EVALUATION OF SOIL BEARING CAPACITY IN SELECTED AREAS WITHIN SOKOTO METROPOLIS

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ABSTRACT

This project emphasizes on the importance of bearing capacity of the soil for any construction project. A large number of buildings are damaged because of an inappropriate design of foundation. 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. Some of the questions addressed in this project are, how water affects the bearing capacity of soil, changes in the bearing capacity with addition of cement and variation in the bearing capacity values of soil in different location/ area within Sokoto metropolis . Tests were conducted on soil samples. The strength of soil was related to depth of penetration of surcharge for which penetrometer records the values obtained. Graphs were plotted for different soil samples taken in different area. Conclusion was drawn that soil Rujin Sambo and Old Airport areas of Sokoto has bearing capacity values of 910KN/M^2 and 950KN/M^2 respectively and were recommended with strip foundation for Bungalow e.t.c While the soil in Mabera has a bearing capacity of 140KN/M^2 which implies low below the minimum bearing capacity to withstand bad foundation. It was recommended that it should be stabilized with cement to at least a bearing capacity of 150KN/M^2 in other to withstand structure.

1. INTRODUCTION

The word soil is used in many professional fields and its meaning depending upon the context in which it is used. Many professional gave their view regarding the meaning of the term “soil”. According to web star (1999), soil is defined as the loose surface material of the earth in which plant grow, in most cases consisting of disintegrated rock with an admixture of organic matter. In civil engineering, it is defined in geotechnical engineering, as all the loose unconsolidated, disintegrated material transported or untransported from its original position lying on top of the hard rock below. The solid rock underneath is defined as bed rock (shegal, 2002).

As early as 5000BC, The Vedas and the Upanishads as well as other ancient scientists in the world mentioned soil as synonymous with land –the mother supporting and nourishing all life on the earth. Soils are formed as a result of weathering of rock and minerals. Weathering is the disintegrated and decomposition of rocks and minerals by physical and chemical process. The physical process involves mainly breaking down into smaller particles whereas the chemical process is responsible for chemical decomposition leading in course of time to the formation of the parent. The first stage of soil formation is the formation of the parent material which is subsequently subjected to a series of soil forming process. The stage and processes involved in the soil formation give rise to variation in properties of soil formed at different stage which equally classified the soil into categories. Therefore, soil is a dynamic natural body developed as a result of pedogenic processes during and after weathering of rocks consisting of mineral and organic constituents possessing definite chemical, physical mineralogical and biological properties having a variable depth and size over the surface of the earth and providing for plant growth and for land use. (shegal, 2002). Bearing capacity is the ability of soil to safely carry the pressure placed on the soil from any engineering structure without undergoing a shear failure with accompanying large settlement. The scientific design of the foundation based upon the bearing capacity of the soil, then becomes very essential to be determined.(verruijt, 2005)

The allowable bearing capacity which is also referred to as safe bearing capacity of a soil mass can be obtained from the following relation;

$$qa = \frac{qu}{fs}$$

where, q_a= safe or allowable bearing capacity, q_u= ultimate bearing capacity and f_s= factor of safety. Factor of safety (f_s) is often determined to limit settlement to less than 1 inch. factor of safety is the degree of the reserved strength built in any structural design due to uncertainty that exist both with respect to actual loading of the structure and uniformity in the quality of material. Factor of safety (F_s) selected for design depends on the extent of information available on sub soil characteristics and their variability.

Therefore, thorough and extensive sub soil investigation may permit use of smaller F_s but should be within the stated range of not less than 2 (Ranyan, 2000). Ranyan (2000) stated that settlement analysis should be performing to determine the maximum vertical foundation pressure which will keep settlements within the predetermined safe value. For a given structure, the recommended design bearing pressure q_d or design bearing force Qd could be less than q_a or Q_a due to settlement limitation.

1.1 Factors Affecting Bearing Capacity of Soil

According to Verruijt (2005), the bearing capacity of a soil for design of foundation is affected by one or more of the following factor:

(i) Types of soil: as earlier stated in the previous index that the soils can be sub divided into two categories- the coarse grained soils or cohesionless soil and the cohesive soils. Base on this classification, coarse grained soils have a better bearing capacities compared to cohesive soils.

(ii) Physical features of the foundation: some physical features of the foundation affect the bearing capacity. These are: (a) type of the foundation (b) size of the foundation (c) depth of the foundation (d) shape of the foundation (e) Rigidity of the structure.

(iii) Amount of total and differential settlement that the structure can stand

(iv) Physical properties of the soil, such as density, shear of strength etc.

(v) Water condition in the ground e.g. the position of the water table has a considerable influence on the bearing capacity values.

(vi) Original stresses

1.2 Research Problem

As a matter of fact, today many foundations are design without any due consideration for the bearing capacity of the soil upon which they are raised. This has caused a lot of dilapidation, collapses, and settlement of majority of building foundations and so many other construction projects. In most cases of building collapse, emphasis is only put on the superstructures and the construction materials, not realizing the great effect of the bearing capacity of the soil underneath the foundation, where the entire load from the building is resting. It is quite evident that in most construction site, the evidence of soil tests for the capacity used to be lacking. Thus, there is great need for the building industry to put more effort in seeing that soils are always tested for their bearing capacity before any kind of structure is put on them.

1.3 Aim and Objectives of the Research

The aim of this research is to determine the bearing capacity of soil in some selected areas in Sokoto metropolis. This was achieved through the following objectives;

1. determining the differences in the soil bearing capacity of the selected locations.
2. determining the loads the soils on the areas can withstand or support successfully
3. predicting the nature of structure that can survive or exist safely on these locations.
4. suggesting the choice of the foundation i.e. foundation design.

2. MATERIALS AND METHODS

The soil samples were taken by disturbed sampling method. This was carried out according to the following procedure. Each of the study area was divided into five zones. Each zone was investigated on reconnaissance and cleared. On each zone cleared, 2m x 2m was dug to depth of 1.2m where samples were taken with shovel. The samples taken on these five locations each of the study areas were mixed together as a final sample for testing. Two series of laboratory tests (Compaction test and C.B.R. test) were conducted on the sample.

Proctor compaction test is a kind of test carried out in the laboratory on a soil sample i.e disturbed soil sample in other to bring its grain particles closely together and expelling its void spaces by mechanical means. This test is very important for the determination of bearing capacity of soil by laboratory method, because, it is an experimental method of determining the optimum moisture content (OMC) at which a given type of soil will become most dense and attain its maximum dry density.

Califonia Bearing Ratio (CBR) test is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25mm/min to that required for corresponding penetration of a standard material.

The California bearing ratio test (CBR) is a penetration test developed by California state highway department for evaluating the bearing capacity of sub-grade soil for design of flexible pavement.

3. DATA ANALYSIS

The data collected in the previous chapter is analysed critically unit by unit in this section of the research. This comprises of calculations, tabular presentation of data, and graphical presentation of data, results and discussion of both table and graphs.

3.1 Method of Data Analysis

The data collected is analysed by tabular and graphical method. Each table and graph is presented accurately and self-explanatory. Data are arranged in rolls and column as follows

Compaction Test 1

TABLE 3.1: WIEGHT OF SAMPLES

S/NO.	% OF WATER ADDED	2%	4%	6%	8%	10%
i.	Wt of cylinder + wet soil (g)	9795	9795	10089	10016	9834
ii.	Wt of cylinder (g)	4	7	6	4	4
iii.	Wt of wet soil (a) (g)	4211	5031	5325	5253	5070
iv.	Volume of cylinder (cm^3)	2	2	7	5	5
v.	Wet Density (g/cm^3)	2.07	2.21	2.34	2.31	2.32

SOURCE: Field Work, 2011

3.2 Calculations of Moisture Content

The moisture content of the sample was obtained using the following relations;

$$\text{Moisture Content} = \frac{M2-M3}{M3-M1} \times 100\%$$

Where M_2 = wet soil by weight, M_3 = Pried soil by weight, and M_1 = Empty tin by weight
Table 5.2 shows the moisture content obtained from the samples.

TABLE 3.2: MOISTURE CONTENT OF SOIL SAMPLE

CONTAINER	109	41	71	80	59A	65	9A	58	177	5A
Wt of soil + tin (g)	723	658	808	72.7	72.8	59.6	77.7	87.5	89.0	80.5
Wt of drysoil+tin (g)	70.9	64.7	78.1	70.4	69.5	57.0	72.9	82.1	82.1	74.4
Wt of tin (g)	15.3	16.1	15.8	16.2	16.7	16.2	16.7	16.1	15.8	16.2
Wt of dry soil (g)	55.6	48.6	62.3	54.2	52.8	40.8	56.2	66.0	66.3	58.2
Wt of Moisture (g)	1.4	1.1	2.7	2.3	3.3	2.6	4.8	5.4	6.9	6.1
Moisture content m(%)	2.5	2.3	4.3	4.2	6.3	6.4	8.5	8.2	10.4	10.5
Average (%)	2.4		4.3		6.4		8.4		10.5	
Dry density (g/cm^1) Dgw = $\frac{100DW}{100+m}$	2.02		2.12		2.20		2.13		2.10	

SOURCE: Field Work, 2011

3.3 Calculations of Dry Density

The dry densities were calculated using the following formulae;

$$\text{Dry density (D}\gamma) = \frac{100 \times Dw}{100 + m}$$

where Dw = Bulk density
M = Average moisture content of two container

Table 3.3 shows the values for moisture content and dry densities for different containers of samples.

TABLE 3.3: MOISTURE CONTENTS AND DRY DENSITIES

Sample container	109 & 41	71 & 80	59^A & 65	9^A & 58	177 & 5^A
Moisture content (%)	2.4	4.3	6.4	8.4	10.5
Dry Density (g/cm^3)	2.02	2.12	2.20	2.13	2.10

4. COMPACTION GRAPH

The moisture contents are plotted against the dry density in other to obtain the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD).

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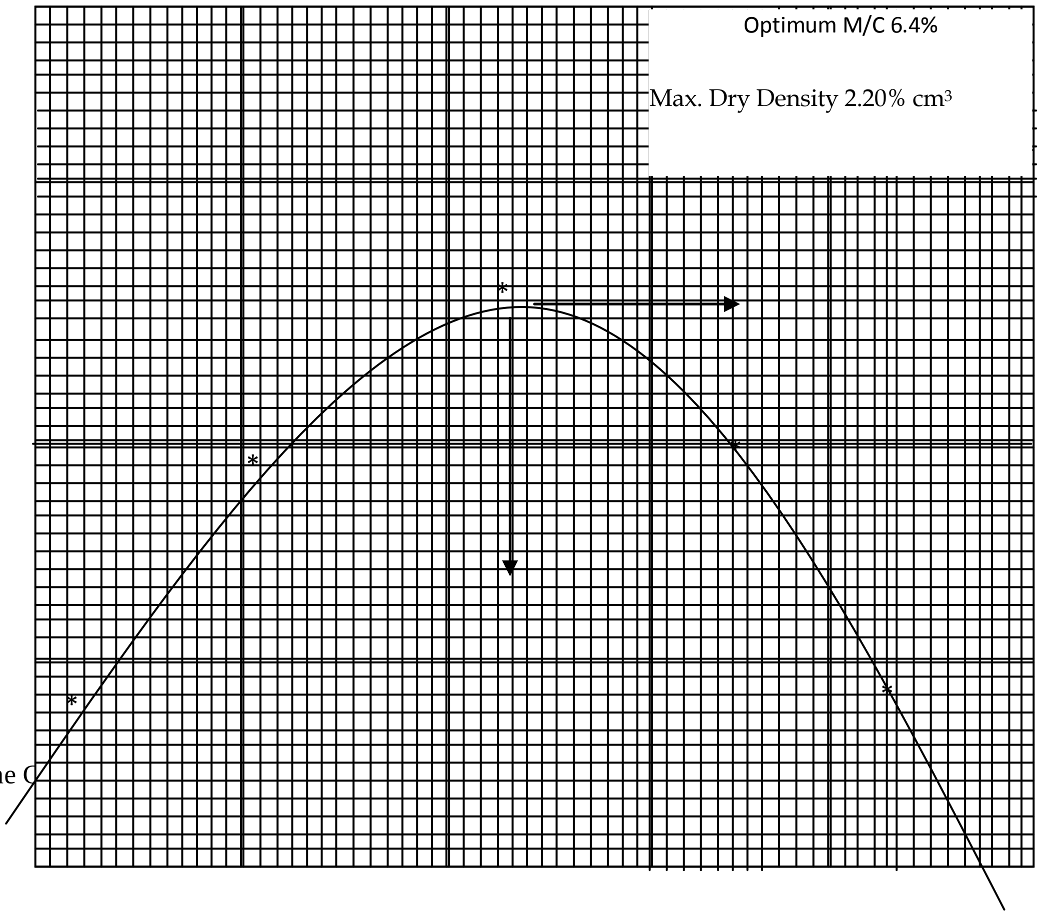


TABLE 5.1: STANDARD VALUES.

PROVING RING FACTORS	2.63
CBR AT 2.5 KN LOAD	13.24 or 1324g
CBR 5.0 KN LOAD/ KG	19.96 or 1996g

TABLE 5.2: PENETRATION (Field Work, 2011)

PENET. MM.	BASE DAIL	LOAD	TOP DAIL	LOAD
0.5	95	250	68	179
1.0	194	510	145	381
1.5	286	752	210	552
2.0	370	973	294	773
2.5	428	1126	375	986
3.0	514	1352	475	1249
3.5	598	1573	525	1381
4.0	680	1788	580	1325
4.5	755	1986	633	1668
5.0	845	2222	702	1846
5.5	925	2433	750	1973

LOAD = DIAL READING X PROVING FACTOR

1. CBR VALUE

The CBR value is usually calculated for penetration of 2.5mm and 5.00mm. If the CBR value of 2.5mm penetration is greater than 5.00mm penetration, it shall be taken as the CBR value. But it less than the 5.00mm the load penetration test shall be repeated and if still the same, that of 5.00mm shall be considered as the CBR value for the sub grade and any other sample of material within the range.

The corrected load value taken from the load penetration curve corresponding to the penetration value at which CBR is required is divided by the standard load for the same depth of penetration taken to percentage. The CBR values are obtained as follows:

$$\text{CBR value} = \frac{Pt \times 100}{Ps}$$

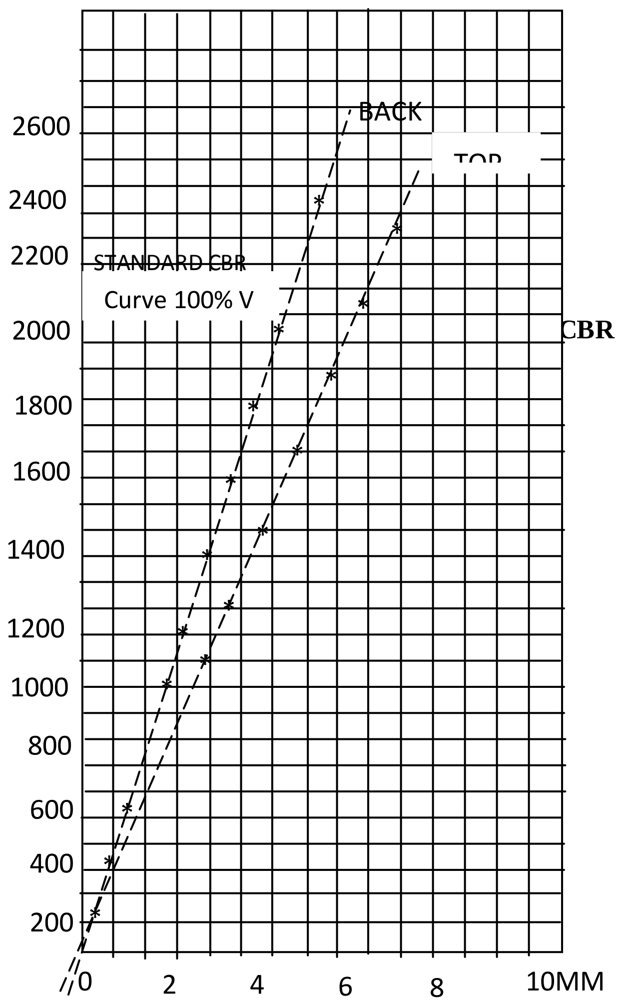
Where Pt = corrected test load corresponding to the chosen penetration from the load.
Ps = standard load for the same depth of penetration as Pt.

TABLE 6.1 CBR Correction Value (Field Work, 2011)

	CORRECTED LOAD	
MM	**BASE**	**TOP**
2.5	1126	986
5.00	2222	1846
CORRECTED CBR%		
2.5	85.0	74.5
5	111.3	92.5
AVR CBR		91%

7. GRAPH OF CBR

The penetration of plunger in mm is plotted against the load on plunger penetration in Kg. The graph comprise of both the load penetration from base and top. The graph plotted as follows.



CBR graph

8. CONCLUSION

With a critical study, the average CBR value obtained from the table connotes the high suitability of the sample of material in the case study for any construction, be it structure or road. This implies that it can be used as a sub-base and base course for any road pavement without the need for stabilization. At the same time this can withstand structure that carries heavy load. Similar process was used to analyse the data collected from the tests carried out on the samples collected on other area of study and their list of figure and table are presented in the appendix.

The CBR values obtained for soil in Mabera and Old airport area are 14% and 95% respectively. It was stated by W.P.M. Black that a CBR value is one –tenth of bearing capacity value of soil. Therefore, the bearing capacity of soil in Rujin Sambo = 91 x 10 = 910 KN/M^2

Mabera = 14 x 10 = 140KN/m^2

Old airport = 95 x 10 = 950 KW/m^2

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