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Analysis The Engineering Index Properties of Soil Sample at Irele Town

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Abstract
The engineering index property of soil deposit of Irele town was investigated due to its economic and engineering significance. Samples were collected at five different locations at Irele town and were tested and analyzed in the laboratory to determine their physical and engineering properties. These samples were subjected to moisture content test, particle gravity, direct shear test, and density test. Particle density of the samples collected at those locations and depth shows relative in the results and falling within 2.69 and 2.40 while only soil from 0.5m of location five has less particle density compare to the rest with 1.95. The moisture content of the surface ranges from 15.6% to 22.9% and the location three having the moisture content (Mc), at the depth of 0.5 within 13.8% -7.94% while 15.1% from location two are the highest at the level of 1.2m while permeability test shows that the samples is not permeable. The result of the direct shear test shows that the samples are collected in the same spot and the area fall with 82kg/m-50 and angle of shearing resistance 18-11 respectively. Plotting the shear stress shows on the graphs.

Keywords: Density, Shearing Resistance, Shear Stress, Permeability, Direct Shear Stress

INTRODUCTION

Background of the Study

The strategic location of Irele in the southern riverine area of Ondo State in Western part of Nigeria informed the keen interest for investigating the properties of the wide deposit of sand in the area. It is on record that the community is by and large becoming an island of industrial set up, therefore necessitating the need for research of the soil properties in anticipation of the use to which the soil would be subjected to both in terms of road construction network and building structures.

Loto C.A and Omotosho E.O (1999) reveal that soil obtain from Irele deposit was characterized as containing kaolin, illite and montimorillnite with kaolin having the highest percentage.

The work further confirmed the presence of montimorillnite by the flame test, which shows the existence of exchangeable cautions not present in kaolin. Soil classification does not eliminate the need for detailed in soil investigation or for testing engineering index properties. However the engineering properties have been found to correlate quite well with the index and classification properties of soil deposit (Braja, 2001). Thus by knowing the soil classification, the engineers already has a fair knowledge of likely behavior of the soil under engineering situation during construction and under structural loads.

Also in the work of Loto C.A and Omotosho E.O (1999) the soil deposit shows the presence of Na, K, Ca, and Fe with sodium as the most potent and exchangeable caution and ions observe not to swell when water was added. Their research work shows further that the Irele soil deposit is acidic in nature with a pH of 4.2 and tendency towards flocculation of the soil platelets due to its high viscosity when mixed with water. It was also reported that deposit shows a very low illite group presence (0.003%k) and specific gravity of 2.2.

The above are general testing and purely with the motive using the deposit for metallurgical works in synthetic molding ,therefore the need for further research with the view of exploring more of the properties index of the sand deposit especially as it affect support for structures that can detrimentally stress such deposit.

The research was concise effort to gather a sample population of Irele soil deposit and carry out standard test on them so that a statistical method can be employed in predicting an accurate and reliable engineering and geotechnical properties index of the soil deposit and also engineering and economic use to which the clay deposit can be put.

In soil classification according to Osho (2014) we have coarse grained soil e.g. sand and gravel and the third are highly organic which is called peat. In soil classification, we consider the sand sized and layers in which its physical nature and state of the soil can be used to give full description, we consider the sand sized and layers in which its physical nature and state of the soil can be used to give full description of the sample of the deposit by means of using visual examination, simply test observation of the site conditions, geological history etc.

Soil classification can be describe as a separation of soil into classes or group in which each are having similar characteristic and potentially similar behavior. But in a classification for the engineering purposes should be based mainly on mechanical properties e.g. permeability stiffness strength.

STUDY AREA DESCRIPTION

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Irele is the study area, and is located in Ondo state of Nigeria. In the map of Nigeria, Irele is located on the latitude 6^0 22^1 -6 34 and longitude 4^0 48^1 east. The relief is a low land coastal relief; the sand depositor is alluvial deposit which is deposited by water. The location of the research work at Irele in Irele local government area of Ondo state.

Five locations were selected for the purpose of this research work at Irele district. They are follows:

- Aduga
- Akingboye
- Gbogi
- Igboke
- Labale

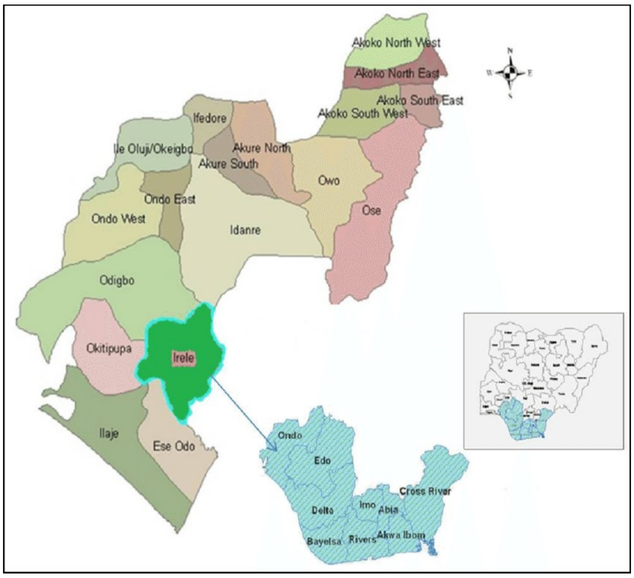

Figure1: Showing the location of the study area (Irele) in Ondo State.

GEOLOGY AND MORPHOLOGY OF THE AREA

Soil makes up outermost layer of our planet. Topsoil is the most productive soil layer which has varying amount of organic matter (living and dead organism) mineral and nutrients soil scientist have identified over 70,000 kind of soil in the world and the foundation of the soil is formed from rocks and decaying plants of 45% mineral, 25% water, 25% air and 5% organic matter.

In soil analysis, different sized mineral particles such as sand, silt, and clay give its texture in which fungi and bacteria help to break down the organic matter in the soil. When everyone thinks of soil, they generally tend to consider only the surface of the land. In fact, this is just the top soil only; soil may go down several meters before solid rock is reached.

There are actually three layers in soils. This is referred to as horizons. We have the top soil, subsoil, and the parent material. The nature of soil varies according to geographical locations, climate, etc. However the top soil can either be dark brown or black in color though not in very arid or dry area in which is made up of rock material that has been chemically and physically broken down and changed and mixed with organic material such as dead plant particularly quartz and other material which can add up to 15% feldspars, 15% rock fragment 5% clay minerals and smaller proportion or calcium carbonate and organic material. Subsoil consist of altered rock material which contained much less plant life and living creature.(the report and book marked blue available from the sea friend library in Auckland.

The Irele sand covered Irele and its environs. Though Irele is a small village surrounded by water located along the bank of river and the exposed quartz sand covers an area of about 150m x 500m excluding those sand that present where the people of Irele build their houses. The reserve at Irele is categorized under quaternary deposit of the guinea coast. This rank is later resulted in the formation of the three distinct group sediments.

i Pre older sand sediment
ii Older sand sediment
iii The young suites deposit.

The reserve of the silica sand at Irele thereby falls under the younger suite deposit. His investigations further reveal that the sediment was deposited with the influence of fluctuating Pleistocene ecstatic sea-level.

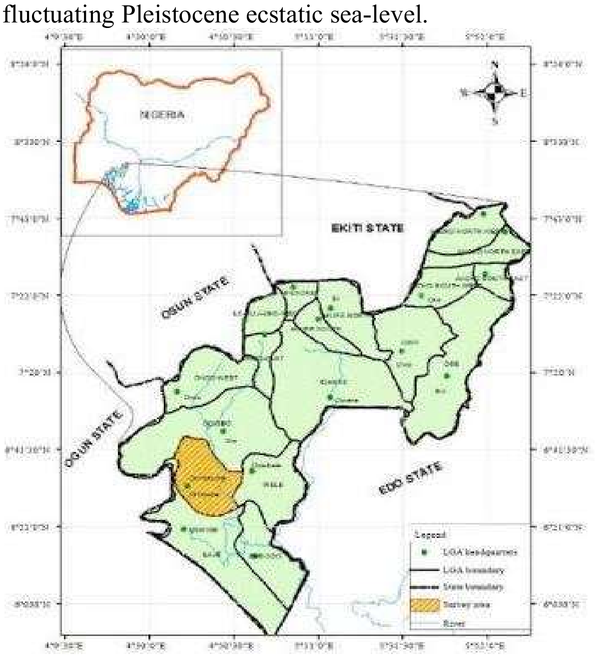

Figure 2: Geological Map of Irele in Ondo State.

FORMATION OF THE SAND

Sand is formed when a large block of continental crust slumped 500-200 meters downward leaving a wide and deep valley to be filed by the river which flow into sea at

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the time and with a large quantity of sand, gravel and other deposit is found filling the undersea chasm above a bed rock of metamorphosed rock.
Heat and pressure will slowly solidity and metamorphosed the new deposit but close to the surface, a very large amount of old sand found will still loosely pack.

GEOLOGY OF SAND

Over 75% of Irele area is cover by unconsolidated sufficient sediments deposit that varies from less than a meter to several hundred meters in thickness. Most of the sufficient sediments own their origin to a number of processes which have during the last few million years (Quaternary), but a few isolated deposit of tertiary age are also known. All of still active today, but their relative importance has change with time especially during the 10,000 year (Holocene).The character and distribution of unconsolidated sediments can be generalized by examine modern geological processes at the time the last age, the sea water level stool 120m lower than today, forming the continental self. The sand locked up in these is radio-carbon dated to about 9,000 years old. As some ice age ended, some 6,000 years ago and the sea level rose, the beaches and dunes moved with level and by the action of waves nearly all the sea sand within certain size range was swept the land. The main component of sand is (Silicon dioxide (SiO_2)) and extremely hard and slowly wearing substances which may have originated from the soil or volcanic eruption millions of years ago since no carbon is found inside silica. It cannot be carbon dated. In between the sand grain, we also find shell (calcium carbonate $CaCO_3$) and organic matter that can be carbon dated. The latest addition to the pool of sand came from present day rivers but before it became a play ball of the water. Sand is formed from neck weathering under layers of soil and vegetation. Although sand grains are found in sandstone and consolidated beach sand, they are not part of the earth crust, metamorphism rock, not even of much stone. During the weathering process, the chemical composition of rock is changed and sand is from dissolved silicate. Other product formed are clay and silt together in which they form many kind of loan and it takes many thousand years of rock to turn into the subsoil, then the top soil being washed into rivers and finally ending into rivers and finally ending up into the sea (GHO GHEOLONG, 1st Edition).

METHODOLOGY

MATERIALS AND EQUIPMENT USED FOR COLLECTION OF SAMPLE

Cutlass: This was used to clear the bush for easy accessibility of the sample location.
Shovel: This was used to excavate the loosed soil from the dug hole.
Digger: This was used to dig the soil to the desired depth for the compatibility of the soil deposit for the representation of the sample.

Sample Bag: polythene bag was used to collect the sample so that the original quality of the sample was retained.

Determination of Moisture Content

This is used to determine the amount of water present in the sample of soil or ratio of the weight of water in the pores of soil to the weight of dry soil.
The test was carried out in the laboratory by weighing soil samples and it was put into polythene bag tight at both ends in order not to lose any moisture content and also weighed to know the amount of water present in it i.e. wet weight-dry weight (after the sample have been oven dried for 18 hours). The moisture content is also referred to as natural water content.
Therefore, weight of water = wet weight-dry weight and moisture content (mc) = weight of water/weight of dry soil.

Procedure:

Place a reweighed large paper plate (9-inch minimum) on the scale and weigh out exactly 100grams of the representative forage sample.
Spread the forage evenly on the paper plate.
Place an 8 oz water glass, three-quarters full of water, in the back corner of the microwave oven keep water level constant during oven use.
Then weigh and record sample weight and mix the sample and place it in the oven for two minutes; remove and weigh again. If the weight has not change more than the gram, use this value and if the change is greater than one gram, continue drying using additional one minutes intervals until the weight change is less than one gram.
Be careful not to char the sample, if this occurs it means the oven was set too high. Discard the charred sample and repeat the test.
Use the following equation to calculate the moisture content, since the wet and dry weight include the weight of the paper plate must be subtracted from wet and dry weight before making any calculation.

Apparatus Used

Temperature controlled drying oven
Aluminum drying cause with lids (Air tight, Non-corrodible)
Weighing balance
Desiccators

Determination of Direct Shear

A direct shear test is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil.
The shear strength is determined as below:

- Shear strength of soil (kg/cm)
- Cohesion (kg/cm)
- Normal stress (kg/cm)
- Angle of shearing resistance (degree)
- C + ŏ tan Φ

Procedure:

- A specimen is placed in a shear box which has two stacked rings hold the sample; the contact between the two rings is at approximately the mid-height of the sample.
- A confining is applied vertically to the specimen, and the upper ring is pulled laterally until the sample fails, or through a specified strain.
- Rate of strain or shear displacement rate should be constant throughout the test.
- Before allowing the sample to shear, the screw joining the two halves of the box should be taken out.
- The spacing screws after creating required spacing between two halves of shear box, should be turned back to make them clear of the lower part.
- One soil specimen should be tested with not more than three normal.

Apparatus Used

- Shear box: size 60mm x 60mm (large size box e.g 300mm x 300mm x 200mm are also used in special test containing gravels up to 25mm size) open at top and bottom, divided horizontally into two halves.
- Container for shear Box: it holds the bottom of the shear box and filled up with water surrounding the shear box when sample is tested at saturated condition.
- Grid Plates: two plain, two perforated with serrations of 1.5mm depth.
- Porous Stone: two numbers each 6mm thick, 60mm x 60mm in size.
- Base Plate: Non-corrosive metal containing cross grooves on its top face.
- Loading Pad: Non-corrosive metal to be fitted in the shear box.
- Loading Frame: The important requirement of the frame is that the normal load is applied uniformly on the soil specimen in the shear box, without any electricity.

Determination of Particle Density Test

This test is performed to determine the specific gravity of soil by using a pycnometer. Particle density is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

Significance and Uses

1. The specific gravity of a soil is used in relating a weight of soil to its volume and in calculation of phase relationship, i.e. the relative volume of solids to water and air in a given volume soil.

Equipment:

1. Two 50ml density bottles (pycnometers) with stoppers.
2. A rod small enough to go through the neck of the density bottle.
3. A constant temperature water bath in the range from 20-30^{0}C.
4. A vacuum desiccator.
5. A desiccator containing anhydrous silica gel.
6. Balance accurate rate to 0.001 gr
7. Oven (24hr at 105^{0}C)
8. Vacuum system.
9. A wash bottle containing air-free distilled water
10. A small riffle box.

Sample Preparation.

At least two specimens, each between 5g and 10g shall be obtained by riffling. The specimens shall be oven dried at 105^{0}C to 110^{0}C and stored in an airtight container.

Execution and Test

Wash the density bottles dry, cool and weigh to the nearest 0.001g(m_1).
Transfer the soil specimen to the density bottle. Weigh the bottle, with stopper to the nearest 0.001g (m_2).
Add enough air-free distilled water to cover the soil in the bottle.
Stir the soil in the bottle. Before removing the stirring rod wash off any soil particles with a few drops of air free water. Replace the lid of the desiccators
This procedure is repeated until no more air is evolved from the soil.
Remove the density bottle from the desiccator and add more air-free water until full.
Remove the bottle from the bath and wipe it dry. Weigh the bottle, with soil full of distilled water to 0.002g (m_3).
Clean out each bottle; fill it completely with de-aerated water.
Take the bottle out of the bath, wipe it dry and weigh it to the nearest 0.001g(m_4).

Calculations

Equation (1)

$$\text{Particle density} = \frac{M_2 - M_1}{(M_4 - M_1) - (M_3 - M_2)} \quad \text{--- Equation 1}$$

Where:
M_1 = mass of density bottle.
M_2 = mass of bottle and dry soil.
M_3= mass of bottle and soil and liquid.
M_4= mass of bottle and liquid.
If the result of the two samples differs more than 0.03Mg/m^3, the test shall be repeated.

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Determination of Permeability Test

Permeability is involved in the problem of low water through soil. This test was carried out on each sample in the laboratory to determine their constant head permeability test, or falling head permeability test.

Procedure

For the constant head arrangement, the specimen shall be connected through the top inlet to the constant head reservoir.

- Open the bottom outlet.
- Establish steady flow of water.
- The quantity of flow for a convenient time interval may be collected.
- Repeat three times for the same interval.

Apparatus Used

- Permeameter mould of non-corrodible material having drainage base and drainage cap.
- Accessories of the permeameter mould-detachable collar, porous stones (2 nos.) dummy base plate.
- Compacting rammer.
- Filter papers.
- Grease
- Stop watch, mixing pan.
- Thermometer, Balance.
- Straight edge, De-aired water.

Determination of Density Test.

The density test was carried out on each sample in the laboratory to determine the undisturbed or in-place soil properties for field quality-control purposes to determine whether an earth compacted to the desired specified density.

Procedure

- Fill the measure can to overflowing with the sample to be tested.
- Pour the contents of the 0.5litre measure, plus an extra handful, into the cox funnel.
- Remove the slide on the cox funnel quickly so that the sample drops evenly into the 0.5litre measure.
- Place the hardwood striker on the rim of the 0.5litre measure and using three zigzag, equal motions, scalp off the excess sample in the measure.
- Pour the sample remaining in the 0.5litre measure into the scale pan. Determine the density in grams of the sample in the scale pan.

Apparatus Used

0.5litre Measure: A cylinder shaped cup with an inside diameter of approximately 90mm and a height of approximately 77.5mm.

Cox Funnel: A funnel with a 3.81cm opening and a drop of 4.41cm, from the opening in the funnel to the top of the measure used to the to uniformly direct the flow of sample into the 0.5litre cup.

Striker: A piece of round hardwood, 2.2cm in diameter and approximately 23cm in length.

Scale: Any CGC- approved electronic metric scale.

Test Density Conversion Charts: used to convert the weight in grams from the 0.5litre measure to kg/hL.

RESULTS AND DISCUSSION

This research work was a concise effort to gather a sample population of Irele soil deposit and carry out standard tests on them, so that statistical method can be employed in predicting and accurate, reliable engineering and geotechnical properties.
Hand dug bores were used to determine the stratigraphy and to obtained disturbed and undisturbed soil sample for testing. The disturbed and undisturbed samples were collected at interval of about 0.5m at an average depth of 1.0m. Three samples were collected in all locations.
The evaluation of the engineering and the geotechnical properties were then carried out at the soil mechanics of civil engineering department of The Federal Polytechnic Ado-Ekiti.
All the laboratory results are shown in the summary table. The natural moisture content of sand was determined from the results carried in the laboratory shows that the moisture content of the surface fall within 22.9% - 15.6% and the location three having the moisture content (mc), at the depth 0.5 it rating within 13.8% - 7.94% when location two has the highest, while 15.1% from location two are also the highest at the level of 1.0m.
From the results of the test of density, it was revealed generally that they fell within 1.67 - 1.45 respectively, having 1.71 as the most in all the locations, showing related results in all the five locations. Particle density of the different location and depth shows relative in the results and falling within 2.69 - 2.40 which meet the standard specification of (B.S 1377) 1975, while only sand from 0.5m of location five has less particle density compare to the rest with 1.95. Subsequently the parameters C and Φ which is cohesion and angle of shearing resistance of the sand deposit was determined undrained quick test showing the highest C and Φ to be 82kg/m² and 11.5° while the cohesion (C) of the area fall with 82kg/m²-50° and shearing resistance Φ 18°-11° respectively. Foundation of any structures built on different types of soil depends upon shearing resistance. All the results are shown on the summary table at the appendix

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CONCLUSION AND RECOMMENDATION

CONCLUSION

The sand deposited is one of the greatest assets of Irele which contributed more and serve as economic value while some make their daily living from it. Through the investigations carried out, it clearly shows that removing of that sand for commercial purpose has certain environmental effect on the communities. Sand deposit from those locations has all it takes as a good sand material for any engineering construction work like roads, when mix with cement, it can be used as pavement, building and bridges etc. From the research work and analysis carried out to confirm engineering properties of the deposited sand it shows that the sand is very reliable for most construction work of any kind.

RECOMMENDATION

The analysis carried out shows that most of the sand deposits has some little percentage of silt at surface, I hereby recommend that it should be excavated to the depth of about 0.2m before the real excavation of sand commences. Also, I shall urge the federal government through the ministry of solid mineral and development to carry out series of mapping to ascertain the deposit reserve in order to carry out the excavation or exploitation of the deposit in accordance to laws of the federation (mining law) also to work in safe environment, ensuring that the owner of the mines should provide enough safety gadgets for the workers.

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APPENDIX

DATA/RESULT

SUMMARY TABLE FOR DIRECT SHEAR

DEPTH A (SURFACE SOIL)

ADUGA AREA OF IRELE DISTRICT

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3141	0.4023	0.459
Shear stress (KN/m^2)	87.25	11.75	127.5

DEPTH B (0.5m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3582	0.4266	0.4896
Shear stress (KN/m^2)	99.5	118.5	136

DEPTH C (1.0m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3735	0.468	0.5751
Shear stress (KN/m^2)	103.75	130	159.75

AKINGBOYE AREA OF IRELE DISTRICT

DEPTH A (SURFACE SOIL)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.2862	0.3573	0.441
Shear stress (KN/m^2)	79.5	99.25	122.75

DEPTH B (0.5m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3609	0.4401	0.5112
Shear stress (KN/m^2)	100.25	122.25	142

DEPTH C (1.0m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3483	0.4482	0.54
Shear stress (KN/m^2)	96.75	124.5	150

GBOGI AREA OF IRELE DISTRICT

DEPTH A (SURFACE SOIL)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3438	0.4419	0.4698
Shear stress (KN/m^2)	95.5	122.75	130.5

DEPTH B (0.5m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3213	0.4518	0.5166
Shear stress (KN/m^2)	89.25	125.5	143.5

DEPTH C (1.0m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3888	0.4482	0.5112
Shear stress (KN/m^2)	108	124.5	142

IGBOKE AREA OF IRELE DISTRICT

DEPTH A (SURFACE SOIL)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.2682	0.3411	0.45
Shear stress (KN/m^2)	74.5	94.75	125

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DEPTH B (O.5m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.369	0.459	0.5436
Shear stress (KN/m^2)	102.5	127.5	151

DEPTH C (1.0m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3888	0.4662	0.5553
Shear stress (KN/m^2)	108	129.5	154.25

LABALE AREA OF IRELE DISTRICT

DEPTH A (SURFACE SOIL)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3051	0.4059	0.468
Shear stress (KN/m^2)	84.75	112.75	130

DEPTH B (0.5m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.35-1	0.4446	0.5202
Shear stress (KN/m^2)	97.25	123.5	144.5

DEPTH C (1.0m)

Normal load	50	100	150
Normal stress (KN/m^2)	13888.89	27777.78	41666.68
Stress load (KN)	0.3771	0.4779	0.5832
Shear stress (KN/m^2)	104.75	132.75	162