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Shallow Foundation Resolution On Near Surface Geo-Material For An Estate Development At Sector Centre B Layout, Kuje, Nigeria

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ABSTRACT: The geotechnical investigation of a site at Kuje, FCT Abuja was carried out to determine the sub - soil condition of the site to suitable depth, which could have an influence on structures, also to understand the engineering and geologic properties of the soil. The field work commenced on the 18th of March and was completed on the 20th of March, 2014. Samples from the field were then analyzed in the laboratory for its strength, consolidation and compaction characteristics. A total number of nine (9) trial pits at an interval of 30m from each other was probed to a depth of 1.5m. With regards to the soil studied in the site, the use of isolated conventional pad foundation at depth of 1.5m below, with ground beam appears suitable across the site. This should be adequate as the investigation shows an average allowable bearing capacity of 121KN/m^2 for strip footings and 150KN/m^2 for square footings. For cuts and fills the soil information suggests that a generalized guideline can be recommended however, the final decision of foundation type should be dependent on the type of structure to be erected and is therefore based on the structural engineer’s discretion.

Keywords: geotechnical, bearing capacity, geologic, consolidation, foundation.

INTRODUCTION

The quest for affordable housing estate within Federal Capital Territory, Abuja and the suburb paved way for private developer to assist the government in the actualization of this dream. The study area is an approximately 12,000m^2 parcel of land at sector centre B layout in Kuje area council, Abuja designed for estate housing development. Many often time its worthy to carry out geotechnical survey of any portion of the earth to ascertain its strength for load bearing. This is a safe measure to overcome possible collapse of building(s). Oyedele, (2009) states that stability of a foundation and its bearing capacity depends on the geologic materials underlying the site. Beckmann, (1994) highlights that faulty planning, insincere monitoring by the regulatory authorities, and development control lapses are reasons for improper foundation. The work of Terzaghi (1943); Vesic, (1973) and Akpila et al. (2008) had shown that among the criteria to be considered for design and analysis of a shallow foundation are stability and deformation. While the deformation requirement ensures that settlement of a structure is within the tolerance limit, the stability requirement ensures that the foundation does not undergo shear failure under loading. This paper attempts to report on analysis of shallow foundations on pre-surface soil for engineering structures at sector centre B, Kuje Abuja,

LOCATION AND GEOLOGIC SETTING

The study area is located in Kuje area council of the Federal Capital Territory, Abuja, Nigeria (fig.1). It is bounded in the north by Gwagwalada, in the south by Yebu, in the east by Karshi and Kwali to the west. Geologically, the study area forms part of the north central basement complex which lies within the Pan-African mobile belt that have been affected by Pan-African events through the ages of orogenic, tectonic and metamorphic cycles (Oyawoye 1964). Geologically, the lithological units in the FCT, Abuja where the study area falls include migmatite, granite gneiss, Quartzo-fedspathic gneiss, Undefferentiated schist, and porphyritic biotite gneiss.

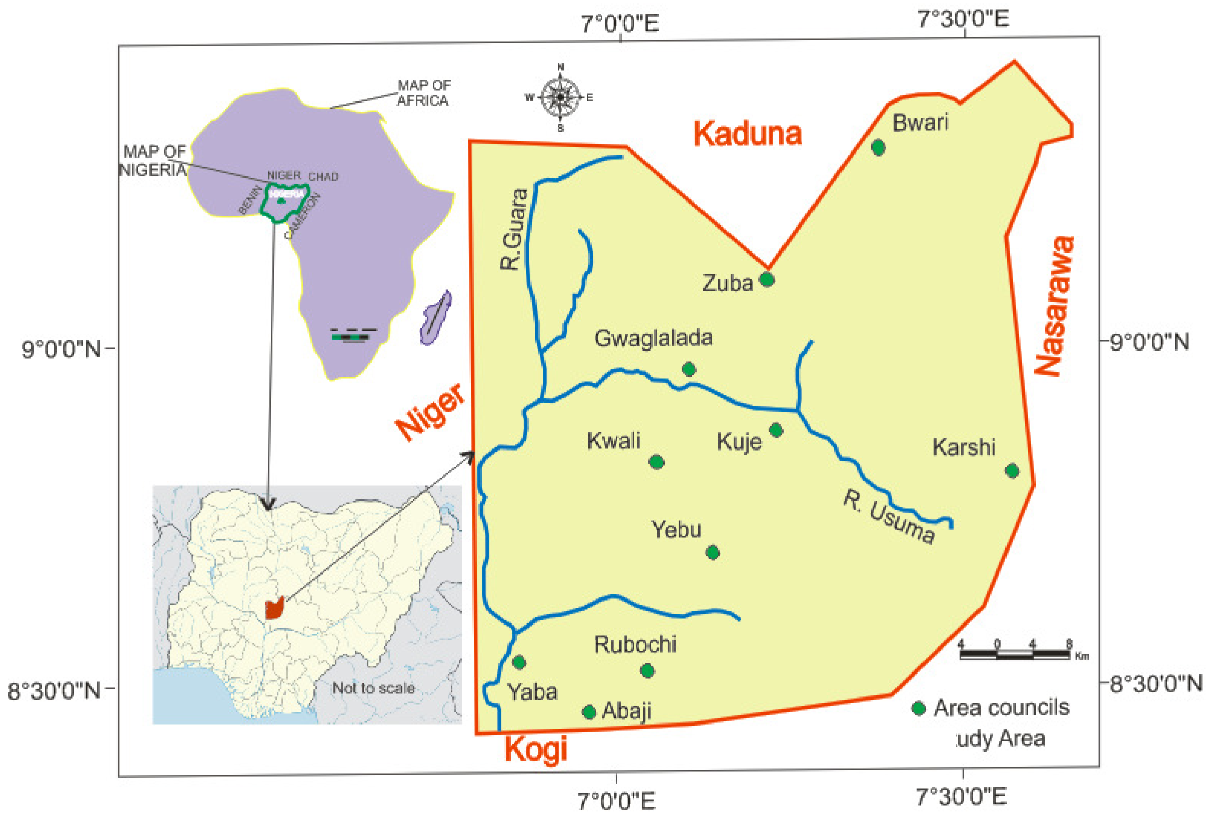

Figure 1: *Location Map of Federal capital Territory, Abuja showing the position of Kuje area council*

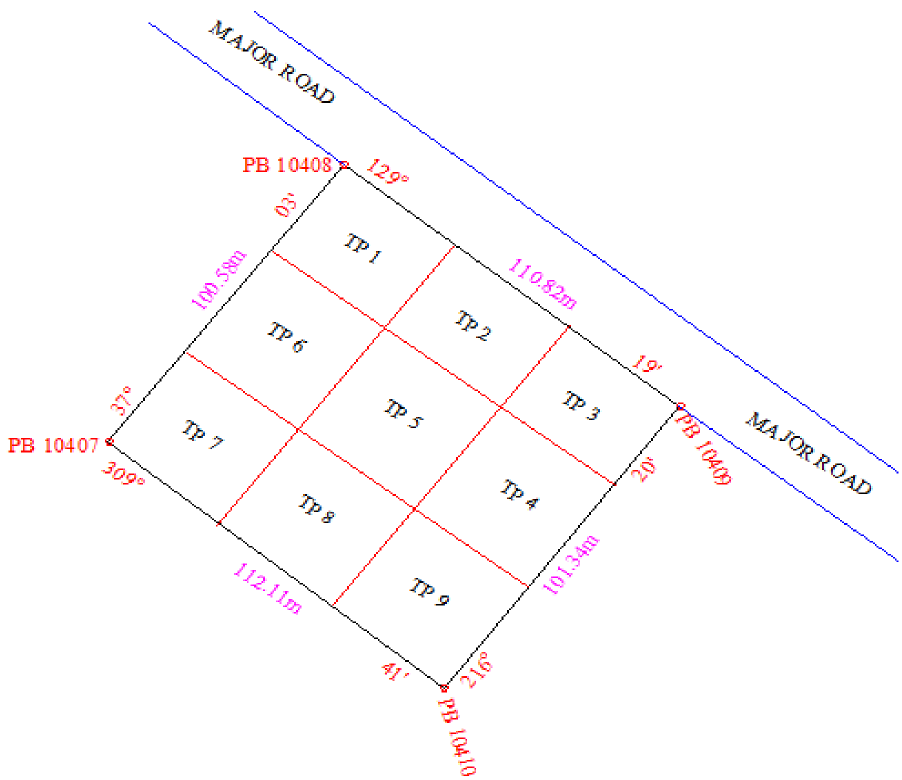

Fig. 2: *Showing trial pit (TP) points within the Site plan of the proposed estate development*

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MATERIALS AND METHODS

Nine (9) trial pits (fig. 2) at an interval of 30m from each other was probed to a depth of 1.5m, samples from the field were then analyzed in the laboratory for its strength, consolidation and compaction characteristics. The following geotechnical test: Natural moisture content, particle size analysis, Atterberg limits (that is, liquid limits, plastic limits and plasticity index), direct shear stress and calculation of bearing capacity tests were carried out. The Particle size distribution and Atterberg limits graphs were plotted using the Geosystem soil test software package.

Using Tergahi's Solution for bearing capacity

Strip Footing: $Qu = CNc + \gamma D Nq + 0.5 \gamma B N\gamma$

Circular: $Qu = 1.3 CNc + \gamma D Nq + 0.3 \gamma B N\gamma$

Square: $Qu = 1.3 CNc + \gamma D Nq + 0.4 \gamma B N\gamma$

Allowable bearing capacity (Q_a) =
(Q_u / F.S) (KN/m^2)

Where; $Nc = \cot\varphi (Nq - 1)$
$N\gamma = 2(N_q + 1) * \tan Ø$
$Nq = e^{\pi\tan\varphi} \tan^2(45+\varphi/2)$

Also;

Q_u - Ultimate bearing capacity (KN/m^2)
C - Cohesion of soil (KN/m^2)
Y - Unit weight of soil (KN/m^2)
D - Depth of footing (m)
B - Width of footing (m)

Note:

The bearing capacity factors, Nc, Nq, Nγ, are function of internal friction angle, φ
F.S = Factor of safety, taken as 3

Example,
@ TP.1 (1.5m) where C = 16, Ø =20

$Nq = e^{\pi\tan\varphi} \tan^2(45+\varphi/2)$
$Nq = e^{\pi\tan 20} \tan^2(45+20/2)$
$Nq = e^{3.142*0.3640} \tan^2(55)$
$Nq = e^{3.142*0.3640} \times 2.0396$

$Nq = 6.4$
$Nc = \cot\varphi (Nq - 1)$
$Nc = \cot 20 (6.4 - 1)$
$Nc = 2.7474 \times 5.5$
$Nc = 14.84$

$N\gamma = 2(N_q + 1) * \tan Ø$
$N\gamma = 2(6.4 + 1) * \tan 20$
$N\gamma = 2(7.4) * 0.3640$
$N\gamma = 5.38$

Therefore;

(1) For Strip Footing:

$Qua = CNc + \gamma D Nq + 0.5 \gamma B N\gamma$
$Qua = 16x14.84 + 12.2x1.5x6.40 + 0.5x12.2x1.5x5.38$
$Qua = 237.44 + 117.12 + 49.28$
$Qua = 403.787$

Allowable bearing capacity (Q_{na}) = (Q_{ua})/3
(Q_{na}) = 403.787/3
(Q_{na}) = 134.60 KN/m^2

(2) **For Square Footing**:

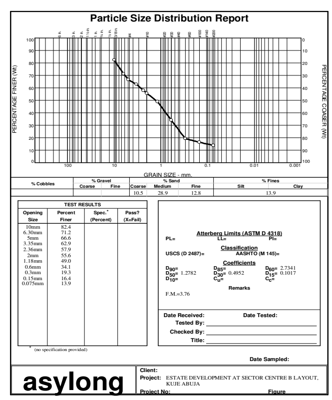
$Qu = 1.3 c Nc + \gamma D Nq + 0.4 \gamma B N\gamma$
(1.3x16x14.84)+ (12.2x1.5x6.40) + (0.4x12.2x1.5x5.38)
(Q_u) = (308.67+117.12+39.38)
(Q_u)= 465.17 KN/m^2

Allowable bearing capacity (Q_a) = (Q_u)/3
(Q_a) = 465.17/3 KN/m^2
(Q_a) = 155.05KN/m^2

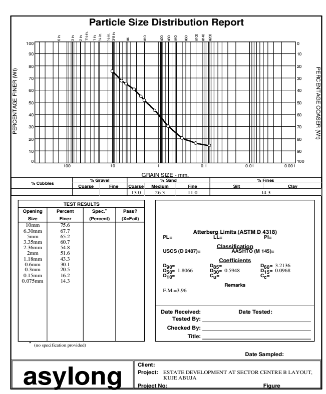
RESULTS AND DISCUSSION

The moisture contents determined from soil specimens collected in the field ranges from 10.3% to 15.5% (table 1). Moisture content of the undisturbed soil samples was carried out following the specification given by BS 1377: part 2: 1990 of using oven dried method. Following the USCS D: 2487, 10mm, 6.30mm, 5.00mm, 3.35mm, 2.36mm, 2.00mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm and 0.075mm mesh sizes were used for particle size distribution and analysis confirm the soil to be predominantly medium-coarse grained (fig. 3). Using the Casagrande liquid limit apparatus, results shows that the soil is of low plasticity ranging from 0-12.2 (fig. 4). The values of the cohesion and angles of internal friction derived from the plot of {shear stress against normal stress (KN/m^2)} (fig.5) is presented in table 1 and was used in the calculation of the bearing capacity of the soil for safe foundation.

T.P. 1@ Depth: 1.5m



T.P. 2 @ Depth: 1.5m



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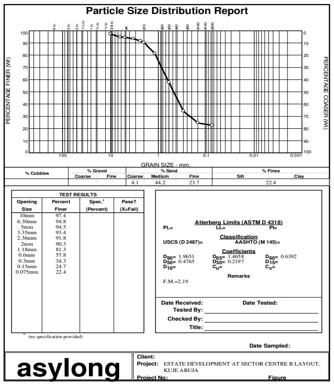
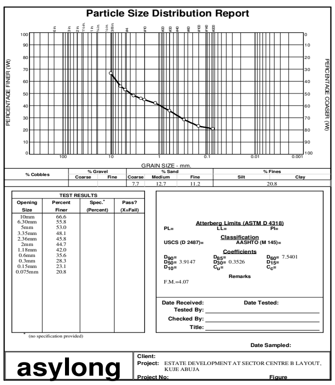
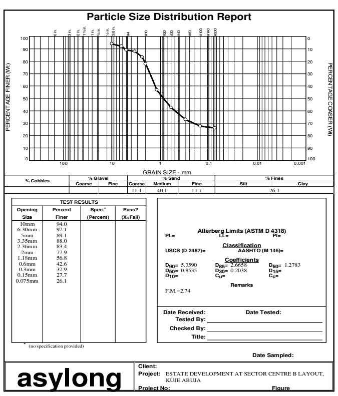
T.P. 3 @ Depth: 1.5m



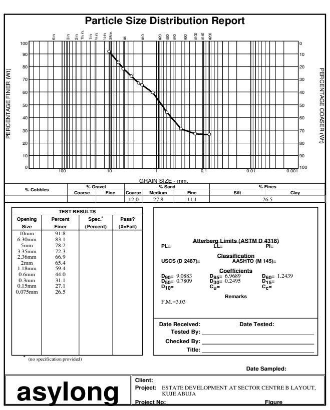
T.P. 4 @ Depth: 1.5m



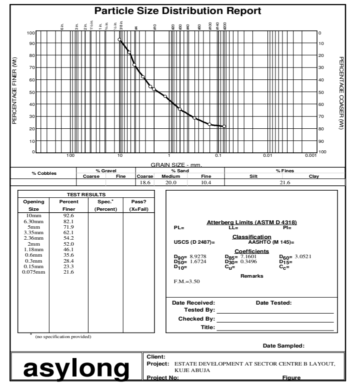
T.P. 5 @ Depth: 1.5m



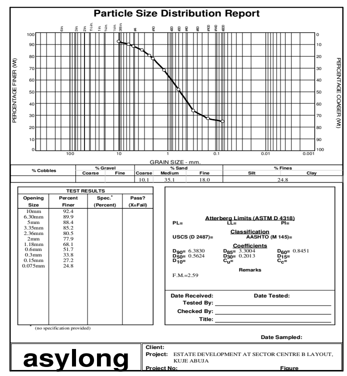
T.P. 6 @ Depth: 1.5m



T.P. 7 @ Depth: 1.5m



T.P. 8 @ Depth: 1.5m



T.P. 9@ Depth: 1.5m

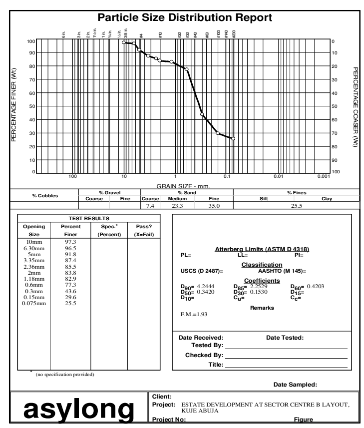
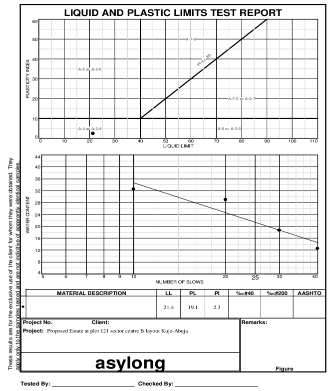
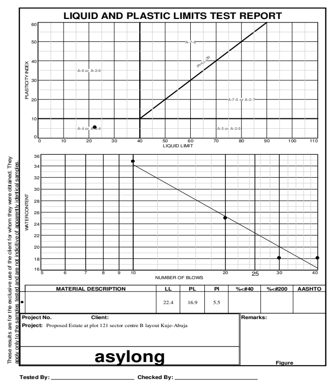


Fig. 3: *T.P. 1-9 shows graphs of particle size distribution at depth of 1.5m*

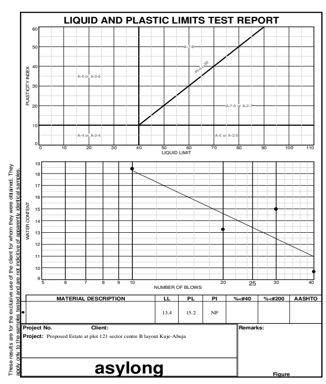
T.P. 1@ Depth: 1.5m



T.P. 2@ Depth: 1.5m



T.P. 3@ Depth: 1.5m



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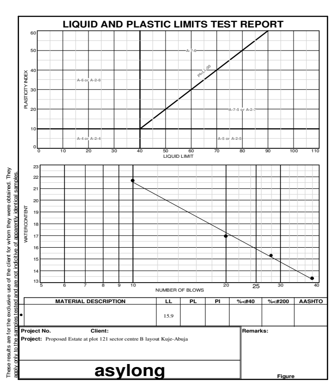
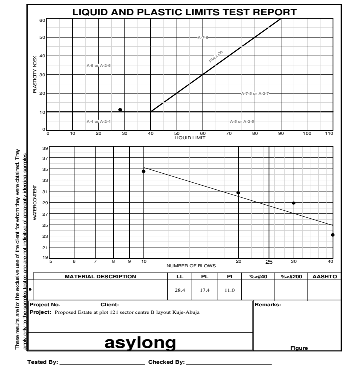
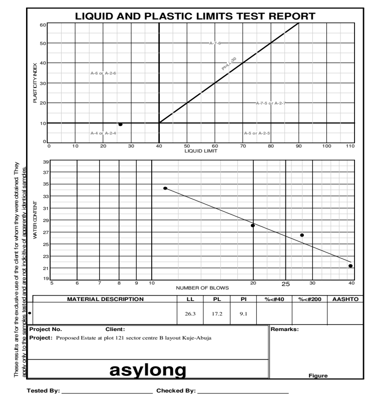


T.P. 5@ Depth: 1.5m



T.P. 6@ Depth: 1.5m



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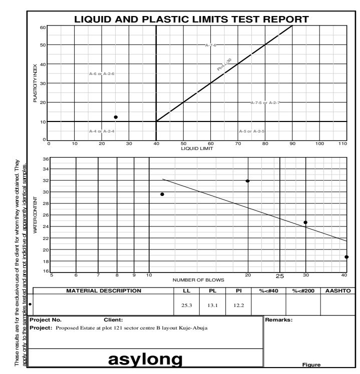
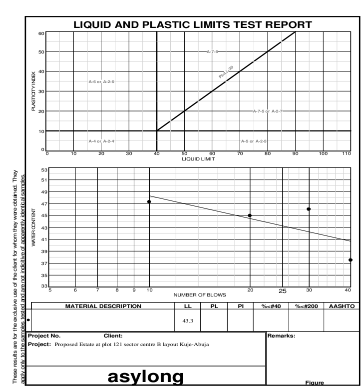


T.P. 8@ Depth: 1.5m



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T.P. 9@ Depth: 1.5m

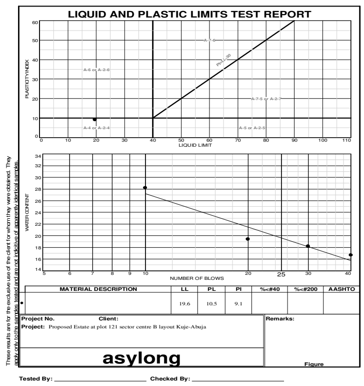
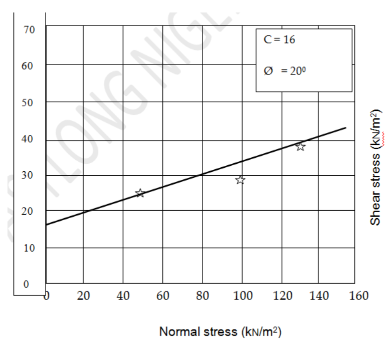
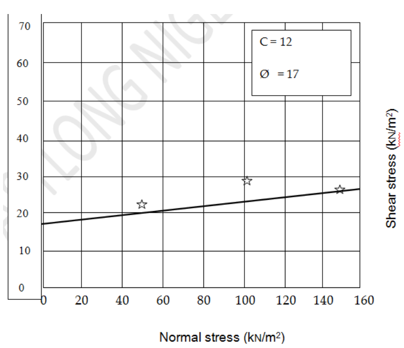


Fig. 4: *T.P. 1-9 shows graphs of Atterberg limits (Liquid & Plastic limits) at depth of 1.5m*

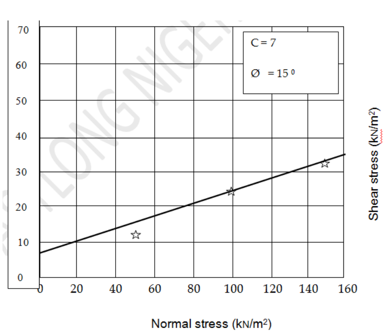
T.P. 1 @ Depth: 1.5m



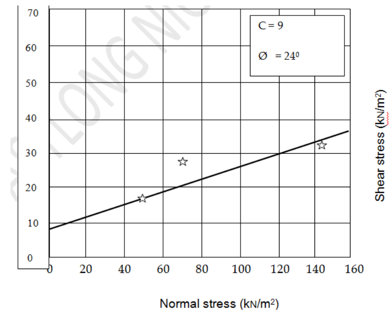
T.P. 2 @ Depth: 1.5m



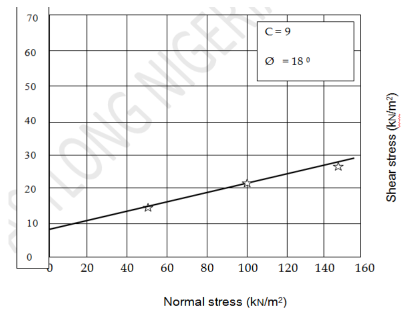
T.P. 3 @ Depth: 1.5m



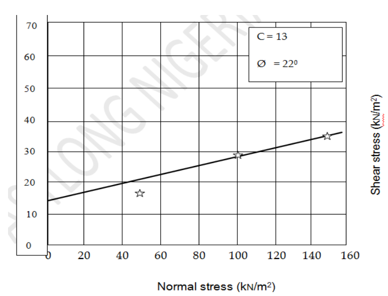
T.P. 4 @ Depth: 1.5m



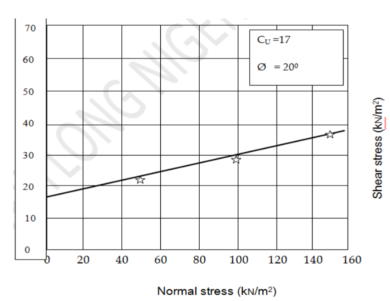
T.P. 5 @ Depth: 1.5m



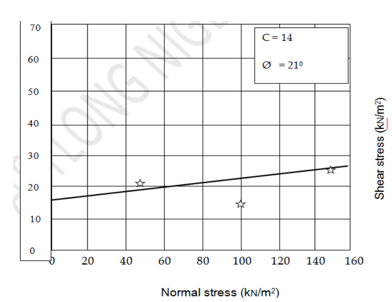
T.P. 6 @ Depth: 1.5m



T.P. 7 @ Depth: 1.5m



T.P. 8 @ Depth: 1.5m



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T.P. 9 @ Depth: 1.5m

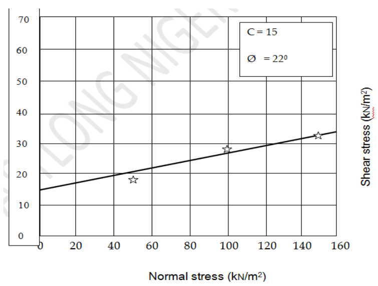

Fig. 5: *T.P. 1-9 shows graphs of Shear box test at depth of 1.5m*

Table 1: Summary of Allowable bearing capacity and other data

TP	DEPTH (z)	Moisture Content (%)	C (KN/m^2)	Plasticity	Ø	N_q	N_c	N_γ	γ	F. S	Q_{na}	Q_a
1	1.5	10.3	16	2.3	20	6.40	14.84	5.38	12.2	3	134.60	155.06
2	1.5	11.2	12	5.5	17	4.78	12.36	3.53	12.6	3	90.68	103.28
3	1.5	10.9	7		15	3.94	10.97	2.65	12.8	3	59.29	195.82
4	1.5	11.8	9		24	9.60	19.31	9.44	12.5	3	147.93	158.91
5	1.5	15.5	9	11.0	18	5.25	13.08	4.06	12.1	3	83.28	92.60
6	1.5	13.9	13	9.1	22	7.82	16.88	7.11	12.5	3	144.23	161.74
7	1.5	14.6	17	12.2	20	6.40	14.84	5.38	12.4	3	140.45	162.34
8	1.5	11.4	14		21	7.04	15.73	6.17	12.3	3	135.67	153.90
9	1.5	12.1	15	9.1	22	7.82	16.88	7.11	12.9	3	157.75	178.50

Note

Q_{na} = Allowable bearing capacity for strip footings
Q_a= Allowable bearing capacity for square footings

CONCLUSION AND RECOMMENDATION

Generally the site soil has good engineering properties and water table was not encountered within the tested depth (Refusal) which indicates that pyretic surface is deeper than the explored depth. The site which is located at Kuje, FCT Abuja was explored in March, 2014 and various soil samples were collected for analysis. The test were carefully conducted in accordance with BS code of practice and therefore revealed the index as well as the engineering properties of the soil. Standard Penetrometer was conducted at different locations on the site and all were probed to the point of refusal 1.5m depth where more compacted sand was still encountered. With regards to the said estate buildings, the use of isolated conventional pad foundation with ground beam appears suitable across the site unless evidence of localized solution cavities is encountered. For cuts and fills the soil information suggests that a generalized guideline can be recommended however localized areas of loose colluviums could be encountered during construction. These will be location specific and will be addressed appropriately.

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