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Detailed Soil Investigation of the Proposed Agricultural Engineering Department Federal Polytechnic, Kaura Namoda

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ABSTRACT

This research was limited to find some index as well as engineering properties of the collected soil samples. The properties tests include; moisture content, particle size distribution (sieve analysis), atterberg limit, and specific gravity test. Similarly, the engineering properties tests conducted include; permeability and triaxial test. From the index properties test, the results obtained from trial pit 1,2 and and 3, the moisture content values are 0.30%, 2.19% and 2.68% respectively. The particle size distribution test (sieve analysis) values are 41.63 and 34.47. the result of the atterberg limit shows that the liquid plasticity index values ranges from 8.5% to 25.4%. the maximum dry density of the soil samples ranges from 1.77g/cm³ to 1.88g/cm³ and the optimum moisture content ranges from 12% to 14% for AASHTO. Similarly, engineering properties: the specific gravity values are 2.3, 2.36 and 2.26 for the trial pits respectively. Permeability test was also found to be 4.358×10^{-4} 6.619×10^{-4} respectively by the triaxial test conducted yield bearing capacity of the soil to be $q_u = 343.30\text{KN/m}^2$, 440.31 656.34KN/m^2 for the trial pits respectively, furthermore, the depth of foundation was calculated and found to be $(D_f) = 87.00/18.33 \times (1-\sin 24) / (1+\sin 24)^2 = 1.42\text{m}$.

Keywords: Soil sample, investigation, index properties engineering properties

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INTRODUCTION

To the soil engineer the word “soil” means a material which is used in any kind of civil engineering job, either as foundation material to support the load exerted by structures, or as construction material itself, as in the cases of earth fill dam and highway constructions (Eridil, 1976). Earth with the above context refers to soil which is unweathered mineral grains, usually formed by weathering of rocks and includes organic matter and water. Growing environment and construction problems facing human kind. The use of earth material, if managed correctly does not lead to same waste generation on biological changes as compared to conventional building material (Bachar et al, 2014). The need for proper subsoil site investigation cannot be overemphasized, they

provide salient information upon which the design and construction of a construction is based. The need for a through soil investigation is occasioned by the fact that, lack of it is one of the major reasons for the collapse and failure of most civil engineering project in countries like Nigeria (Sulaiman & Illiyasu, 2014).

AIM

This research aims at investigation the geotechnical properties of soil around the proposed Agricultural Engineering Department in the Federal Polytechnic Kaura Namoda.

OBJECTIVES

- i. To obtain the soil samples from the proposed site of Agricultural Engineering Department Federal Polytechnic Kaura Namoda
- ii. To conduct laboratory test on the soil samples obtained and find out its index properties as well as the engineering properties.
- iii. Recommendations are to be made from the lab test result which will later be used as basis for foundation design.

PROBLEM STATEMENT

The rate of collapse of building in Nigeria is increasingly giving lots of concern to the client and the professionals. Similarly, rate of unequal settlement of foundation results to dangerous cracks within the Polytechnic's building largely due to un-scientific construction approach and the use of very local contractors.

JUSTIFICATION

Neglecting soil investigation may lead to severe damage or even collapse of structure just as failure to carry out soil exploration gives way to negative effect on the structure which can make structure unfit and/or unsafe. Improper soil investigation also leads to over design or under design making the structure uneconomical or unsafe for use. Technique to be used during construction can also be determined through soil investigation and failure to do that may lead to difficulties in construction with settlement of foundation, shear failure, development of cracks etc. all occurring due to improper soil exploration or investigation.

LIMITATION

This research is limited to accessing, investigating, analyzing and describing of the geotechnical properties of the soil around the proposed Agricultural Engineering Department in the Federal Polytechnic Kaura Namoda.

LITERATURE REVIEW

As civil engineering material soil is just as important as steel and concrete. It may be dug into, heaped up, spread out in the construction of civil engineering works, All man-made structures, except those which fly or float are supported by natural soil or rock deposits, and are constructed from soil and many engineering structures, such as water retaining, banks and airfield pavement are constructed from soil and rock material (Sutton 1986). Terzaghi and Peck (1948) Define engineering soil as a natural aggregate of mineral compacted by strong and

permanent cohesive forces. According to Brandy C N and Well R.R (1999) classified soil into four main types based on three constituent and individual properties which are sandy soil, city soil, lean a lot of space, poses an significant and strong building (smellingly) characteristics and this reason, black clay soil geotechnical properties is required to investigate before allowing it to be used for any construction above the earth surface (Mishra 2015).

The amount of swell generally increases with increase in the plasticity index. The swelling potential depends on the type of clay mineral, crystal letter structure exchange capacity, and inability of water absorptions, density and water cement (Isamil, 2004) CKY soil has many crevices that can hold onto salts and can make plants enable to ground successfully (Moses 2012).

Soil near the surface may contain human or organic and that resulted from the decay of vegetation etc. these soils near the surface i.e top soil are not useful for civil engineer or may not suitable for use in construction (both road and building construction). They are suitable for farming and farming and usage by Agricultural Engineering, British standard 1377 part 4 (1990).

Soil properties. Generally, soil properties can be category characterized into two namely, index properties and engineering properties index properties are the properties of soil which are used to categorized the soil in accordance to various soil classification standard, an example of these standard in British soil classification standard (BSCS). Therefore, soil that belongs to the same class has similar index properties, index properties of soil are usually used to provide rough estimate of its engineering properties and compare with of established correlation. Dino Abdella A. (2017).

METHODOLOGY

The methods to be used in achieving the aims and objective of this research are:

Firstly online search study had been carried out where journals and reports were reviewed to enable good and precise understanding of how the work could be done.

Secondly, having an access to the exact position of the proposed construction site to enable boring of sample pits (collection of sample).

Thirdly, field works where trial are located and samples are taken for geotechnical test (i.e the soil samples will be taken at different locations around the proposed site or location thereby digging of a pit to a depth says 1.5m and 2m before taking the sample).

Fourthly, the laboratory analyses were carried out in order to know the possible characteristic of the sample (i.e the sample so taken will be analyzed to determine the

soil index properties as well as its engineering properties).

MATERIALS AND METHODS

MATERIALS

Study area: The proposed Agricultural department, federal polytechnic kaura Namoda.

Soil sample: Nine samples were taken at different levels of the boreholes (pits).

METHOD

Method of sampling: the soil samples were taken at different location within the proposed department of agricultural engineering technology at federal polytechnic kaura namoda and the samples taken at each point was labeled in order to get mixed up. The collected sample from each trial was done by digging of pit to a depth 1m, and 2m respectively at each individual hole before taking the samples.

Test method: this section presents the experimental procedures adopted in conducting the tasters carried out.

The tests are:

- Moisture content test
- Sieve analysis test
- Atterberg's limit (liquid and plastic limit) test
- Specific gravity test
- Permeability test
- Direct shear box or triaxial (determine C & Q)

MOISTURE CONTENT TEST

This is performed to determine the water (moisture) content of soils. The water content is the ratio, expressed as a percentage, of the mass of "pore" or "free" water in a given mass of soil to the mass of the dry soil solids. For establishing the relationship between the way a soil behaves and its properties. The consistency of a fine grained soil largely depends on its water content. The water content is also used in expressing the phase relationships of air, and solids in a given volume of soil. ASTM D2216 standard test method for laboratory determination of water (moisture) content of soil, rock and soil aggregate mixtures.

SIEVE ANALYSIS TEST

This test is performed to determine the percentage of different grain sizes contained within a soil.

The mechanical or sieve analysis is performed to distribution of the coarser, larger sized particles, and the hydrometer method is used to determine the distribution of the finer particles. The distribution of different grain sizes affecting the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil. ASTM D 422 standard test method for particle size analysis of soil.

ATTERBERG'S LIMIT (LIQUID AND PLASTIC LIMIT) TEST

The physical properties of fine soil gently differ at different water content; a soil which is very soft at a percentage of water content may become very hard with a decrease in water content. The consistency of soil is may also be called atterbegs limit. Atterberg in 1911 evolved certain tests which are used to determine the consistency and plastic behaviors of fine soil. These tests are; Liquid limit, plastic limit and shrinkage limit. ASTM D 4318- standard test method for liquid limit, plastic limit, and plasticity index of soils.

SPECIFIC GRAVITY TEST (BS 812, 1984)

The specific gravity test is used to measure the weight of a given volume of material (or vice versa) specific gravity is defined as the ratio of the weight of a given volume of aggregates to the weight of an equal volume of water volume, specific gravity test will be conducted in ABU concrete laboratory in accordance to BS 812, (1984).

PERMEABILITY TEST (BS 812, 1984)

Permeability as a term is described as the ability of water or any fluid to be able flow through a soil by moving, passing through the spaces and void in the particles. It is very essential property of soil for the analysis of water flowing through the soil. Essential factors in testing permeability are types of hydraulic gradient, effective stress, head conditions and how representative the sample is. Soil permeability can be determined by field test and direct laboratory , this properties is influenced by effect of state and anisotropy Jackson Neil and Dhir K R (1996) (soil permeability)

DIRECT SHEAR BOX OR TRIAXIAL (DETERMINE C & Θ)

This test is performed to determine the consolidated drained shear strength of a sandy to silty soil. The shear strength is one of the most important engineering properties of a soil, because it is required wherever a structure is dependent on the soil shearing resistance. The shear strength is needed for engineering situation such as determining the stability of slopes or cuts, finding

Table 1: Moisture Content.

| TEXT NO PIT NO. | 1 | | |
|--|--------|--------|--------|
| | 1 | 2 | 3 |
| CONTAINER NO. | A1 | B1 | C1 |
| WEIGHT OF WET SOIL + CONTAINER W1 (g) | 183.00 | 177.00 | 190.00 |
| WEIGHT OF DRIED SOIL + CONTAINER W2 (G) | 180.50 | 170.00 | 179.00 |
| WEIGHT OF CONTAINER W3 (G) | 16.00 | 17.00 | 17.00 |
| WEIGHT OF MOISTURE = W1-W2 (G) | 2.50 | 7.00 | 11.00 |
| WEIGHT OF DRIED SOIL = W2-W3 (G) | 164.50 | 153.00 | 162.00 |
| MOISTURE CONTENT M% = ((W1-W2)/(W2-W3)*100 | 1.52 | 4.58 | 6.79 |
| AVERAGE MOISTURE CONTENT MC (%) | | 4.30 | |

Table 2: Moisture Content.

| PIT NO. | SAMPLE A | SAMPLE B | SAMPLE C |
|---------|---------------|---------------|---------------|
| | At 1.0m depth | At 1.5m depth | At 2.0m depth |
| 1 | 1.52 | 1.23 | 0.67 |
| 2 | 4.58 | 1.6 | 3.16 |
| 3 | 6.79 | 3.66 | 4.22 |
| Average | 4.30 | 2.19 | 2.68 |

Table 3: Sieve Analysis.

| Diameter (mm) | Weight (gm) | Retained % | Cumulate Retained % | Passing % |
|-----------------|-------------|------------|---------------------|-----------|
| 75 | 0 | 0 | 0 | 100 |
| 63 | 0 | 0 | 0 | 100 |
| 50 | 0 | 0 | 0 | 100 |
| 37.5 | 0 | 0 | 0 | 100 |
| 28 | 0 | 0 | 0 | 100 |
| 20 | 0 | 0 | 0 | 100 |
| 14 | 0 | 0 | 0 | 100 |
| 10 | 0 | 0 | 0 | 100 |
| 6.3 | 0 | 0 | 0 | 100 |
| 5 | 20 | 2.2 | 2.2 | 97.8 |
| 3.35 | 13 | 1.43 | 3.63 | 97.8 |
| 2 | 26 | 2.86 | 6.5 | 93.5 |
| 1.18 | 29 | 3.19 | 9.19 | 90.31 |
| 0.6 | 29 | 3.19 | 12.89 | 87.11 |
| 0.425 | 100 | 11.01 | 23.9 | 76.1 |
| 0.3 | 158 | 17.4 | 41.3 | 58.7 |
| 0.212 | 120 | 13.22 | 54.52 | 45.48 |
| 0.15 | 163 | 17.95 | 72.47 | 27.53 |
| 0.063 | 150 | 11.01 | 100 | 11.01 |
| Pass 63 Microns | 100 | 11.01 | 88.99 | 11.01 |
| Total | 908 | 100 | | |

| | | |
|-----------------|---------|---------|
| Cobbles = | 0.00% | 0.00% |
| Coarse gravel = | 0.00% | 6.50% |
| Medium gravel % | 0.00% | |
| Fine gravel | 6.50% | |
| Coarse sand | 6.39% | |
| Medium sand= | 41.63% | 82.49% |
| Fine sand = | 34.47% | |
| Fines= | 11.01% | 11.01% |
| Total | 100.00% | 100.00% |
| D10 | 0.06 | |
| D30 | 0.17 | |
| D60 | 0.3 | |
| Cu | 5 | |
| Cc | 1.61 | |

the bearing capacity for foundations, and calculating the pressure exerted by a soil on a retaining wall. Standard References ASTM D 3080 – Standard Test Method for

Direct shear device will be used to determine the shear strength of a used to determine the shear strength of a cohesion-less soil (i.e angle of internal friction $c = 0$),

Table 4: Average result of the sieve analysis test @ 1.0m depth of the study area.

| PIT NO. | DEPTH | Cc | Cu | Fines modulus \sum cummu. Retained = 100 |
|---------|-------|-------|-------|--|
| 1 | 1.0m | 1.61 | 5.00 | 4.16 |
| 2 | 1.0m | 18.29 | 14.00 | 4.39 |
| 3 | 1.0m | 9.31 | 13.00 | 4.39 |
| Average | | 9.73 | 10.66 | 4.38 |

Table 5: Average result of the sieve analysis test @ 1.5m depth of the study area.

| PIT NO. | DEPTH | Cc | Cu | Fines modulus \sum cummu. Retained = 100 |
|---------|-------|-------|-------|--|
| 1 | 1.5m | 19.00 | 19.00 | 4.20 |
| 2 | 1.5m | 9.09 | 11.00 | 3.54 |
| 3 | 1.5m | 4.32 | 7.00 | 4.67 |
| Average | | 10.83 | 12.33 | 4.14 |

Table 6: Average result of the sieve analysis test @ 2.0m depth of the study area.

| PIT NO. | DEPTH | Cc | Cu | Fines modulus \sum cummu. Retained = 100 |
|---------|-------|-------|-------|--|
| 1 | 2.0m | 10.29 | 14.00 | 4.66 |
| 2 | 2.0m | 11.08 | 13.00 | 4.58 |
| 3 | 2.0m | 9.31 | 4.32 | 4.45 |
| Average | 2.0m | 10.23 | 10.44 | 4.56 |

Table 7: ATTERBERG'S LIMIT (LIQUID AND PLASTIC LIMIT).

| Liquid limit sample from the trial pit | | | |
|--|-------|-------|-------|
| Sample no. | A | B | C |
| Container no. | A1 | B1 | C1 |
| Wt. of container | 9.00 | 9.00 | 9.00 |
| Wt. container +wet soil | 23.43 | 18.00 | 29 |
| Wt. container + dry soil | 22.00 | 16.70 | 23.80 |
| Wt. of moisture | 1.43 | 1.30 | 5.20 |
| Wt. of dry soil | 13.00 | 7.70 | 14.80 |
| Moisture content (%) | 11.00 | 16.88 | 35.14 |
| Number of blows | 19 | 27 | 39 |

RESULTS AND DISCUSSION

MOSITURE CONTENT

Moisture content result of the soil sample of pit 1, 2 & 3 at 1.0m depth of the study area (Tables 1-2).

SIEVE ANAYSIS TEST

The result of pit No. 1 sample at 1m depth is presented (Tables 3-6). Sieve analysis result for test pit No.1 1m depth

ATTERBERG'S LIMIT (LIQUID AND PLASTIC LIMIT)

Atterbegs's limit result of the soil sample of pit A, B & C at 1.0m depth of the study area (Tables 7-10).

SPECIFIC GRAVITY TEST

PERMEABILITY TEST

The result shown below is for pit @ 1m depth and analysis of first run after 4 minutes is presented (Table 13).

Sample calculation

Permeability (K) is given by:

$$\frac{2.3a1 \times \text{Log} \frac{H1}{(A(t2-t1))}}$$

Where a = area of stand pipe, A area of mould, L height

Table 8: ATTERBERG'S LIMIT (LIQUID AND PLASTIC LIMIT).

| Liquid limit sample from the trial pit | | | |
|--|-------|-------|-------|
| Sample no. | A | B | C |
| Container | X1 | Y1 | Z1 |
| Wt. of container | 7.00 | 7.00 | 7.00 |
| Wt. container + wet soil | 18.39 | 16.43 | 24.23 |
| Wt. container + dry soil | 16.28 | 14.69 | 20.43 |
| Wt. of moisture | 2.11 | 1.74 | 3.80 |
| PLASTIC LIMIT | 24.55 | | |

Table 9: Sieve Analysis.

| PIT NO. | SAMPLE A At 1.0m depth | SAMPLE B At 1.5m depth | SAMPLE C At 2.0m depth |
|-------------|---------------------------|---------------------------|---------------------------|
| 1 | 11.00 | 20.67 | 40.00 |
| 2 | 16.88 | 21.05 | 23.08 |
| 3 | 35.14 | 38.46 | 21.43 |
| Average (%) | 21.00 | 26.72 | 28.17 |

Table 10: Plastic Limit.

| PLASTIC LIMIT | SAMPLE A At 1.0m depth | SAMPLE B At 1.5m depth | SAMPLE C At 2.0m depth |
|---------------|---------------------------|---------------------------|---------------------------|
| AVERAGE | 24.55 | 10.79 | 45.04 |

of specimen t_1 = initial time

t_2 = final time for water to flow H_1 to H_2

For pit No. 1. @ 1m depth

$D = 10\text{mm} = 1\text{cm}$, $D = 100\text{mm} = 10\text{cm}$, $a \pi d_{2/4} = 0.7854\text{cm}^2$, $A = \pi d_{2/4} = 7.854\text{cm}^2$

$L = 125\text{mm} = 12.5\text{cm}$, $H_1 = 50\text{cm}$, $H_2 = 12\text{cm}$, $t_1 = 0.00$, $t_2 = 240\text{sec}$

$(2.3(0.7854)(12.5)) \log_{10} 63/18$

$K = 7.854 (240-0)$

Show in the table 14

Mohr circle for circle pit No. @ 1m depth

From the graph of Mohr of tri axial test, it has shown that the soil sample has $c = 2 \text{ KN/M}^2$ and Θ at depth of 1m the two parameters are used to calculate bearing capacity as indicated below.

The unit weight of the soil (γ) $10+15+30/3 = 18.33\text{KN/M}^2$ and $B = 1.5\text{m}$

Using strip foundation $q_u = CN_c + \gamma D_f N_a + \frac{1}{2} \gamma B N_\gamma$

Table 3.1 Terzaghi is bearing capacity factors, with respect to $\Theta = 24^\circ$

$N_c = 23.36$, $N_q = 11.40$ and $N_\gamma = 7.08$

Hence

$$Q_u = CN_c + \gamma D_f N_a + \frac{1}{2} \gamma B N_\gamma = (2 \times 23.36) + (18.33 \times 1 \times 11.40) + (1/2 \times 1.5 \times 7.08)$$

$$Q_u = 260.99 \text{ KN/m}^2$$

Therefore the allowable bearing capacity of the soil sample for a proposed strip foundation 260.99KN/m^2 . Soil investigation report produced by a geotechnical engineer

usually contains the bearing capacity of soil in a site different depths. The selected depth and bearing capacity used for the foundation design should give an idea of what the maximum depth of foundation should be. A typical example is shown in the (Tables16, 17).

Depth and bearing capacity used for foundation design

DISCUSSION

MOISTURE CONTENT TEST

The result of the moisture content test conducted indicated that the sample from the study area have no much water thoroughly. Looking at the average value of the moisture content for all trial pits with different depth 1.0m, 1.5m and 2.0m which is 0.30% 2.19% and 2.68% respectively.

SIEVE ANALYSIS TEST

The result of the sieve analysis of various samples shows that high percentage of sample passing different sieve sizes are fine and medium sand with 34.47% and 41.63 respectively (see table 4.1). This is used to ascertain the uniformity of the soil its gradation as well. It also helps in AASHTO classification of soil.

ATTERBERG LIMIT TEST

The atterberg limit is carried out to know the liquid limit

Table 11: Specific Gravity.

| PIT NO: | 1 | 2 | 3 |
|---|-----------|-----------|-----------|
| PYCNOMETER CLEAN PYCNO = W1 (g) | A1 | B1 | C1 |
| Weight of empty clean pycno = w1 (g) | 210 | 210 | 210 |
| Weight of pycno + dry soil = w2 (g) | 260 | 257 | 264 |
| Weight of pycno + dry soil + water = w3 | 1235 | 1228 | 1235 |
| Weight of pycno + water = w4 (g) | 1205 | 1205 | 1205 |
| Specific gravity GS | 2.50 | 1.95 | 2.25 |
| AVERAGE | | 2.23 | |

SAMPLE CALCULATION OF THE SPECIFIC GRAVITY

$$G_s = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)} = \frac{(260 - 210)}{(1205 - 210) - (1235 - 260)} = 2.50$$

Table 12: Specific Gravity.

| PIT NO. | SAMPLE A At 1.0m depth | SAMPLE B At 1.5m depth | SAMPLE C At 2.0m depth |
|---------|---------------------------|---------------------------|---------------------------|
| 1 | 2.50 | 2.68 | 2.75 |
| 2 | 1.95 | 2.16 | 2.30 |
| 3 | 2.25 | 2.25 | 1.75 |
| AVERAGE | 2.23 | 2.36 | 2.26 |

Table 13: Permeability Test.

| Initial level of Water H1 (cm) | Final water Level H2 (cm) | Volume (cm3) Collaxa dwected | Lapsed lme | K (cm/sec) |
|-----------------------------------|------------------------------|---------------------------------|---------------|---------------|
| 63 | 18 | 21 | 40 | 0006780 |
| 63 | 13 | 18 | 20 | 0011390 |
| 52 | 14 | 16 | 20 | 0005680 |
| 38.8 | 12.5 | 20 | 609 | 0006130 |
| 36 | 18 | 28 | 200 | 0003750 |
| 21 | 17 | 16 | 380 | 0003750 |
| 20 | 15.5 | 14 | 680 | 000110 |
| 12 | 8 | 12 | 920 | 0002190 |
| 12 | 8 | 10 | 160 | 000219 |
| Average K (cm/sec) | | | | 0.00045264 |

and plastic limit. This is shown in (Table 9) the result show a liquid of all samples ranges from 21.00%, 26.72% and 28.17% of 1.0m, 1.5m and 2.0m respectively, which can be classified as high compressive soil. Further, the plastic limit of the soil was also found to be greater than 8% (i.e 24.5510.79 and 45.04).

SPECIFIC GRAVITY TEST

From the result obtained with the analysis of the specific gravity test which was conducted shows that, the soil sample with average specific gravity of 2.3, 2.36 and 2.26 which falls within the general standard range of the specific test between 2.65 and 2.80 with coarser soil, generally, a soil is described as a finer soil when it possess lower specific gravities.

PERMEABILITY TEST

From the test result, since the test carried out is constant head method which is suitable for fine soil. From

standard coefficient of permeability for dense sandy soil 5×10^{-5} cm/sec 5×10^{-3} cm/sec. the result obtained was 4.358×10^{-4} , 6.619×10^{-4} and 8.136×10^{-4} . Since the result got from the test carried out fall within the rangers, that means the result taken from the sample location is dense sandy soil. The dense sand wills higher permeability i.e it is not suitable for highway sub grade. Rather it can be used unless otherwise for building construction as a foundation material. From the result of the test sample 1,2 and 3 1.0m have the highest value of permeability coefficient while the other sample have lowest coefficient of permeability. This indicates that sample with highest coefficient of permeability will high permeable ratio which is not suitable for foundation while the lowest coefficient will be adequate.

TRIAXIAL TEST

From the test result, the value of the two parameters of shear strength which is required for the design of slope and for many other analysis (i.e Θ and C) had been used

Table 14: Permeability Test result at 1m depth of the study area.

| Pit No. | th (m) | fficient Permeability cm/sec |
|---------------------------------|--------|------------------------------|
| | 0m | 4.5264×10^{-4} |
| | " | 4.4517×10^{-4} |
| | " | 4.095×10^{-4} |
| verage permeability at 1m depth | " | 4.358×10^{-4} |

Table 15: Permeability Test.

| Depth (m) | Average of permeability cm/sec |
|-----------|--------------------------------|
| 1.0m | 4.358×10^{-4} |
| 1.5m | 6.619×10^{-4} |
| 2.0m | 8.136×10^{-4} |

Table 16: Bearing capacity value for the study area

| PIT/NO. | Depth | Θ^0 Value | C Value | Bearing Capacity | Average KN/m ² |
|---------|-------|------------------|---------|------------------|---------------------------|
| 1 | 1.0m | 24 ⁰ | 2 | 260.99 | |
| 2 | " | 20 ⁰ | 3 | 181.20 | 343.30 |
| 3 | " | 28 ⁰ | 2.2 | 587.71 | |
| 1 | 1.5m | 32 ⁰ | 4 | 297.06 | 440.31 |
| 2 | " | 35 ⁰ | 3 | 345.86 | |
| 3 | " | 31 ⁰ | 2 | 678.02 | 656.34 |
| 1 | 2.0m | 40 ⁰ | 5 | 485.99 | |
| 2 | " | 37 ⁰ | 4 | 520.00 | |
| 3 | " | 35 ⁰ | 4 | 520.00 | |

Table 17: Bearing Capacity.

| Depth (mm) | Allowable bearing pressures (Kn/m ²) |
|------------|--|
| 500 | 81 |
| 1000 | 87 |
| 1500 | 93 |
| 2000 | 99 |
| 2500 | 106 |
| 300 | 118 |

to find the 440.31KN/m² and 656.34KN/m² for the average depth of 1.0m, 1.5m 2.0m respectively.

Furthermore, from the above data available we can apply Rankine formula of determining an actual depth of the foundation.

The actual depth of foundation (D_f) = $(qa/y) \times \frac{(1 \sin\Theta)}{(1+\sin\Theta)^2}$

where,

D_f = Depth of foundation, qa = allawabale bearing capacity, epth of foundation, qa = allawabale bearing capacity, y = unit weight of soil and Θ = angle of, response or shearing resistance of soil.

Thus, $qa = 87N/m^2$ ($\gamma = \frac{10+15+30}{18.33KN/m^2}$) $\phi = 24^0$

Now, the actual depth of foundation (D_f) = $(87.00/18.33) \times \frac{(1-\sin 24)}{(1+\sin 24)^2} = 1.42$

CONCLUSION

The soil sample around the proposed Agricultural

Engineering Department in the Federal Polytechnic Kaura Namoda was taken and was properly investigated. A lot of information and engineering data on sample have been deduced from the result of the laboratory analysis. From the analysis of the result that was obtained, the following drawn are listed below:

- From the results of the index properties tests carried out on the sample from the study area, it can be concluded that, soil sample trial pit, 1,2 and 3 can be classified as fine and medium sand with 34.47% and 41.63% respectively. This is used to ascertain the uniformity of the and its graduation as well. It also helps in AASHTO classification of soil (i.e MH, ML and ML).
- From the engineering properties test conducted on the soil sample obtained from the area , the specific gravity values are 2.3, 2.36 for the trial pits respectively. Permeability test was also found to be 4.358×10^{-4} and 8.136×10^{-4} respectively. Where by the triaxial test conducted yields bearing capacity of the soil to be $qu = 343.30KN/m^2$, $440.31 KN/m^2$ and $656.34KN/m^2$ for the trial pits respectively.

RECOMMENDATIONS

From the nature and the information obtained from this research the following recommendation are desirable;

- Before any civil engineering construction will be carry out soil exploration or investigation is supposed to be carried out in order to know the present condition of the subsoil of such site. Within the results obtained after conducting the tests from the laboratory, a geotechnical engineer will determine whether the present condition of the site can suit the intended purpose or some treatment have to be made.
- Understanding the soil properties of a site also helps in making good construction decision leading to success of the project, a structural engineer can efficiently and accurately design the structural elements required based on the result of the soil test analysis so that for long term viability and soundness of the project. The result also helps to determine whether there is need for soil stabilization and the foundation depth to attain the required bearing capacity.

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