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Full Length Research Paper

Evaluation of soil bearing capacities and its implication for foundation compatibility in Calabar, Nigeria

Eni, Devalsam Imoke, Oko, Comfort and Oka, Peter Onen

Department of Geography and Environmental Science, University of Calabar Calabar, Nigeria

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Recently in Nigeria, failure of a foundation occurs due to inadequate bearing capacity of the soil beneath the foundation, leading to shear failure, overturning and sliding of the foundation. The study seeks to assess soil bearing capacities for soils of different locations in Calabar Municipality to ensure that proposed developers are guided properly. A hand penetrometer was used in measuring the soil bearing capacities of soils and it provided readings in pounds per square foot. The highest value was obtained at Atekong Street, which was characterized by silt sand with a load bearing value of 5000 psf. Also the percentage of sand and silt was 96.4% and 15. 5% respectively. It was observed that settlement occurs on cohesive less soil before the bearing capacity B reached. Based on this, the researchers recommended that deep foundations should be placed at greater depths (i.e. D>3m) while shallow foundations should be D<3m.

Keywords: Bearing capacity, foundation, soil types, profile pits

INTRODUCTION

Nigeria is one of the developing countries in the world faced with high rural-urban migration. Although, the country is generally characterized by poor social amenities, both in quality and quantity rural communities are disproportionately more disadvantaged than the urban centres due to governmental neglect. Consequently, the number of rural inhabitants that migrate to urban areas with high hopes of overcoming low standard of living and housing is unprecedented. This puts more pressure on the available land and soil.

Soil is an environmental resources which serves as a medium for plant nutrient and support. It is also a living natural body, formed by the interaction of environmental resources which serves as a medium for plant nutrient and support Cordes, (1993). It is also a living natural body, formed by the interaction of environmental factors such as climate, parent materials, topography and living organisms. Nevertheless, this said soil which served as a sink to every matter on planet earth can be use for different purposes, but engineering purpose without proper evaluation of its present status it may result in soil degradation, rupture, structures collapse and alteration of the soil physical and chemical properties (Shepherd et al. 2002).

A foundation is the part of a structure which transmits the weight of the structure to the ground. All structures constructed on land are supported on foundations. A foundation is therefore, a connecting link between the structure proper and the ground which supports it. Bearing capacities have a safety factor built in to prevent failure. So, the ultimate bearing capacity would be its perceived point of failure with no safety factors built in. The need for sort bearing capacity is based on the fact

*Corresponding Author E-mail: devimoke@yahoo.com; Tel: 234-703-198-5619

that foundations for different types of structure rest on soils. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil.

Foundation can also be defined as the supporting based on a structure which forms the interface across which loads are transmitted to the underlying soils. The depth must be sufficient to prevent conditions on the ground surface from affecting the foundation, example of the factors and climatic changes rainfall, temperature and freezing. The depth must also be adequate to resist changes resulting in ground water level movement, the effects of horizontal loads and overturning moment.

Soil aggregation and its stability are dynamic processes because both are affected by many factors such as soil management practices, soil properties and soil environment such as soil water content (Bronick and Lai 2005).

Aggregate stability is a vital property of soils used for agriculture because it is often related to soil fertility and agronomic productivity (Bronick and Lal, 2005).

The objectives of the study is to determine the soil bearing capacities for different soils in Calabar Municipality so that proper information can be given to developers intending to erect buildings to ensure that their foundations are properly designed and planned, to avoid collapse in future.

Location and accessibility

The proposed building is to be situated at No. 25 Amika Utuk Street, Calabar. The site is located within the following co-ordinates; longitude 008^0 15^1 E and 008^0 25^1 E and Latitude 04^0 54^1 N and 04^0 54^1 N respectively. The site is located in Calabar South; it can be accessed by land, air and sea. By road it can be accessed through Goldie and Uwanse streets. Calabar metropolis has an airport linking to all the major cities and international departing points with daily flight. There is a commercial port which currently has a maximum draft of six meters, but there are plans to dredge the channel to accommodate drafts of up to thirteen meters.

Landform, Topography and soil conditions

Lithologically, the site is made up of sand particles which are mostly medium to coarse grained, pebbly moderately sorted with local lenses of fine-grained, poorly cemented sand and silty clay. The study sit is characterized by thick overburden of weathered soil deposits of sediments from hill top and such deposits are rich in humus which supports plant growth. The drainage pattern is dendritic. The region is characterized by an undulating landscape with varying gradients ranging from 25m to 35m above sea level. The major landforms in the area are deposits of sedimentary rocks on top of exclusive igneous rock which is constantly facing repeated attacks of weathering. Porosity and permeability tend to decrease with increasing geological age because of reduction of void spaces.

Land use

The site for the proposed project is a residential area. It is complimentary to the existing developments and indeed situated at the Central Business Districts of Calabar South.

Climate

The project site has an equatorial type of climate. The rainfall distribution shows that it is characterized by double maxima-rainfall, which starts from the months of March to October, reaching its climax in the months of July to September. It records an annual average rainfall of 3000mm and a relative humidity of between 85% and 95% respectively. The climate depends on the movements of the inter-tropical front air mass which marks the boundary between humid air masses from the south and dries from the North. Usually, in December and January, there is a tropical continental dust harmattan wind blowing across the area from the Sahara. Evapotranspiration is very high in the region due to the fact that the average daily maximum temperature is about 25^0C. The major type of rainfall predominant is conventional.

MATERIALS AND METHODS

A vibrating plate compactor for sandy and gravel soil consistencies was used. A hand penetrometer was utilized in measuring the soil bearing capacity and it provides readings in pounds per square foot. The soil profile used for the testing contains several inches of topsoil, a deeper layer of sub soil composed of sand, silt, clay and a layer or substratum that is unweathered gravel. The samples were taken at a depth of 2 m and sealed in plastic bags for transport to the laboratory for testing. Disturbed samples were derived from backhoe and air-tract and anger drills. Drilling with coring capability provided cylindrical cores. Also disturbed samples were collected and wrapped in plastic and aluminum for soil at depth of 2 m intervals and were transported for laboratory testing too.

Terzaghi (1943) was used to derived the equation for

Table 1. Soil bearing capacity

Sample location	Types of soils	Load bearing (pounds per square foot)
1	Rock/Gravel	3,000 psf +
2	Gravel	2,000 psf +
3	Sandy gravel	3,000 psf +
4	Silt sand	5,000 psf +
5	Sand	4,000 psf +
6	Silt gravel	1,500 psf +
7	Clay	1,500 psf +
8	Sandy clay	2,000 psf +
9	Silt clay	1,000 psf +
10	Sandy silt	2,000 psf +

Table 2. Bearing capacity factors and its relationship with Ø values

Ø	Nc	Nq	Ny
1	44	1.1	0
2	46	1.2	0.1
3	4.8	1.3	0.2
4	5.0	1.4	0.3
5	5.2	1.6	0.4
6	5.4	1.7	0.5
7	5.5	1.8	0.6
8	5.8	1.9	0.8
9	6.2	2.1	0.9
10	6.8	2.3	1.0

an infinitely long strip foundation as shown below;

quit – CNc + YDNq + 0.5BYNY

Where C = cohesive strength of soil

Ro=Over burden pressure = YD

B = Width of foundation

Y = limit weight of soil

Nc = Bearing capacity factor (Cohesive)

Nq = Bearing capacity factor (Surcharge and friction)

Ny = Bearing capacity factor (Self weight and friction)

RESULT AND DISCUSSION OF FINDINGS

Table 1 shows that silt sand had the highest soil bearing capacity of 5000 psf + while the least was silt clay with a value of 1000 psf +. This high value of or silt sand suggest that the foundation depth should be deep enough to ensure that much of the over burdens are excavated before any structure is erected on the soil. The size and thickness of the footer is based upon the fact that profile pits should be leveled out with gravel, rather than throwing the soil back in the pit hole. This is because the soul added back will have expanded by as much as 50%.

Table 2 reveals that the corresponding bearing capacity factor (cohesive) Nc, bearing capacity factor (Surcharge and friction) Nq and bearing capacity factor (self weight and friction) Ny, varies for different values of O. the bearing capacity of saturated cohesive soils (clay and silt) with low permeability is very critical after construction, before the excess pure water pressure dissipate. As time proceeds, consolidation occurs, the soil becomes stiffer and has more strength. Therefore foundation on fine grained soils such as silt sand should be in terms of total stress.

It was observed that large settlement occur in cohesion less soils before the ultimate bearing capacity is reached. Settlements occur under foundations in all soil conditions, though lightly loaded structure locations may experience negligible settlements ground movements beneath a structure foundation can occur due to shrinkage or swell of expansive soils caused by climatic changes and slope instability. The results reveal that the maximum average contact pressure between the proposed formulation and the soil would not produce shear failure.

Table 3. Percentage of gravel, sand and silts

Sample location		Percent gravel 22mm (%)	Percent sand 2mm to 0.074mm (%)	Percent silt and clay <0.74mm (%)
1	Otop Abasi	0.6	84.5	4.2
2	Yellow Duke 2	0.7	93.4	5.5
3	Satellite town	0.8	90.5	9.7
4	Atekong street	0.9	96.4	15.5
5	Diamond Hill	0.4	79.5	3.7
6	Atu street	0.3	87.6	8.9
7	Ekpo abasi	0.5	81.5	4.8
8	Etta Agbor	0.6	82.5	10.5
9	Goldie street	0.8	63.0	13.5
10	Parliamentary	0.7	85.5	7.6

Table 3 indicates the percentage of gravel, sand and fine grain soil particles obtained in the study area. The percentage of gravel, sand, silt and clay was seen to be higher at sample location 4 (Diamond Hill) with values of 0.9, 96.4 and 15.5 % respectively.

This suggest that the strategraphy of the study locations is mainly dominated by sand particles with tiny pores. This aides infiltration and peculation of water.

CONCLUSION

The research reveals that soil bearing capacities for different soil in Calabar Municipality have different load bearing limits. The depth for foundations in the study area must be sufficient to prevent conditions on the ground surface from affecting the foundations examples of such factors are climatic changes, rainfall, and temperature. Soil bearing capacities must be undertaking before erecting structures in Calabar Municipality to ensure longitivity of the structure and avoid failure causes by shear stress and strain.

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