PROJECT TITLE

EFFECT OF SOIL ON FOUNDATION

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GRADUATE DIPLOMA IN ENVIRONMENTAL MANAGEMENT.

BY

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PGD/GEO/99/2000/096

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CERTIFICATION

This is to certify that, this thesis is an original work undertaken by Ibrahim Yusuf PGD/GEO/99/2000/096 and it has been prepared in accordance with the regulations governing the preparation and presentation of he project in Federal University of Technology, Minna – Niger State.

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DEDICATION

This project is dedicated to my beloved daughters, Maimunat Yusuf and Yasmin Yusuf.

ACKNOWLEDGEMENTS

I wish to express with deep respect my gratitude to my able supervisor (Dr.M.T. Usman) for his efforts and depriving himself of so many leisure hours in order to make this write-up what it is today.

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CHAPTER ONE

INTRODUCION:

The term soil is regarded as a natural aggregate of mineral grains with or without organic constituents, that can be separated by gentle mechanical means such as agitation in water.

Soil has many application in Civil Engineering works ranging from their usage as construction material. The civil engineering works includes construction of foundation, buildings of houses, construction of earth dams etc.

Also, soil can be referred to as rock since there is no sharp distinction between them. Soil is describe and identified by civil engineers as Gravels, sand, silt and clay respectively.

The forces which bring about soils formation from soil materials are commonly grouped under the term **WEATHERING.**

These forces are physical forces mechanical forces which result in rock disintegration chemical reaction which changes the composition of rocks and minerals and lastly Biological forces which result in intensification of the physical and chemical forces.

There are various ways of classifying soils. A soil is classified by mainly its properties which includes geological origin, mineral content, particle size and shapes, and taste or odour etc.

Soil as a main carrier of the dead and impose leads, therefore, it is essential to identify the rock or soil on which the foundation will be built. It should be fairly obvious that a general knowledge of geologist is useful, indeed essential, to the designer of foundation.

FOUNDATION:

The foundation may be define as an expanded base of a wall in addition to the ground or sub-soil which support it.

The main purpose of foundation is to distribute the weigh to be carried ver a sufficient area of bearing surface, so as to prevent the sub-soil from spreading and to avoid unequal settlement of the structure. The foundation material include the followings:

1. Plain concrete
2. Reinforce concrete
3. Stones and Bricks.

For foundation to perform it functions accurately. It must be carefully designed to suit the load it has to carry without failure, this in corporate soil information concerning soil types and topographic aspect of soil.

There are different type of foundation, these varieties are base on the nature of soil and the type of structure the foundation is going to carry. The choice of any type of foundation to be used, depend on its structural efficiency, economic valve and behaviour of the soil type under such foundation.

AIMS:

This project aims at investigating the general effect of soil on foundation design.

ii. OBJECTIVES:

The main objectives of this project is to find out the different categories of nature of soil. Also to compare soil structure interaction of two or more soil samples (relating to geology and texture etc.)

iii) SCOPE:

The scope of this project will be based on preliminary site soil investigations analysis the structural foundation and failure to the nature of soils.

iv) **METHODOLOGY:**

Investigation on site, analysis soil samples obtained from site.

CHAPTER TWO

LITERATURE REVIEW

IDENTIFICATION AND CLASSIFICATION OF SOIL AND ROCKS

2.1 Definition of soil and rock:

The term soil is regarded as a natural aggregate of mineral grains with or without organic constituents, that can be separated by genlt mechanical means such as agitation in water.

Soil can also be referred to as rock, since there is no sharp distinction between them. Soil is describe and identified by civil engineers as gravels, sand silt and clay respectively.

Rock is regard as natural aggregate of mineral grains connected by strong and permanent cohesive forces.

The distinction between rock and soil is not very definate but as a general rule, if material can be removed without blasting it can be consider as soil whereas if blasting is required it can be considered as rock. Soil may be separated into three very broad types:

1. Cohesionless soil
2. Cohesive soil
3. Organic soil.

OHESIONLESS SOIL: The particles do not tends to stick together, three ommon type of cohesionless soils are as follows:

Gravel

Sand

Silt

Gravel are particles size greater than 5mm, sand has particles size ranging from 0.1mm to 5mm.

Both gravel and sand can further (i) be divided into fine and coarse. (ii) Silt has particles size ranging (iii) from 0.005mm to 0.1m.

(iv) Cohesive soil:

Cohesive soils are characterised by very small particles size where surface chemical effect pre-dominate. The particles tend to stick together as a result of water particles interaction and attraction and attractive forces between particles.

Cohesive soil are therefore both sticky and plastic. A common type of cohesive soil are therefore both sticky and plastic. A common type of cohesive soil are clay which has particles sizes of less than 0.005mm. Clay soil cannotbe separated bysleve analysis into size category because no practical sleeve can be made with opening so small, instead particle size may be determined by observing settling velocity of the particle in a water mixture.

ORGANIC SOIL: Organic soil are typically spongy. Crumbly and compressible. They are undesirable for use in supporting structure. An example of organic soil is peat.

2.2 **CLASSIFICATION OF SOIL:** There are various system of soil classification. There are classified mainly by the followings:

) Physical properties

) Geological origin

i) Chemical composition

) Particle size

) Shapes

vi) Taste or odour.

It has been established that the physical properties of soils can be closely associated with their particle size both of which are of importance to the foundation engineer, architect or designer.

All soils can be defined as being coarse grained or fine grained each resulting in different properties.

COARSE –GRAINED SOILS: These would include sands and gravels having a low proportion of voids, negligible cohesion when dry high permeability and slight compressibility which takes place almost immediately upon the application of load.

FINE-GAINED SOILS: These include the cohesive silts and clays having a high proportion of voiles high cohesion, overflow permeability and high compressibility which takes place slowly over a long period of time.

SIZES LIMITS: Based on the size unit there are various ways of classification some of which are:-

SYSTEM	GRAIN SIZE (MM)
. MIT	Gravel: 2mm-60mm
	Sand: 0.06 – 2mm
	Silt: 0.002mm- 0.06mm
	Clay: Less than 0.002mm
AASHTO	Gravel: 75mm – 2mm
	Sand: 2mm –0.05mm
	Silt: 0.05mm –0.002mm

Clay: Less than 0.002mm

3. UNIVIED Gravel: 75mm – 4.75mm

Sand: 4.75mm – 0.075mm

Silt and Clay less than 0.075mm.

2.3 MOISTURE EXISTANCE IN SOIL:

Water exists in soil in four stages.

a) Capillary
b) Gravitational
c) Hygroscope
d) Adsorbed water.

Capillary water is contained in minute pore by action of capillary forces in soil. Water that percolates through soil and that can be drained or pumped out is called gravitation water.

Hygroscope or film water, is water that surrounds the individual grains with a thing film that cannot be removed by air drying. It can only be removed by oven drying. Absorbed water clings to the surface of the soil grains and cannot be removed by drying.

2.4 SWELLING AND SHRINKING:

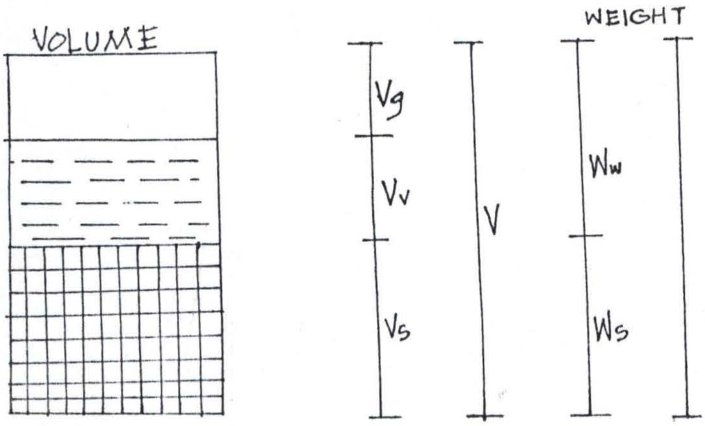
The volume of clay soils tends touching as the moisture contents changes even though no change occur in the external load. This volume change maybe a swelling or a shrinking. The change result from stresses exerted by capillary action in the soil pores.

The pore sizes of sands are so great that no volume change occurs because of this capillary effect, but in clays as such and form a base for foundation due to limit of swelling and shrinking.

2.5 WEIGHT VOLUME RELATINSHIP OF SOIL:

Definition:

The looseness or denseness of a soil sample may be determined quantitatively in the laboratory, the term probity, void ratio and relative density are commonly use to determine the density of the sample. The figure below shows a soil sample in sealed container as it would look if the solid liquid and gaseous phase could be segregated.



Where V is volume of sample

Where Vs is volume of solid

Where Vw is volume of water

Where Vg is volume of gas.

Since the relationship between Vg and Vw usually change with ground water condition as well as imposed load, it is convenient to designate all the volume not occupied by solid materials as void spale, Vv. If the total volume of the sample is designated as V then the porosity is defined by the equation porosity $n = Vv/v$

Void ratio $e = Vv/vs$.

Many soil below the water table and some fine grained above it are in a saturated condition. The degree of saturation is define as degree of saturation. Sr (present) =

100 Vw/Vv. Thus afa degree of saturation of 100% all at the void space filed with water.

2.6 SOIL INVESTIGATION:

Soil investigation is specific in its requirements whereas site investigation is all embracing, taking into account such factors as topography, location of existing services, means of access and any local restriction. Soil investigation is a means of obtaining date regarding the properties and characteristics of sub-soils by providing samples for testing or providing a means of access for visual inspection.

The actual date required and the amount of capital involves on any soil investigation programme will depend upon the type of structure proposed and how much previous knowledge the designer has of a particular region or site.

The main method of soil investigations are as follows:

1) Trial pits - Small contracts where foundation depths are not likely to exceed 3.000.
2) Boreholes – medium to large contracts with foundation up to 30.000 deep.
3) Light cable percussion borings
4) Wash borings
5) Wash probing.

TRIAL PITS: This is the cheapest and easiest method obtaining soil data by enabling easy visual in spection of the soil strata in its natural condition.

The pits can be hand or machine excuated to a plan size of 1.200 and spaced at centers to suit the scope of the investigation.

The pits need to be positioned so that the data obtained is truly representative of the actual conditions but not in such a position where their presence could have detrimental effect on the proposed foundation.

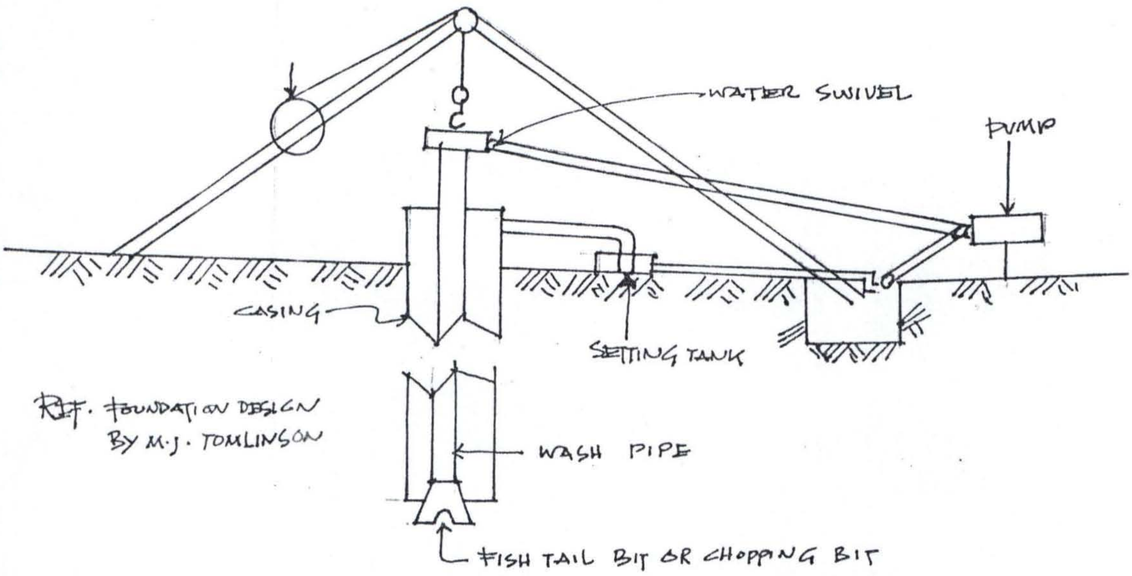
In very loose soils or soils having a high water table trial pits can prove to be uneconomical due to the need for pumps and/or timbering to keep the pits dry and accessible. The spoil removed will provide disturbed samples for testing purposes whereas undisturbed samples can be cut and extracted from the walls of the pit.

BORE HOLES: These enable disturbed or undisturbed samples to be removed for analysis and testing but undisturbed samples are sometimes difficult to obtain form soils other than rock or cohesive soils. The cove diameter of the samples obtained vary from 100 to 200mm according to the method employed in extracting the sample. Disturbed samples can be obtained by using a rotary flight auger or by percussion boring in a similar manner to the foremdion of small diameter bored piles using a tripod or shear legrig. Undisturbed samples can be obtained from cohesive soils using 450mm long x 100mm diameter sampling tubes which are driven into the soil to collect the sample within itself upon removal the tube is capped, labeled and sent off to a laboratory for testing.

Undisturbed rock samples can be obtained by core drilling with diamond tipped drills where necessary.

WASHING BORING: The soil is loosened and removed from the bore hole by stream or water or drilling mud issuing from the lower and of the wash pipe which is worked up and down or rotated by hand in the bore hole.

The water or mud flow carries the soil up to the annular space between the wash pipe at the casing, and it over flows at ground level. Samples obtained from this processes is unreliable as the cutting are mixed as they flow up the bore hole. The figure below illustrated a typical wash boring equipment.



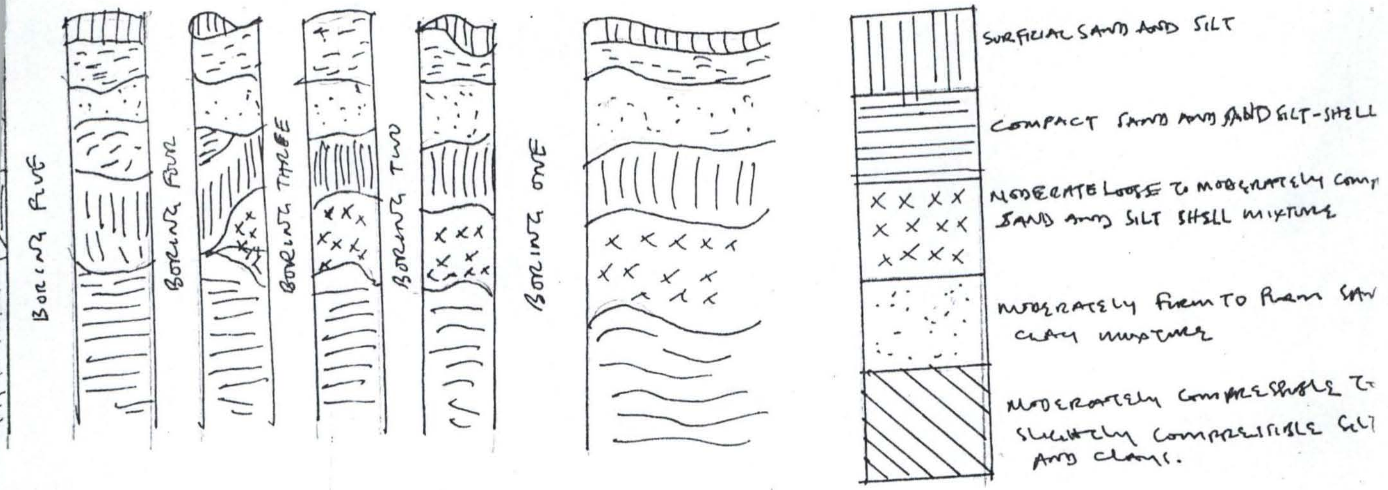
WASHING PROBING: Is a simple method determining the depth of an interface between soft or loose soils and a stiff of compact lawyer wash pipe delivering water high pressure are worked up and down in an uncased hole.

Thus there is no positive identification of the soil, since there is often no return of the wash water however, if ample water is available and if the soil does not contain large cobbles or boundlers, the method is rapid and cheap in establishing the level of a well defined stratum which can be located by the fell of the wash pipes as they are worked up and down.

2.7 SOIL SAMPLING:

There are two main types of soil samples which can be recovered from bore holes trial pits. Disturbed samples, can be obtained by using a rotary flight anger or by percussion bring in a similar manner to the formation of small diameter bored. Its using a tripod or shear leg-rig. The structure of the natural soil may be disturbed to a considerable degree by the action of the boring tools or excavation equipment.

Undisturbed samples, represent as closely as is practicable the tune in-sit structure and water content of the soil. The usual method of obtaining undisturbed samples is to driven tube into the soil to collect the sample within itself, upon removal the tube is capped, labeled and sent off to a laboratory for testing.



2.8 EXPLORATION IN ROCK:

These are three method used for sub-surface exploration in rocks.

1) Test pit
2) Drilled shaft
3) Rotary core drilling

1) **TEST PIT:** They are the most suitable means of assessing foundation condition in rock; since the layer of ground can be closely inspected.

The strength of the rock and its case of excavation can be determined by trial with a pick r compressed air tools. However, this test pit method cost less when bed rock is fairly close to the ground surface.

2) **DRILLED SHAFTS:** The excavation of rocks is done from shaft drilled by a rotary mechanical anger. The shafts should have a minimum dissector of

750mm and should be supported throughout by a steel tube inner which can be raised from the bottom of the shaft to permit examination of the rock surface. This method if adopted where rock lies deeper than 3m.

3) **ROTARY CORE DRILLING:** This method is regarded as the most satisfactory method of assessing the character of rock foundation which lies for depth below the surface specimens of rock in the form of cylindrical cores are obtained from the drill holes by means of core barrel.

Rotation of the barrel by means of the drill rods cause the core bit to cut an annular in the rock the cutting being washed to the surface by stream of water pumped down the hollow drill rods. The pump water also cools the drilling but at bottom of operation.

2.9 **SOIL TESTS:** Another important property of soils which must be ascertained before a final choice of foundation type and design can be made is compressibility and two factors must be considered:

1) Rate at which compression take a place
2) Total amount of compression when full load is applied.

COMPRESSIONS TEST: In designing foundation it is essential for engineer to know compressibility of soil when soil is subjected to increased load decrease in volume. The load maybe due to structure foundation, embarkment or even lowering of the ground water table.

A soil is compressed when loaded by the expulsion of air and/or water from the voids and by the natural rearrangement of the particles. In cohesive soils the voids are very often completely saturated with water which in itself is nearly incompressible and therefore compression of the soil can only take place by the water moving out of the voids thus allowing settlement of the particles. Expulsion of water from the voids within cohesive soil can occur but only at a very slow rate due mainly to the resistance offered by the plate – like particles of the soil through which it must flow. This gradant compressive movement of a soil is called consolidation. Uniform settlement will not normally cause undue damage to a structure, but uneven settlement can cause progressive structural damage.

This test can be carried out in two method.

a) Placing hydraulic jack between the test plate and a large heavy and inmorable object and pumping up the pressure registered on a gauge to the required test pressure.

   Test plate are usually made of steel cast iron and varying size from 300 x 300mm on sand to 900 x 900mm on clay. The results one more accurate withlarge size and the test is carried out at the level depth of required foundation.

b) Heavy weight object are stake on a platform of timber or steel joint balanced over the test plate or a pile of known area.

Example: If an actual foundation is to measure 1500 x 1300mm to support 50 tonne for a 600 x 600mm test plates 35 tones would have to be applied to produce a stress of three times the required safe bearing stress of 16 tones forces.

TEST PLATE PROCEDURE:

1) The test plate is slightly sunk below the level of the button of the trial hole.

2) The loads are applied increasement of about one fifth the actual ultimate load every 24 hours, to allow time for settlement. Consequently, the test can take along time. Settlement reading are taken every hours for the first 6 hours after

each weight increasement is applied and then every 12 hours load are taken up to three times the design load if failure does not occur earlier.

3) Failure is assumed if the settlement can usually be predicated to within 20% of actual settlement.

4) If there is a high water table, soil must be first de-watered down to the level of the bottom of project foundation.

<u>CONSOLIDATION TESTS:</u> When a saturated soil mass is subjected to a load increament the load is usually carried initially by the water in the pores, because the water is incompressible in compression with the soil structure.

The pressure which results in the water because of the load increament is named as **HYDROSTATIC EXCESS PRESSURE**, because it is in excess of that pressure due to the weight of that water.

As the water drains from the soil pores the load increament is shifted to the soil equal to the volume of water drained, this process is known as consolidation.

There are two most important soil properties furnish by a consolidation test are as follows:-

1) The compression index which indicates the compressibility of the specimen.

2) The coefficient of consolidation which indicate the rate of compression under a load increasement.

<u>PURPOSE:</u>

The main purpose of consolidation tests, however, is to obtain soil date which are used in predicting the rate and the amount of settlement of structures founded on clay.

Although some of the settlement of a structure on clay maybe caused by shear strain, most of it is normally due to volume change, particularly if the clay stratum is a thick one or one at volume depth below the structure.

Three piece of apparatus are in common used for a consolidation testing:

a) The pedometer

b) The triaxial apparatus

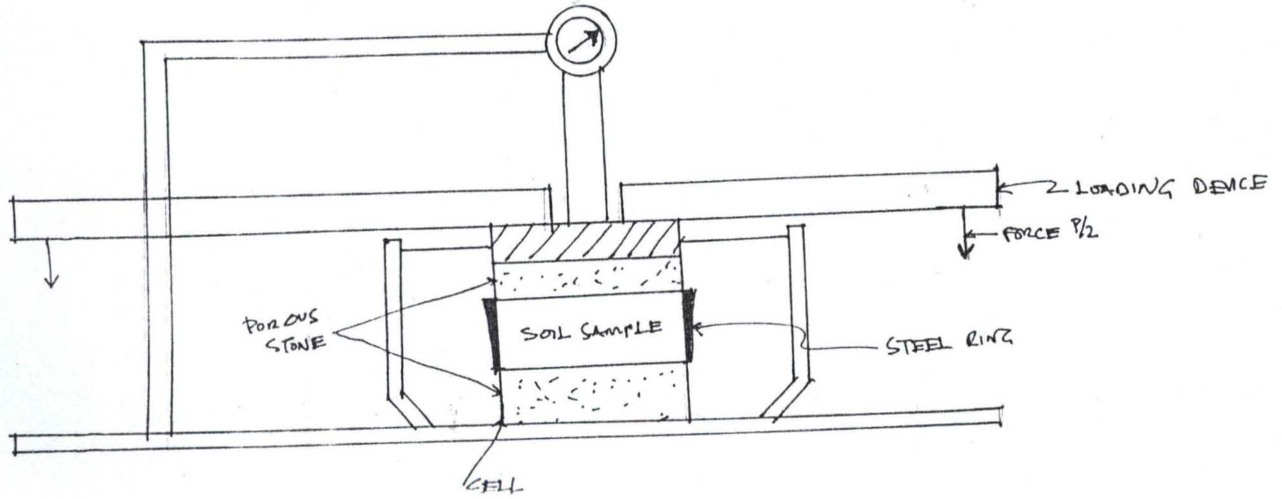
c) The hydraulic consolidation cell.

THE OEDOMETER TEST:

The test is carried out on compressible soil samples, e.g. silt and clays which are usually undisturbed circular slices of size 187.5mm thick by 750mm in diameter. The sample is placed in a cell between two porous stones and connected to a water reservoir so that it is always fully saturated loads are applied increment to simulate pressures ranging from 113.4kg/mm2 – 1814.4kg/mm2 each load increment is applied for 24 hours and the compression of the samples is measured by means of a dial gauge, compression are taking at frequent intervals at the beginning of theist the time interval between readings is doubled up to 2-4hrs and a final reading is taking at the end of the 24hours period.

The diagram below shows the Oedometer apparatus used in the laboratory for standard consolidation tests.

THE OEDOMETER.



The result of all the Odometer load stages are normally combined in one graph of void rotio as a function of the logarithm of effective pressure as shown below, constructed on the basis of the calculated void ratios at the end of each of the load stages.

These results are also used to calculate the coefficient of compressibility (MV=Deloted) (1/DP) where De is the void ratio change for a pressure change DP is used to predict the magnitude of settlement.

SHEAR STRENGTH TESTS:

In all soil stability problems, such as design of foundations retaining walls and embarkments, knowledge of the strength of the soil involved is required. The shear strength of a soil is its maximum resistance to shearing stresses. When this resistance is exceeded failure occurs. There re two common methods of shear testing:

a) Direct shear test

b) Triaxial compression test.

1. **DIRECT SHEAR BOX TEST:** In this case the soils is stressed to failure by moving one part of the soil container relative to another.

The apparatus involved in carrying out the test are:

a) Direct shear machine

b) Tamper for comparting soil

c) Balance (0.1g)

d) Drying oven

e) Timer

The procedure include the followings:

a) Sample of soil is taken from site either in an undisturbed or disturbed stage.

b) Small part of the sample is taken into a tin to determine the moisture content.

c) Part of the sample is taken into a box of 60mm x 60mm square, the box is then compled back into the machine.

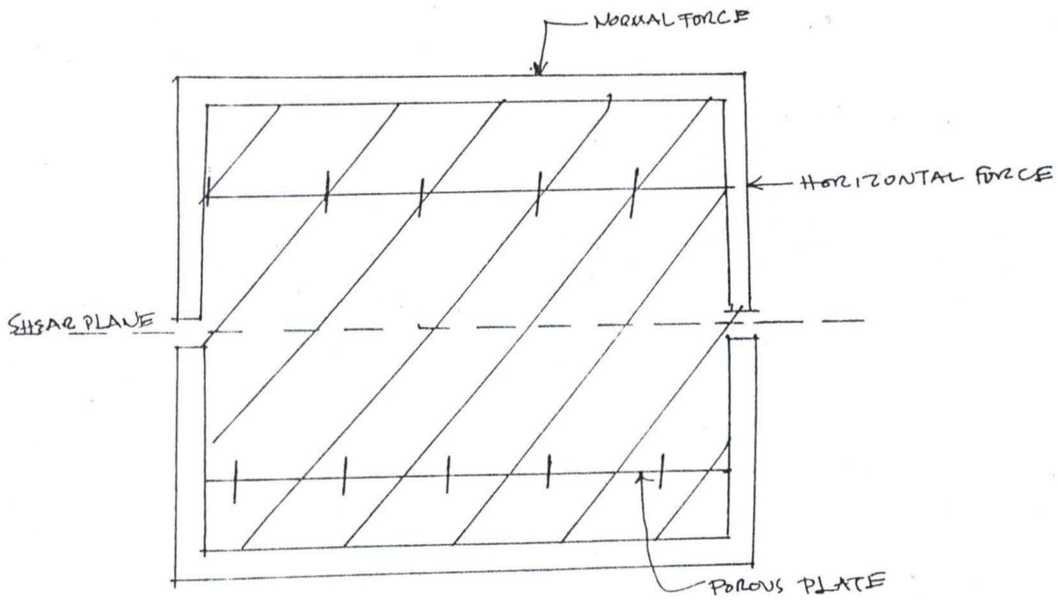
d) Water is applied to the side of the box to simulate the soil.

e) An axial load is applied to the soil with the help of a loading frame, the ratio of the increase in loading is i.e. 10,20,30kg.

f) A lateral force is applied to the side of the box by gradual wining of the fake at the rate of 1.25mm per minute.

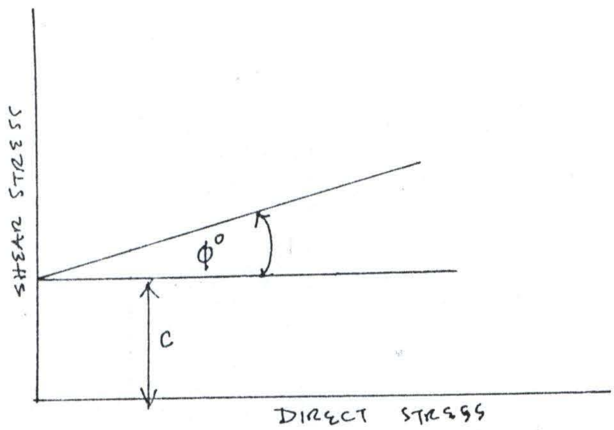
g) The readings on the dial gauge is taken and multiplied by the calibrating factor of the dial ring (2.5kg/m).

Finally, this procedure is repeated for about Area time, with different loadings.



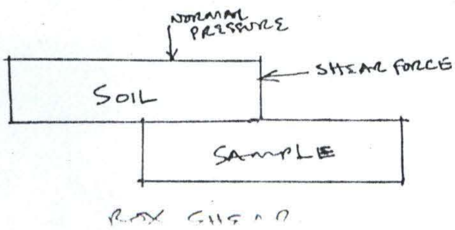
Tests result of the samples of the particular soil are potted on a shear strength/direct stress and the points joined making the tests fit, straight line (graph). The point at which the graph cuts the shear strength axis is noted and the magnitude gives the valve of the cohesion for the soil.

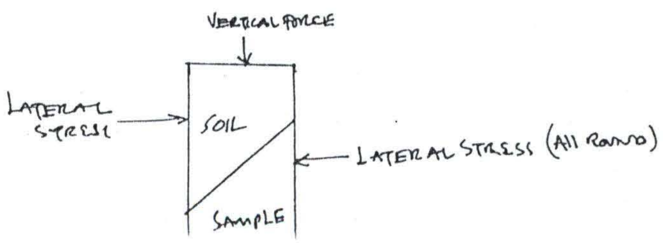
The straight line graph makes an angles and with the horizontal and this angle is the angle of internal friction for the soil samples. This graph is mathematically expressed by the Colombo's equation.



2. **<u>THE TRIAXIAL SHEAR TEST:</u>** (Also called trivial Compression) is more complicated but more reliable. A cylindrical sample of soil is surrounded by a rubber membrance with a rigid cap on one end and a piston on the other.

It is then place in a special closed cell to which a lateral stress is applied to all sides of the sample by relating the air pressure within the cell. An axial load (vertical stress) is applied to the upper end of the cylinder through the piston. The stress is increased until shear takes place, usually along a diagonal plane through the sample. A schematic presentation of force component in shear tests are shown below:





2.9 SOIL STABILIZATION:

Many soil are subject to differential expansion and shrinkage when they undergo changes in moisture content. Many soils also move and rut when subjected to moving wheel loads. It pavement are to be constructed on such soil, it is usually necessary to stabilize them to reduce the volume change and strengthen them to the point where they can carry the impose load.

Stabilization refers to any treatment of the soil, which render it more stables.

There are two types of stabilization, mechanical and chemical. In engineering construction however stabilization is most often referred to when compaction is preceded by the addition and mixing of an inexpensive admixture, termed a stabilization agent, which alters the chemical make up of the soil, resulting in a move stable material

Also, stabilization maybe applied in a plant and then transported to the job site for placement and compaction. Method of stabilizing soils include the following operations:

1) Blending asphalt with the soil

2) Blending and mixing heterogeneous soil to produce more homogeneous soils.

3) Incorporating lime or lime-fly ash into soils that are high in clay content.

4) Incorporating varies salts into soils

5) Incorporating Portland cement into soils that are granular in nature.

6) Incorporating certain chemical into the soil

7) Compacting the soils after they are processed.

1. BLENDING AND MIXING SOILS:

If the soils that are to be used in a fill are heterogeneous in their original states, such as in a borrow pit, they maybe mixed during excavation by a deep-culting belt loader kto excavate through several layers in on a operation. When such materials is placed n a fill, it maybe subjected to further blending by several passes with a disk harrow.

2. STABILIZATION OF SOIL WITH LIME:

In combination with compaction, soils stabilization with lime involves a chemical process where the soil is improved with the addition of lime. Lime, in its hydrated from (Ca CoH)2 will rapidly cause cation exchange and fluctuation agglomeration, provide it is intimathy mixed with the soil.

This reaction begins to occur within an hour after mixing and significant changes are realized within a very few days, depending upon the PI of the soil and the amount of lime used. The cementing reaction of the lime as a Ca (OH(2 with the clays a very show process. The slow strength with time experienced with lime stabilization of clay provide flexibility in manipulation of the soil.

Lime can be added and the soil mixed and compacted, initially drying the soil and flocculating it. Several days to several weeks lateen the soil can be remised and compacted to form a densed stabilized layer that will continue to gain strength for many years.

3. LIME FLYASH STABILIZATION:

Fly as his a by-product in the production of electricity using coal. Fly as his extremely fine in size (often finer than cement) and contains the silicates and illumination necessary to combine with the lime in soil stabilization.

4. ASPHALT SOIL STABILIZATION:

When asphalt's, such as an emulsion or a cut back are mixed with ganular soils usually in amount of 5 to 7 perveant of volume of the soil.

5. CEMENT SOIL STABILIZATION:

The construction method involve spreading the Portland cement uniformly over the surface of the soils, preferably with a pulverize type machine to a specified depth, follow by fine grading and compaction. If the moisture content is low, it will be necessary to sprinkle the surface with water during the processing operation.

The material should be compacted within 30 minutes after it is mixed using tampering or pneumatic tired rollers, followed by final rolling with smooth-wheel rollers.

It may be necessary to apply a seal of asphalt or other acceptable material to the surface to retain the moisture in the mix.

CHAPTER THREE

CASE STUDY

3.01 INTRODUCTION:

this case study was conducted at Kuje in FCT on the on-going project of Sharia Court of Appeal Complex in connection with the construction of water tank reservoir for water storage, and all the findings and data obtained were analyzed in stages.

3.02 SITE INVESTIGATION:

To start with the introduction of site investigation, site investigation is the process by which geological, geotechnical, and other relevant information which might after the construction or performance of a civil engineering works or construction of foundation is required.

The site investigation range in scope from a simple examination of the surface soil with a few shallow trial pits.

The extent of soil investigation depends on the importance and foundation arrangement of the structure. A detailed site investigation involving deep bore hole and laboratory testing of soils is always a necessity for heavy structures, e.g. multi-storey building, water tanks, bridges etc.

3.03 PROCEDURE OF SITE INVESTIGATION:

It has been found necessary that all site investigation involves a considerable numbers of activities, and these activities include the followings:

1. Preliminary desks study or fact finding

2. Air photograph interpretation

3. Site walk over survey, lesson by geotechnical engineer with site staff during the project work etc.

3.04 INFORMATION REQUIRED FROM SITE INVESTIGATION:

The information below is of importance to all foundation engineers before deciding on a particular choice of foundation:

1. The general topography of the site as it affects, foundation design and construction e.g. surface configuration, adjacent property, the presence of water courses, ponds, trees etc and access to site.

2. The location of buried services such as telephone cables, orator mains, and sewers.

3. Special features such as the possibility of earth quakes or climatic factors such as floodings seasonal swelling and shrinkage, perm frost, or soil errosion.

4. Result of laboratory tests on soil and rock samples appropriate to the particular foundation design.

5. Result of chemical analysis of soil or ground water to determine possible deleterious effects on foundation structures.

3.05 A TYPICAL SOIL INVESTIGATION ANALYSIS:

The ability of a structure to stand depend on the nature of soil supporting it, so with these reason, a typical soil investigation was carried out to determine the suitability of the soil for steel pillar construction to carry water reservoir.

The soil sample was excavated to a depot 650mm below ground level. Manual excavation was adopted in order to obtain undisturbed sample as possible. When the depth was reached, a steel cylinder was harmed into the soil and thus the undisturbed was obtained.

From the site, the soil sample were carry to the laboratory and the moisture content was determine to be 11%.

The followings test was carried out on soil sample in order to determine various particles sizes present in the soil sample for classification:

1) Sieve analysis
2) Liquid limit test
3) Plastic limit test
4) Soil bearing capacity

3.06 VISUAL TEST:

The visual test was carried out on the site, which included the close, examination of colour, texture, odour and consistency of the soil sample.

After the examination it was found to be a dark brown soil with an odour, it was also a clay soil which contained thin root particle which can be easily picked by hand.

3.07 PARTICLE SIZE DISTRIBUTION TEST:

The particles size distribution is a method of classifying soils.

Sieve analysis was used to obtain a grading curves which were plotted on a chart.

In carrying out these test, a 500gms of oven dried soil sample was passed through a batch of United State bureau of standard sieve by using mechanical shaker for four minutes.

The weight retained on each sieve was recorded and hence the percentage of total sample passing each sieve was plotted on the sem-logatithm chart.

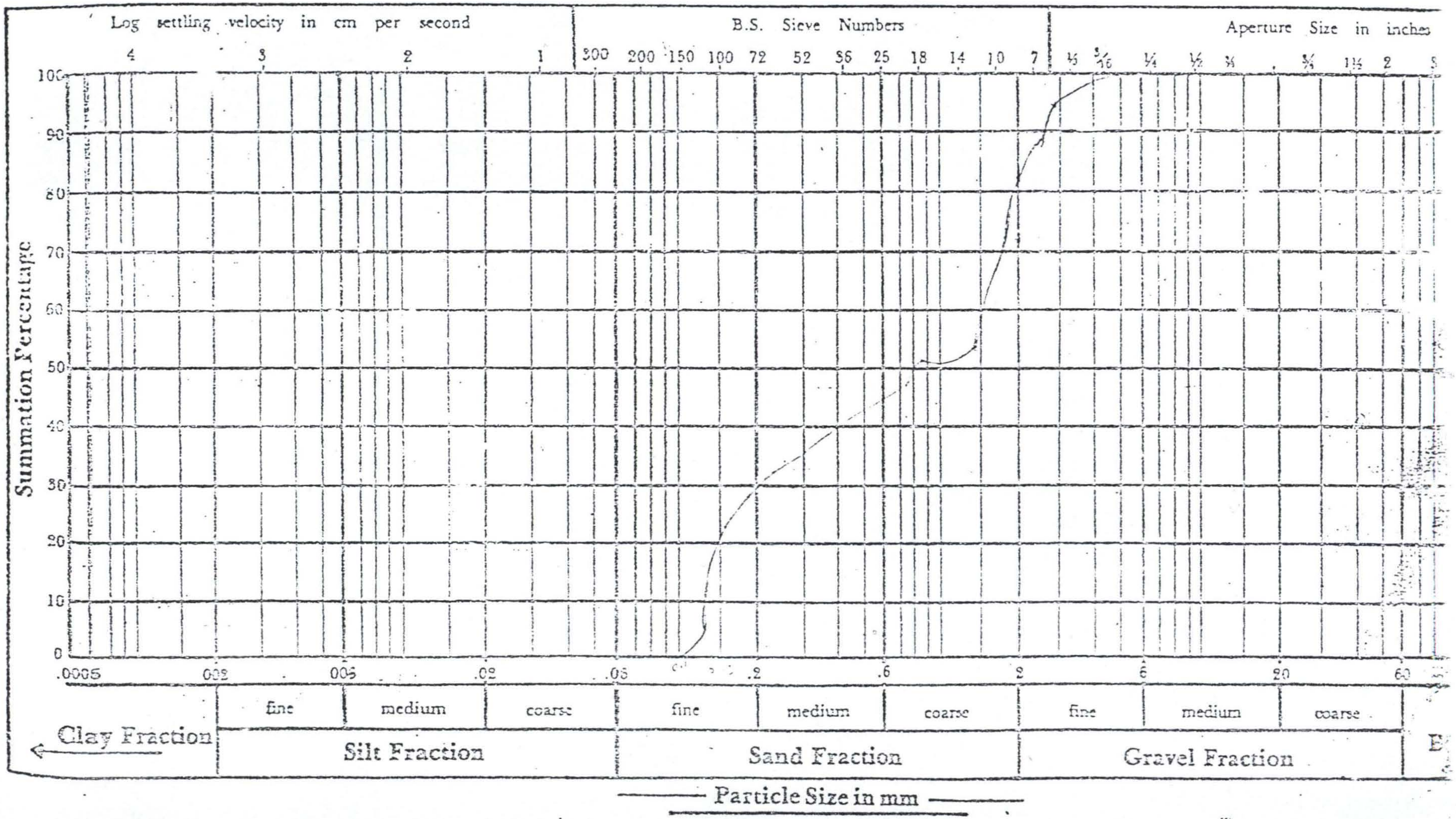
The values obtained during the test are shown in a tabular form below.

SIEVE SIZE (mm)	WEIGHT RETAINED (GM)	TOTAL WEIGHT PASSING(GM	TOTAL PERCENTAGE PASSING (%)
4.76	0	500	100
2.8	27	473	94.6
2.36	30	443	88.6
2.0	32	411	82.2
1.7	45	366	73.2
1.18	73	293	53.6
.850	37	256	51.2
.710	23	233	46.8
.300	58	175	35
.212	22	153	30.6
.180	12	141	28.2
.150	10	131	26.2

Particle Size Distribution

Location. Kuje [redacted] .... Boring No ...1........... Sample No. ONE .... Date of Test 10 - 0

Description ... well graded sand with fines ....



PLASTIC LIMIT = 31.22%

.125	98	33.	16.
Pan.	33		

From the particle size distribution curve.

Effective size D10 = 0.131

60% size D60= 1.20

Coefficient of uniformity, $CU = \frac{D60}{D10} = 9.16$

It a well graded sand with fines.

3.08 **PLASTIC LIMIT TEST:**

This is the minimum moisture content at which the soil can be rolled into a thread of about 3mm diameter without breaking up.

Here crumbling sample of 3mm diameter, was taken in a small quantity for moisture content determination.

The test was repeated up to five times and the corresponding moisture content was taken, and the average gave the plastic limits. The detail of the laboratory result are shown below:

THE RESULT OF PLASTIC LIMIT TEST:

TEST NO(GM)	WEIGHT OF CONTAINER (GM)	WEIGHT OF SAMPLE AND CONTAINER	WEIGHT OF DRY SAMPLE CONTAINER (GM)	WEIGHT OF TURE CONTENT (GM)	WEIGHT OF DRY SAMPLE (GM)	MOISTURE CONTENT
1	5.5	10.5	9.1	1.4	3.6	38.9
2	9	14.1	13.1	1.6	4.1	39
3	8.5	13.6	12.5	1.1	4	27.5
4	30	35	34	1	4	25
5	18.5	22.9	22.	0.9	3.5	25.7

PLASTIC LIMIT = 31.22%

3.09 LIQUID LIMIT TEST:

This is minimum moisture content at which the soil will flow under its own weight. Plastic and liquid limit tests were dealt with to ascertain the plasticity and compressibility of each soil.

The following are the apparatus used in carrying out the test.

1) Liquid water

2) Distilled water

3) Balance

4) Drying oven

5) Dessicator

6) Evaporating dish

7) Watch glasses

8) Spatula

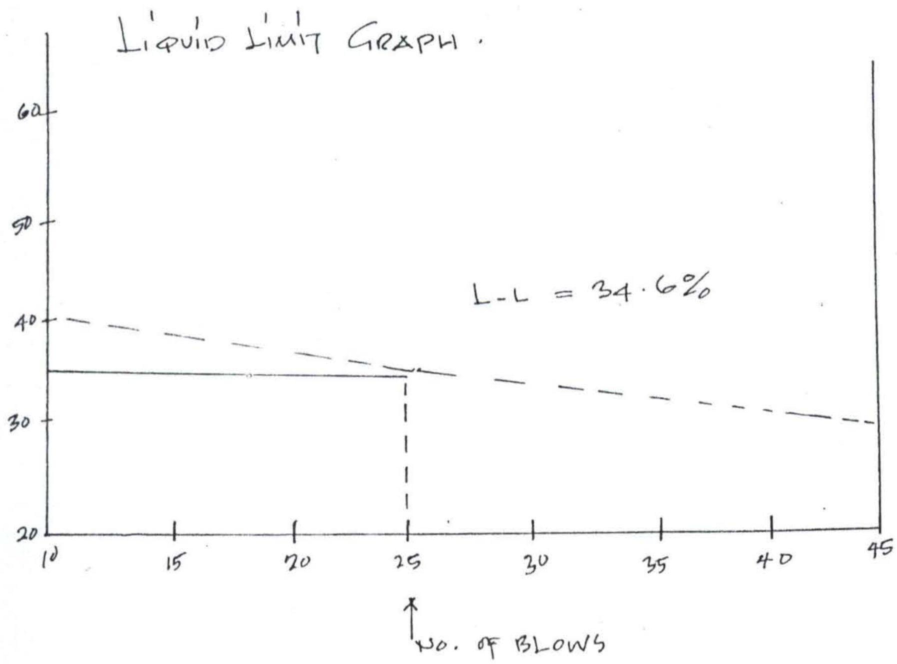
PROCEDURE:

A portion of the soil were taken for moisture content determination.

The graph of number of blows against the moisture content was plotted on graph sheet and the moisture content at 25 blows taken as the liquid limit. Also here the detail of the laboratory result and the plotted graph sheet are seen below:

TEST NO.	NO. OF BLOWS	WEIGHT OF CONTAINER (gm)	WEIGHT OF WET SAMPLE AND CONTAINER (gm)	WEIGHT OF DRY SAMPLE AND CONTAINER .(gm)	WEIGHT OF MOISTURE CONTENT(gm)	WEIGHT OF DRY SAMPLE(gm)	MOISTURE CONTENT
1.	16	30.8	52.8	47	5.8	16.2	35.5
2.	43	29	47	43	4.1	14	29.3
3.	22	19.1	40.2	348	5.4	15.7	34.6
4.	15	L9	39.5	34.	5.5	15	36.6
5.	10	9	26.8	22	2.8	13	36.9

LIQUID LIMIT = 34.6%



3.10 SOIL BEARING CAPACITY

Soil bearing capacity is of important, to determine the strength of the soil. The soil bearing capacity for stability purpose must not be exceeded, once this condition is not certified the size of the foundation is in adequately chosen leading to the soil being unable to sustain the applied load.

The soil sample is obtained at the depth of 650mm below ground level. The natural moisture content was found to be 11%.

The weight unit density = 17Kolm2, the width of the footing was 2.5m. Since the angle of internal friction 0 = 18o and cohesion C = 5KN/m2, using the terzaghs bearing capacity factor chart, Nc = 15, Nq = 6.5 and Nr = 3.5 where Nc, Nq and Nr are constant factor.

Substituting these valves in bearing capacity (q) equation.

q = $\frac{Br}{2}$ Nr + C, Nc + q Nq. But q1 = 2 = 17 x.650.

q = 2 x 17 x 3.5 + (5x.650) + (17 x.650 x 6.5)

= <u>134.6KN/M2</u>

Using a factor safety 0.650, the effective bearing capacity of the soil = $\frac{134.6}{.650}$ = q = 207.1KN/M2.

<u>PROCEDURE IN DETERMINING S.B.C:</u>

The undisturbed sample was obtain in its nature moisture content condition. A shear box test was then carried out to determine the cohesion and the angle of internal resistance of the soil (O) this was done by putting part of the sample in the shear box was (60 x 60)mm2 in size.

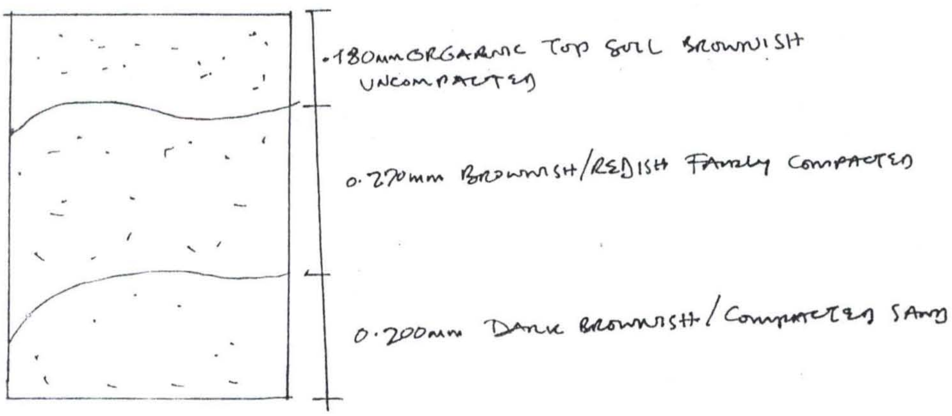
A vertical load of 10kg Ws put on the shear box and by applying gradually a horizontal load, the shear failure of the sample was done for three times, with 20kg and 30kg loads respectively, their respective proving ring reading were recorded. The valves obtained during the test can be seen on the table below:

The proving ring reading were multiplied by a constant factor of 2.5 as stated by the manufacturers.

INTERNA LOADS	SHEAR FORCE(N)	INTERNAL STRESS KN/m2(r)	SHEAR STRESS KN/m2
10kg=62.2N	1.88x2.5x6.22 =27.9N	21.32	13.0
20kg =137.1N	3x2.5x6.22 = 46.7N	37.6	23.0
30kg =211.4N	4.6x2.5x6.22 = 71.5N	62.36	36.0

3.11 **SOIL PROFILE:**

The below illustrate graphical representation of soil stratum of the investigation.



3.12 DESIGN OF FOUNDATION:

A foundation was design for a steel column, to carry a water reservoir tank. The design was based on the report of site investigation conducted in this chapter.

CHOICE OF FOUNDATION:

Considering the information from site investigation report, it was seen that the nature of soil at the depth of .650mm is dark brownish/compacted sand.

From the above information, an isolated pad foundation was used, since it is a frame work with steel columns carrying the overall load.

3.13 ISOLATED OR PAD FOUNDATION:

This type of foundation, is used to support and transmit the load from piers and columns. The construction is usually of square or rectangular in shape, and there are reinforced with blinding before the reinforcemnt bars are laid.

BLIDING:

A blinding layer k50 to 75mm thick of weak concrete, coarse sand or building paper should be placed under all reinforced concrete foundation.

The function of the blinding are to fill in any weak pockets encountered during excavations and to provide a true level surface from which the reinforcement can be positioned.

Furthermore, it is to prevent the cement in the concrete foundation from washing into the soil.

3.14 THE CALCULATIONS INVOLVES IN PAD FOUNDATION ARE AS FOLLOWS:

1) Calculate the plain size of the footing using permissible bearing pressure of the soil.

2) Calculate the upward not bearing pressure resulting from column load only.

3) Determine thickness of the base

4) Check for punch shear

5) Determine the reinforcement required

6) Check for local bond stress.

DATA:

Bearing pressure = 207KN/M2

Load to be transmitted = 520KN.

Column self weight = 28KN.

Total applied load = 548KN.

Base plate = 400 x 400mm2

Fcu = 15N/m2

Fy = 250

1) To calculate area of base = $\frac{\text{app. Load}}{\text{Bearing pressure.}}$

= $\frac{548}{207}$ = 2.6mm2

Since the footing is to be in square base

:. L = $\sqrt{2.6}$

2) To calculate net upward bearing pressure.

Q = $\frac{\text{app.load}}{\text{Aea.}}$

= $\frac{520}{2.6}$ = 200kn/M2

3) To calculate thickness of footing at the column face which is the critical section for bending.

M = qxLxB xX.

M = 207x2.5x1.2x0.3 =186.3 187knM

Ultimate moment due to load mu 1.2x187 = 224KN

Mu = mr due to concrete

:. 224 = 1.15 Fen bd2.

D = $\sqrt{\frac{224}{0.15\text{x}15\text{x}1200}}$ = 288m

Using 16mm 0 bar and concrete cover 30mm.

Let H = 350mm

Then effective depth = 350-50 = 300m.

5) To calculate for punch shear.

Critical perimeter = Column perimeter + 3 h

= 2x400+3 Iix600 = 645.6mm

Area within perimeter = 400+ 3h/2-(4-II) (15.h)2

= (400 +1800)2 – (4 – 3.142) 900

= 4.1 x 10⁶mm

Punch shear O = q (A-G).

200 (2.5 4.1)

= 320KN

Punch shear = $\frac{V}{\text{Perimeter x d}}$

= $\frac{320x\ 10^3}{6456 \times 300}$ = 1.67N/mm2.

5) For concrete.

Mu = 0.15 fcu bd2

0.15x15x2500 x300₃ x 10₆ = 5063KN/m.

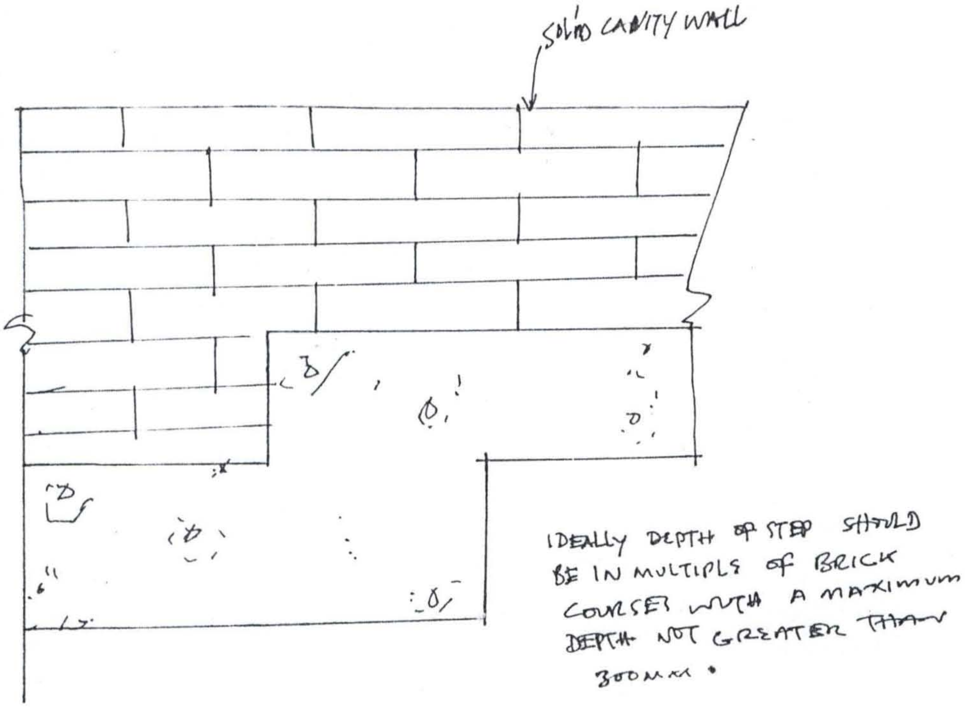
To determine r-t required.

Moment due to r-t

Mu = 0.87Fy AsZ

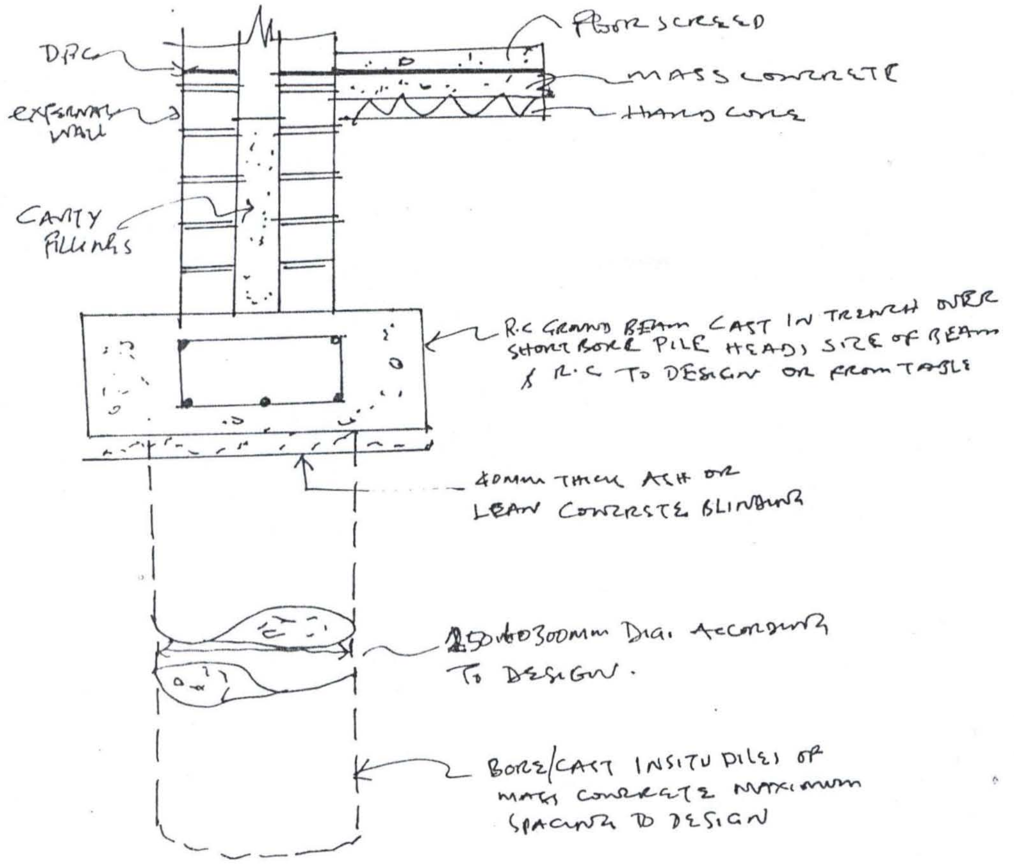
As = $\frac{M}{0.87\ Fyz}$

The minimum lap of one layer of concrete over the lower one must be equal to the thickness of the concrete or 300mm which ever is the greater. The steps should not be of greater height than the thickness of the foundation unless special precautions are taken and should be in multiplies of brick thickness so that the brickwork will bond without being cut at each of the steps.



6) **SHORT BORED PILED FOUNDATION:**

These are a form of foundation which are suitable for domestic loading and clay sub-soils where ground movements can occur below the 900 to 1000mm depth associated with traditional strip and trench till foundations. They can be used where trees are planted close to the new building since the trees may eventually cause damaging ground movements due to extracting water from the subsoil and root growth. Conversely where trees have been removed this may lead to ground swelling.



PILE FOUNDATION:

These can be defined as a series of columns constructed or inserted into the ground to transmit the loads of structure to a lower level of sub-soil. Pile Foundations can be used when suitable foundation condition are not present at or near ground level making the use of deep traditional foundations uneconomic. The lack of suitable foundation conditions maybe caused by:

1) High water table-giving rise to high permanent dewatering costs.
2) Natural low bearing capacity of sub-soil.
3) Presence of layers of highly compressible sub-soils such as peat and recently placed filling materials which have not sufficiently consolidated.

PILES TYPES:

1) Wood. Steel, concrete composite.

PILE CLASSES:

a) Bearing pile

b) Friction pile

c) Sheet pile

d) Wood pile.

Concrete pile.

Composite pile.

1) **BEARING PILES:**

It transfer the heavy loads through the unsuitable surface soil to the denser more stable soil below loads are carry vertically down to the bed rock or materials of high bearing strength.

2) **FRICTION PILE:**

This does not necessary reach high bearing materials, but does not reach soils resistance to a point where the load is carried by the underlying soil and the soil pressure surrounding the pile. Friction pile does depend on soil density and side pressure for a great percentage of their load bearing ability. Friction is based on soil density and side pressure.

3) **SHEET PILE:**

It is not intended to carry vertical load but rather to resist horizontal pressure. The Principal use is to hold back earth around the perimeter of the excavation.

4) **WOOD PILE:**

The should be free from large loose knots, decay, splits and shakes. Suitable timbers are the pines, firs larch and western hemlock. Wood pile are treated by precious impregnation with creosote. Wood pile are light and have indefinite life of expectancy even when place under water.

CONCRETE PILES:

TYPES OF CONCRETE PILE:

Are SITU-CAST and PRE-CAST: The situ cast type is divided into two general group namely:-

1) The shell-less type.

2) The shell type is made by driving a steel shell or casan into the group, filling it with concrete and leaving the shell in place. The shell acts as a formwork and prevent muds and water from mixing with the concrete, such pile may not be reinforced. It is useful where the soil is too soft to form a hole for an uncased pipe or where the soil is extremely too hard to compress and may deform an uncased pipe.

   The shell may be cylindrical or tapered with smooth or curagated outside surface.

THE SHELL-LESS: Is made by driving a steel pipe fitted with a special ends or tapered shoe into the ground for the depth of the pipe. The pipe is then pull up leaving the shoe at the bottom and the hole filled with concrete. This pipe is satisfactory where the soil is cohensive.

COMPOSITE PILES: Two material may sometime be combined to make up a single pile. The most common combination is wood and concrete condition for use are:-

1) If the permanent water head is not more than 21m below ground level. This is about the length limit for the upper concrete section of the pile.

2) Where the used of wood piles alone would need about 3m of extra dry excavation, or as little as 1.2m of wet exavation. This can be avoided by the use of composite pile.

3) When the overall length of the pile is to great and economically impossible to handle a straight wood or concrete pile.

PILE SPACING:

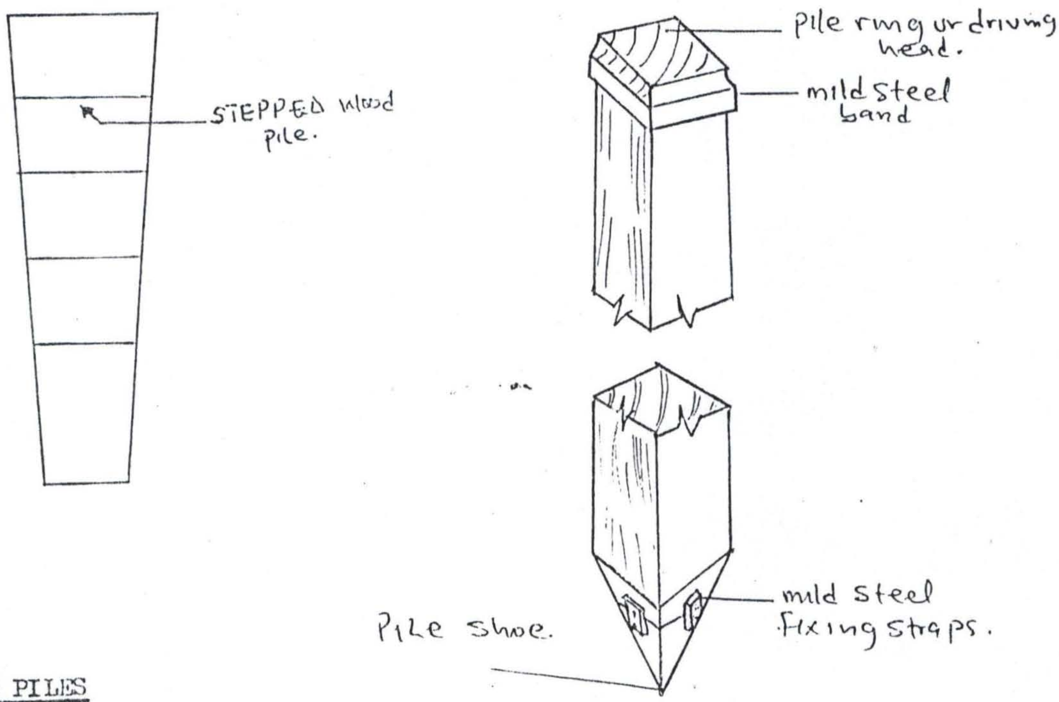
When a number of piles are driven close together the load bearing valve of each is reduce. As a result a number of building codes have established .750 to 1.5m oneter to center.

PILE DRIVERS: Pile drivers consist of a drop, mechanical or vibratory hammer.

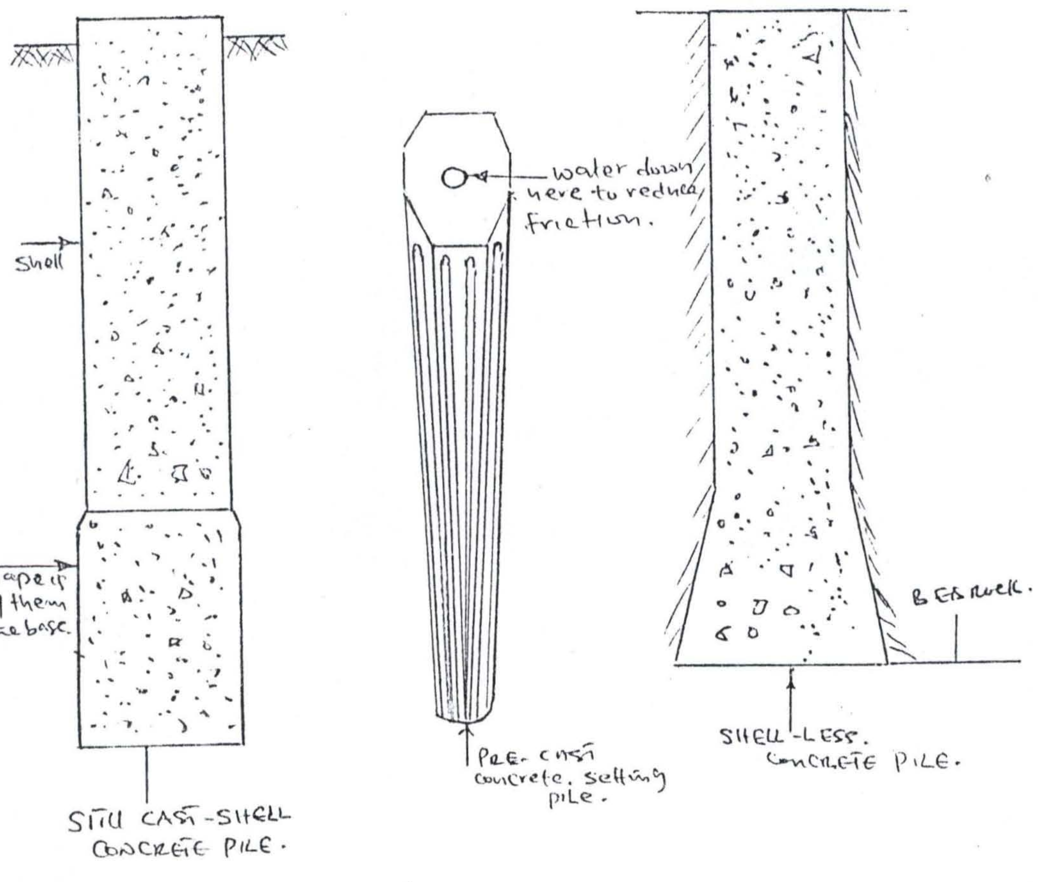
[redacted].

The diagrams below illustrate different types of piles.

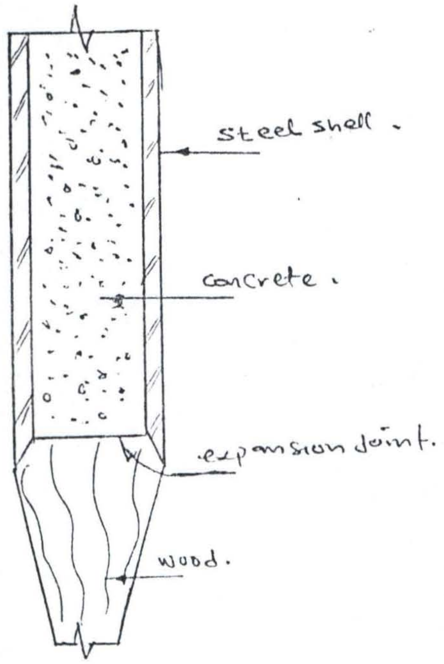
WOOD PILES.

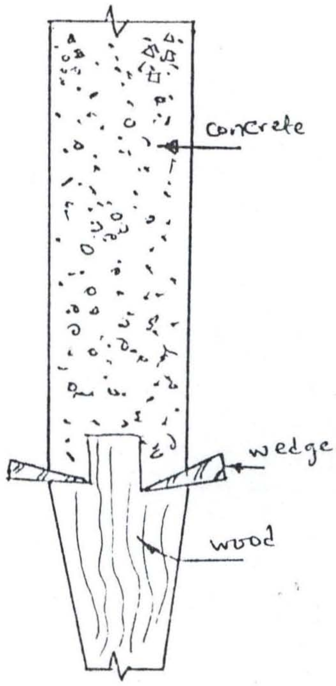


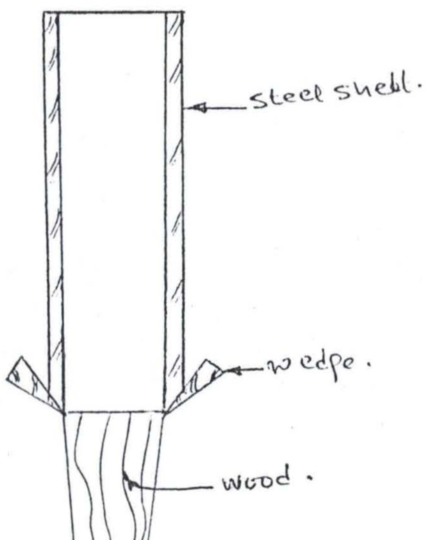
CONCRETE PILES



COMPOSITE PILES







4.5CHOICE FOUNDATION

For an engineer to choose a suitable type of foundation he shall depend on a number of factors have to be considered then are soil and site condition, type of structure the foundation will support, is loading and amount of movement (total and differential) which can be tolerated.

Choice can also be affected by economic consideration, resources and time available for construction. In selecting foundation type for a certain construction, consideration of their general characteristics and basic soil and structural principles, lead to general conclusion on which type of foundation is likely to be most suitable.

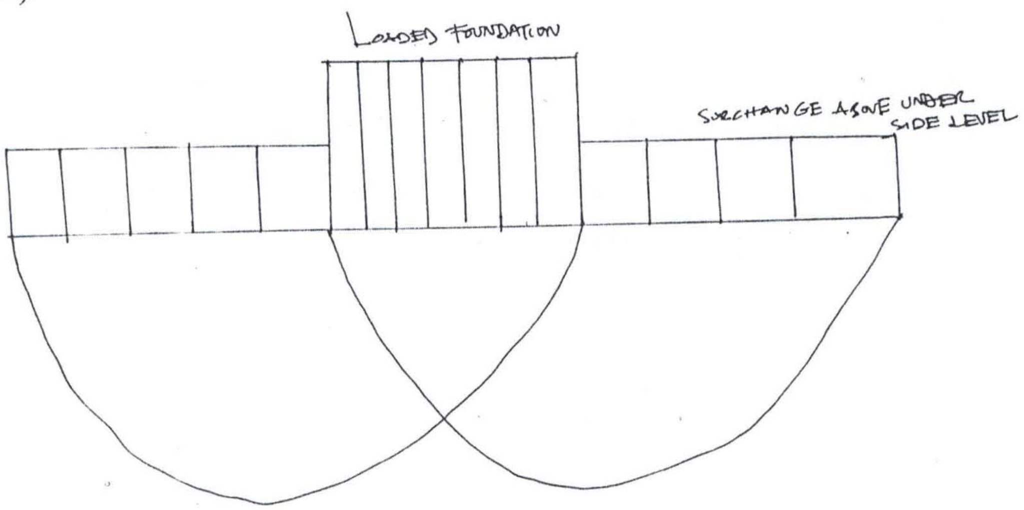
The general tabulating of foundation choice is as follows: -

SOIL TYPES	SUITABLE FOUNDATION	REMARKS
(1) Sands and Gravels	Raft foundation	Found above water table if possible may settle if subjected to vibration. If found deeper, use raft.
(2) Clay and silta	Pads, strips or raft, for individual column strip or raft for walls or closely spaced column.	Strip or raft may be required for bearing capacity or Settlement requirements especially with silt or soft clay. Short bores piles may have the advantages for light building on clay.
(3) Loose sand and gravel (especially hoer water table)	Strip or raft	Depend on bearing capacity and settlement requirement consider Improving soil by vibroflotation

4.6 WHAT LEADS TO FOUNDATION FAILURES?

Foundation for structures or buildings fails or collapses, due to soil failure in shear or unequal settlement of different parts of the foundation or combination of both.

A knowledge of the distribution of contract pressures between a foundation and the soil assists in determine the most suitable arrangement of foundation to avoid relative settlement. Typical mode of failure of the soil under a loaded foundation block is shown below diagrammatically in figure 4.7 (A).



Plastic failure: this form of failure, which can occur in cohesive soils if the ultimate bearing capacity of the soil is reached or produced.

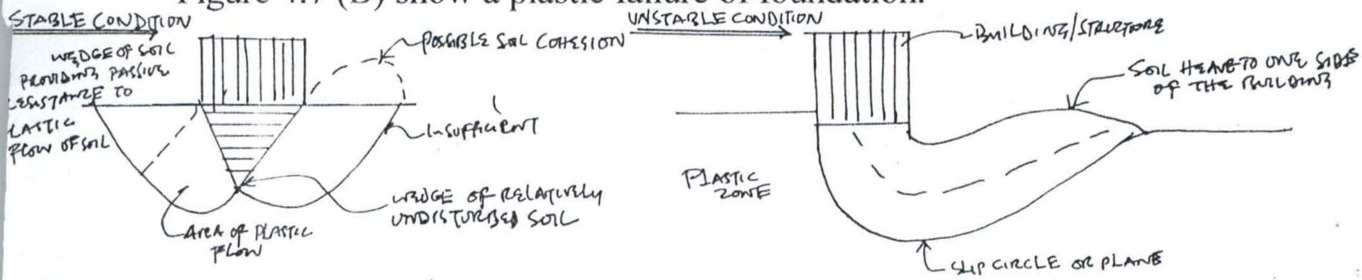
As the load on a foundation is increased the stresses within the soil also increased until all resistance to settlement has been over come.

Elastic failure, which can be related to the shear strength of the soil, occurs when the lateral pressure being exerted by the wedge of relatively undisturbed soil immediately below the foundation causes plastic shear failure to develop resulting a heaving of the soil at the sides of the foundation moving along a slip circle or plane.

In practice this movement tends to occur on one side of the building, causing it to tilt and settle.

Plastic failure happen when the pressure applied by the foundation is approximately six times the shear strength of the soil.

Figure 4.7 (B) show a plastic failure of foundation.



4.7 PRESURE DISTRIBUTION

Various pressures are produced in a soil mass when a load is applied. They are of interest because of their effect on the ability of the soil to safely support a given loading and also because their calculation is normal preliminary to the determination to the determination of settlement produced by the loadings.

Contact pressure: - It is very often incorrectly assumed that a foundation, which is uniformly loaded, will result in a uniform contract pressure under the foundation.

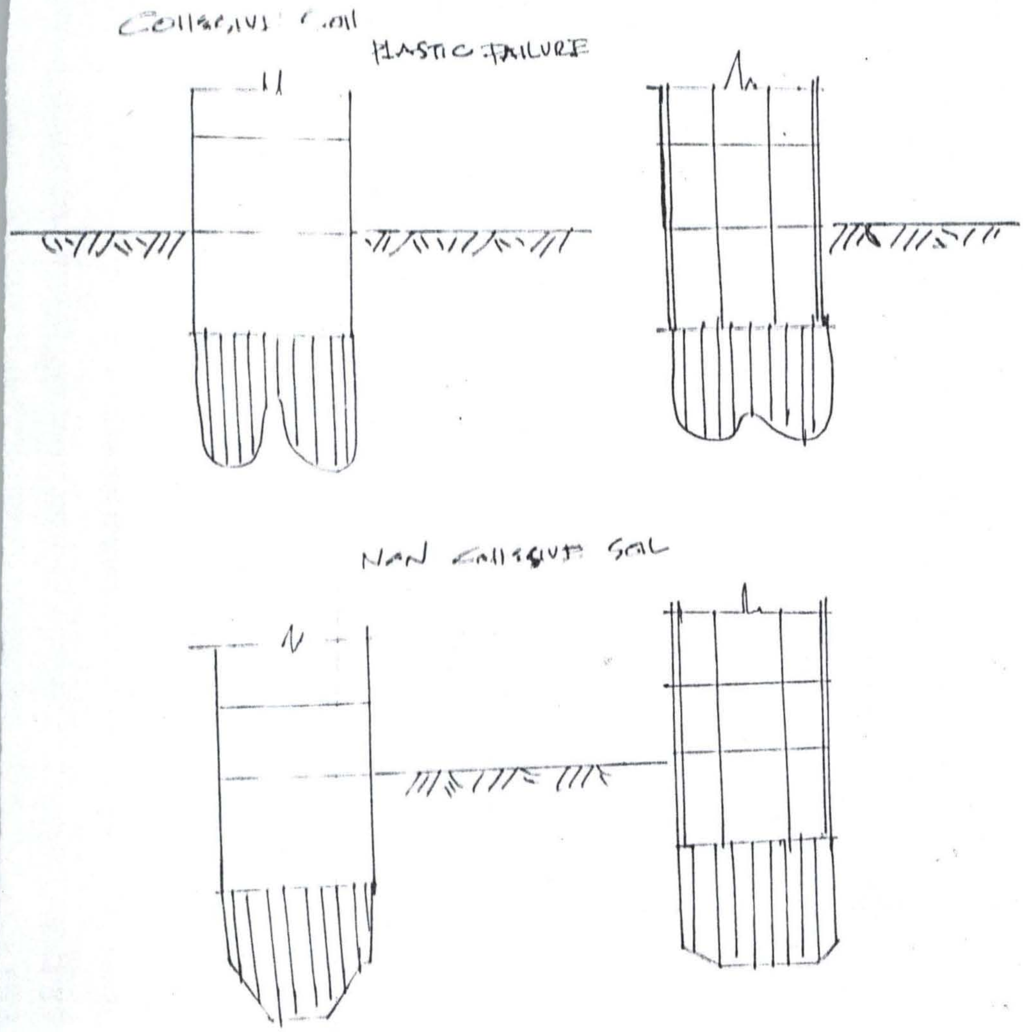
This would only be true if the foundation was completely flexible such as the base to a pin-jointed frame.

The actual contract pressure under a foundation will be governed by the nature of the soil and the rigidity of the foundation, and since in practice most large.

Structure have a rigid foundation the contract pressure distribution is not uniform.

In cohesive soils there is a tenderly for high stresses to occur at the edges which is usually reduced slightly by the yielding of the clay soil.

Non-cohesive soils give reset to a parabolic contact pressure distribution with increasing edge pressures, as the depth below ground level of the consideration must be increases. When selecting the basic foundation formal consideration must be given to the concentration of the major loads over the position where the theoretical contact pressures are at a minimum to obtain a balanced distribution of contract pressure is shown below in figure 4.8.



4.8 FOUNDATION SETTLEMENT:

Settlement due to consolidation of the foundation soil is usually the most important consideration in assessing allowable bearing pressure, it is necessary to investigate the likelihood of settlement before the allowable bearing pressures can be fixed.

The settlement of structural foundation consists of two parts. The immediate settlement (P1) takes place during application of the loading as a result of elastic deformation of the soil without change in water content "consolidation" settlement (Pc) takes place as a result of volume reduction of the soil. The final settlement (P.P) is the sum of (P1+P0) settlement calculation for a cohesive soil. Immediate settlements are calculated using Bouss...theory.

A valve for the modulus of elasticity E (young's modulus) is obtained either from direct testing or experience, is needed; also a valve for poisons ratio (ratio of lateral to primary vertical strain) is needed and is usually taken to be 0.5. For reasonably uniform soil conditions, settlements are calculated direct, using foundation sizes and pressures in a standard formula.

The settlement of non-cohesive soils under applied loading, through almost immediate, may be complicated because the effective modulus of elasticity normally increases with depth. When it warrant to calculate the settlement accurately the best method is to divide the soil onto a number of suitable layer, and determine the settlement of each by a formula which involves thickness its constant of compressibility, C initial effective stress P0 and stress increase due to C. is determined by penetration test.

Settlement calculation. The long-term consolidation of a layer of clay may be estimated from p=2 (U.M.J.) where p= settlement z= average vertical pressure in the layer under the settlement points calculated from the net foundation pressures (qn) due to long-term loads, u= geological factor for particular clay, Mv= co-efficient of volume decrease, H= (layer thickness).

Mv= is normally determined from soil test as corresponding to pressure of p0 + Z/2, but typical valves are given in table below.

TYPES OF CLAY		Mv (M2/MN)u
Very soft alluvial	>1.0	110 to 1.2
Normally consolidated Alluvial.	0.25 to 1.0	0.7 to 1.2 depending on sensibility
Normally consolidated at Depth.	0.1 to 2.5	
Weathered and less stiff Fissured.	0.1 to 0.25	0.5 to 0.7
Boulders and very stiff Fissured.	0.05 to 0.1	0.2 to 0.7 depending on degree of over Consolidation.
Heavily over consolidated Boulder and heard fissured At depth.	< 0.05	0.2 + 0.5

Reference: Handbook on Building structure by A.J.

4.9 <u>FOUNDATION ON COHESIVE SOIL</u>

Cohesive soils itself includes, stiff boulder clays, stiff clays, sandy clays, firm clays, soft clays, sandy silts, very soft clays and silts. Most of this cohesive soil has capacity from 65 to 5 tones; f/m2 most of these clay soils are saturated and behave as if they are cohesive (angle of resistance equal to zero), provided that unwanted is expelled from the soil as the load is applied.

This is acceptable as the basis for calculating ultimate capacity for most normal cases of structural loading.

On the assumption that the angle of shearing resistance of the soil is equal to zero, the simplified formulas for the bearing capacity of strip foundation design and pad foundation are as follows:

Ultimate bearing capacity, qF = cNc + P.

Net ultimate bearing capacity, qnf = cnc.

Where C = undrained cohesive.

Nc = bearing capacity factor.

P = total layer burden are sure at foundation level.

The cohesive © is determined from the result of laboratory tests on soil samples, from foundation level within the zone which is stressed significantly by the foundation loaded. Foundation on a cohesive soil shall be arranged with the loads towards the center of the foundation where pressure intensity is least as shown in figure (4.9A).

4.10 <u>FOUNDATION ON NON-COHESIVE SOIL</u>

Non-cohesive soil includes compacted well graded sands, gravel sand, mixture loose well graded sands, compacted uniform sands, and loose uniform sands, most of this soils have bearing capacity only for narrow foundation on loose submerged sand. For most practical purpose for obtaining the valves of Nq and Nv graph below. It is sufficiently accurate to assume a valve for the angle of shearing resistance (0) on basis of the relative density of the sand as given by empirical in sitn penetration test. Suitable test are the standard penetration test.

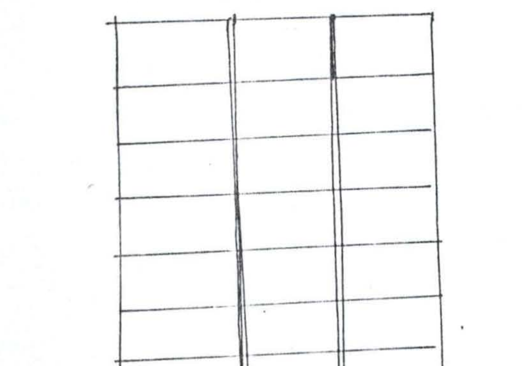
Table above illustrate determination of angle of shearing resistance of granular soils from in-sit test.

Table (A) is the relationship between standard penetration resistances (N. valves) and angle of shearing resistance of granular soil.

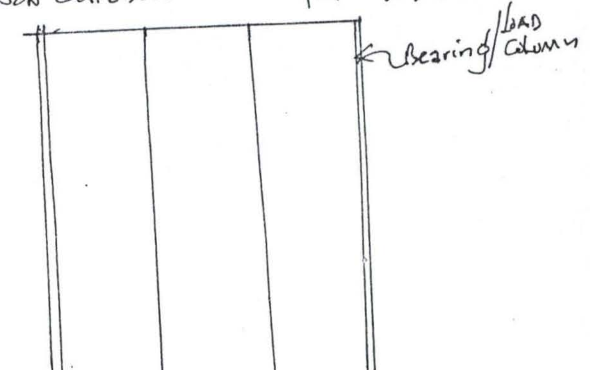
(B) Meyer hoof correlation between static cone penetration resistance and of shearing resistance of a sand.

Summary, for a foundation design on a non-cohesive soil such as sand should be designed so that the move heavily waied columns would be towards the edge of the foundation where contact pressure is least and the lightly loaded columns towards the center to allow uniformity or settlement over the areaof the building as shown in figure 4.9 (B).

COHESIVE SOIL FIG. 4:9(A)



NON COHESIVE SOIL FIG. 4:9 (B)



5.00 CHAPTER FIVE

5.01 SUMMARY CONCLUSIONS

The project has been able to identify some courses of foundation failure and this was arrived at through investigation on site and analysis of data obtained from site. Since soil is an important material in all-engineering work, it is of great important to investigate the forces that bring about the formulation of soil.

The sources formation of soil can be grouped under the term "WEATHERING". These forces include the physical forces, mechanical forces and chemical forces e.tc.

The term soil is regarded as natural aggregate of mineral grains with or without organic constituents that can be separated by gentle mechanical means such as agitation in water.

Soils are broadly classified by these physical properties, geological origin, particular size and taste or odor e.t.c. Investigation is all embracing in its requirement where as site investigation is all embracing, taking into consideration, such factors topography, location of existing services, and access to the site.

Soil investigation is a method of acquiring data; regard the properties and characteristic of sub soil by providing samples for testing or providing a means of access for visual inspection.

The method of soil investigation includes the followings:

1. Trial pits, and its best adopted where the depth of foundation are not likely to
   Exceed 3.00m.

2. Boreholes – used where foundation depth is up to 30.000m deep and other

 Methods were also discussed in the literature review.

Soil test is also an important aspect to be considered by the designers of foundation. Some of theşe tests are shear strength test, compressibility test, and particle size distribution test e.t.c.

A soil investigation was carried out to determine the suitability of soil to stand a steel pillar construction to carry a water reservoir. In determining the stability of soil, the following tests were conducted.

1. Visual test, soil bearing capacity, particle size distribution test, plastic limit tests and lastly liquid limit test.

In final analysis of these tests, pad foundation was designed to transmit the load from the steel column to the ground on which it rests.

Foundation is define as an expanded base of a wall or a pier, and a sustain and transmit to the ground both dead, imposed and winds loads.

Also chapter four has discussed the various types of foundations, where they can be used, including the courses of foundation failure.

5.02 RECOMMENDATION

Since the soil is the main carrier of the dead and impose load, therefore it is essential to identify the soil on which the foundation will stand.

Also it has been established that the physical properties of soil are associated with their particle size, both of which are of importance to the foundation engineers, architects or designers.

It should be fairly obvious that a general knowledge of geologist is useful, indeed essential to the designer of foundation.

Awarding of building contract should be base on merit, the contract must be awarded to somebody with basic knowledge on construction of buildings or a specialist in foundation design must be employed in the case of a local contractor to represent him on site.

The engineer must see that the actual load design for a particular foundation is not exceeded.

Finally, if the above suggestions are followed up, and emphases are made on them, it will help us in reducing the futures occurrence of foundation failure.

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