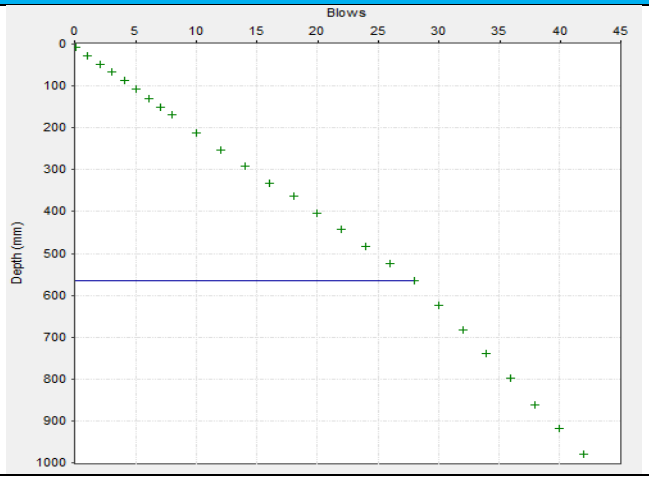
KYAMBOGO UNIVERSITY

DYNAMIC CONE PENETROMETER TEST RESULTS

SUBJECT: STRUCTURAL INGERGRITY INVESTIGATION ON PLOT ___, AMURIA DISTRICT BUILDING

CLIENT: AMURIA DISTRICT LOCAL GOVERNMENT	**TEST PIT No.:** TP 01	**Test commencement depth, (m):** 0.00





Checked by:

PAUL O.

APPROVED BY;

DR. J. NYENDE.

Notes:

Layer property analysis

No.	*Penetration rate (mm/blow)*	*CBR (%)*	*Layer thickness (mm)*	*Total depth penetrated (mm)*
1	19.93	13	566	980
2	29.57	08	414	

SOIL AND CONCRETE LABORATORY

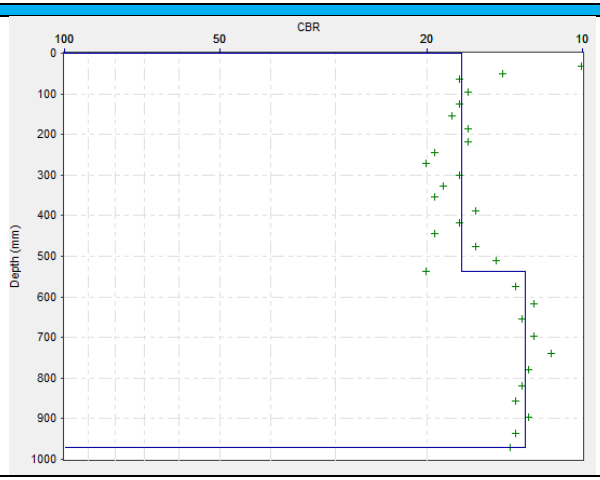
DEPARTMENT OF CIVIL AND BUILDING ENGINEERING

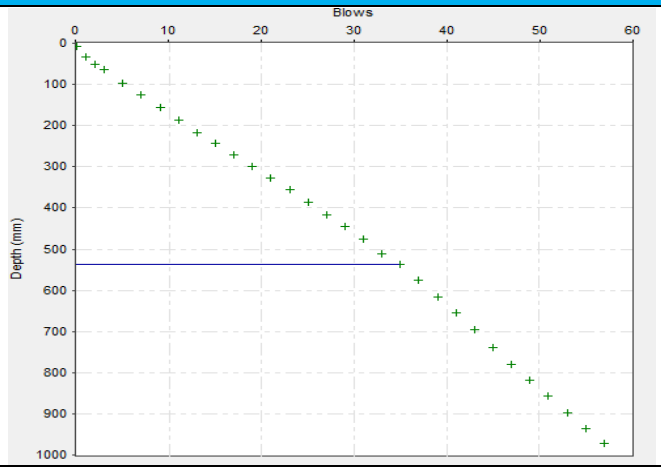
KYAMBOGO UNIVERSITY

DYNAMIC CONE PENETROMETER TEST RESULTS

SUBJECT: STRUCTURAL INGERGRITY INVESTIGATION ON PLOT ___, AMURIA DISTRICT BUILDING

CLIENT: AMURIA DISTRICT LOCAL GOVERNMENT	**TEST PIT No.:** TP 01	**Test commencement depth, (m):** 1.50





Lab tech:

OYAT E.

Checked by:

PAUL O.

APPROVED BY;

DR. J. NYENDE.

Notes:

Layer property analysis

No.	*Penetration rate (mm/blow)*	*CBR (%)*	*Layer thickness (mm)*	*Total depth penetrated (mm)*
1	15.14	16	537	972
2	19.77	13	435	

SOIL AND CONCRETE LABORATORY

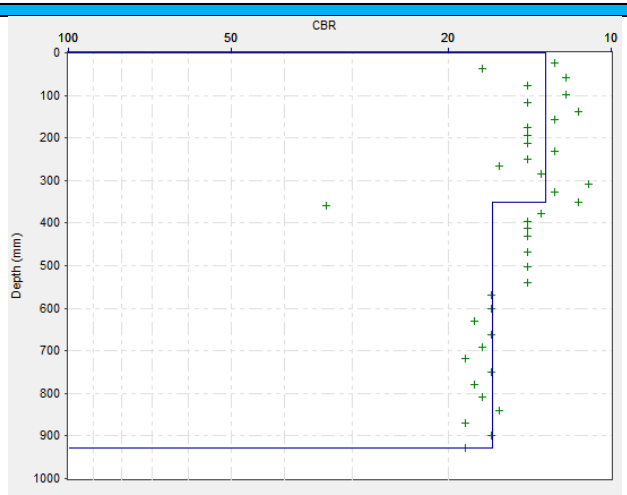
DEPARTMENT OF CIVIL AND BUILDING ENGINEERING

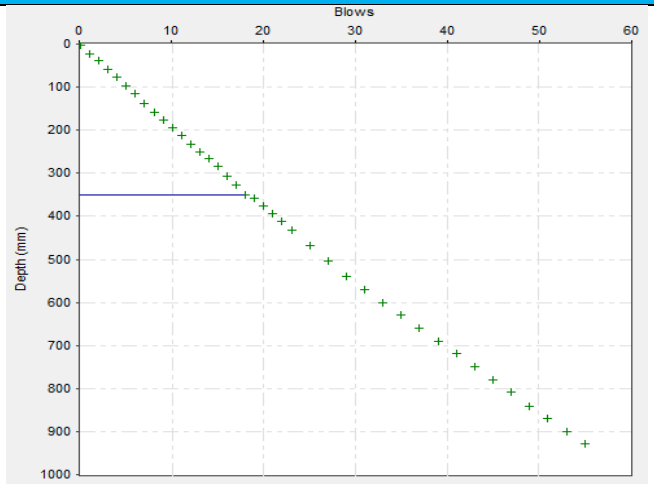
KYAMBOGO UNIVERSITY

DYNAMIC CONE PENETROMETER TEST RESULTS

SUBJECT: STRUCTURAL INGERGRITY INVESTIGATION ON PLOT ___, AMURIA DISTRICT BUILDING

CLIENT: AMURIA DISTRICT LOCAL GOVERNMENT	**TEST PIT No.:** TP 01	**Test commencement depth, (m):** 2.50





Lab tech:

OYAT E.

Checked and approved by:

PAUL O.

Checked and approved by:

PAUL O.

Notes:

Layer property analysis

No.	*Penetration rate (mm/blow)*	*CBR (%)*	*Layer thickness (mm)*	*Total depth penetrated (mm)*
1	19.28	13	350	928
2	15.62	17	578	

SOIL AND CONCRETE LABORATORY

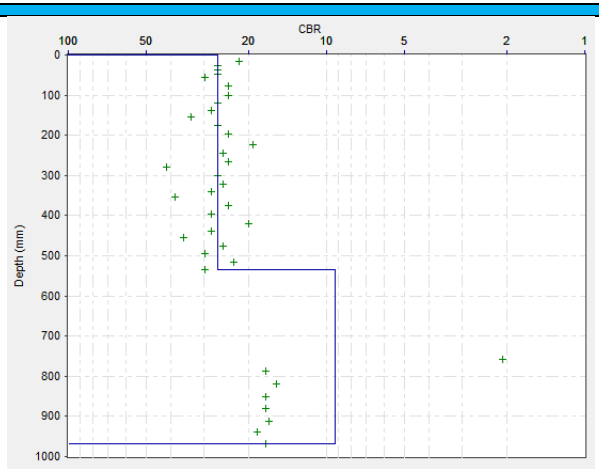
DEPARTMENT OF CIVIL AND BUILDING ENGINEERING

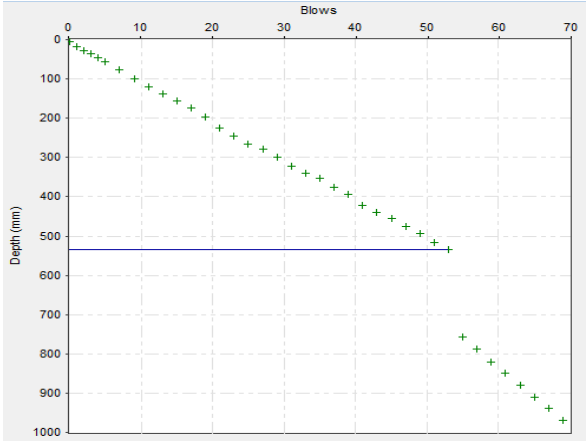
KYAMBOGO UNIVERSITY

DYNAMIC CONE PENETROMETER TEST RESULTS

SUBJECT: STRUCTURAL INGERGRITY INVESTIGATION ON PLOT ___, AMURIA DISTRICT BUILDING

CLIENT: AMURIA DISTRICT LOCAL GOVERNMENT	**TEST PIT No.:** TP 02	**Test commencement depth, (m):** 0.00





Lab tech:

OYAT E.

Checked by:

PAUL O.

APPROVED BY;

DR. J. NYENDE.

Notes:

Layer property analysis

No.	*Penetration rate (mm/blow)*	*CBR (%)*	*Layer thickness (mm)*	*Total depth penetrated (mm)*
1	10.00	26	535	969
2	27.13	09	434	

SOIL AND CONCRETE LABORATORY

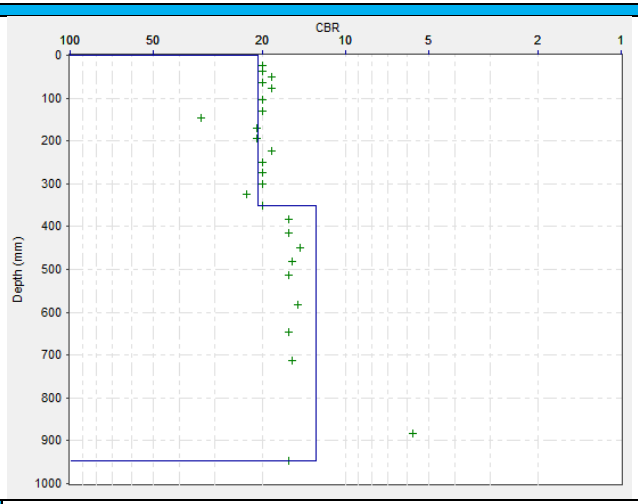
DEPARTMENT OF CIVIL AND BUILDING ENGINEERING

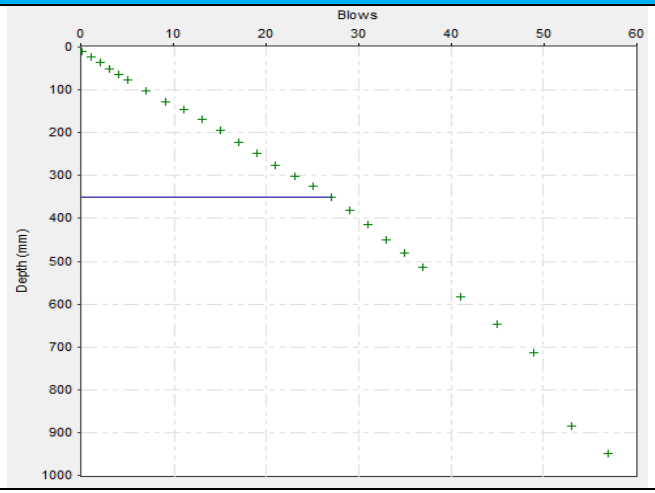
KYAMBOGO UNIVERSITY

DYNAMIC CONE PENETROMETER TEST RESULTS

SUBJECT: STRUCTURAL INGERGRITY INVESTIGATION ON PLOT ___, AMURIA DISTRICT BUILDING

CLIENT: AMURIA DISTRICT LOCAL GOVERNMENT	**TEST PIT No.:** TP 02	**Test commencement depth, (m):** 1.50





Layer property analysis

No.	*Penetration rate (mm/blow)*	*CBR (%)*	*Layer thickness (mm)*	*Total depth penetrated (mm)*
1	12.59	21	350	948
2	19.93	14	598	

Lab tech:

OYAT E.

Checked and approved by:

PAUL O.

Checked and approved by:

PAUL O.

Notes:

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