

Assessing the Load-Bearing Capacity of Soils in Different Areas of Osogbo, Osun State, Nigeria: Case Study of Alekunwodo, Oke- Baale and Osun State University Campus, Osogbo

Ogunbiyi Moses¹, Olawale Simon², Olaleye Seye³

Senior Lecturer, Department of Civil Engineering, College of Science, Engineering and Technology, Osun State
University, Osogbo, Osun State, Nigeria¹

Senior Lecturer, Department of Civil Engineering, College of Science, Engineering and Technology, Osun State
University, Osogbo, Osun State, Nigeria²

Research Student, Department of Civil Engineering, College of Science, Engineering and Technology, Osun State
University, Osogbo, Osun State, Nigeria³

ABSTRACT: This study sets out to assess the load-bearing capacity of soils in three localities of Osogbo, Osun State, Nigeria; for the purpose of identifying suitable soil type for foundation construction in the State of Osun, Nigeria. The investigation assesses the load-bearing capacity of soils in different parts of the state, employing standard penetrometer tests at three points on each location investigated. This study identifies that soils in Alekunwodo, Oke-Baale and Osun State University Campus, Osogbo belongs to the AASHTO Classification; A-2-7, A-7-5 and A-4 classifications; also, SW, SM, and SC using the unified soil classification system (USCS). This investigation reveals that the specific gravity value of soil in Alekunwodo is 1.95 and composes of Montmorillonite, while the soil in Uniosun and Oke-Baale has specific gravity; 2.03 and 2.37 respectively. The LL, PL, and PI for Alekunwodo is; 53.3%, 39.3%, and 14%; Uniosun and Oke-Baale yields 48.4%, 26.3%, 21.6% and 33.1%, 17.3%, 9.8% accordingly. The standard penetration tests carried out at the designated sites resulted in; Alekunwodo with average (from 3 points of testing), BC of 137.42 KN/M2 at an average depth of 0.5m which coincides with the water level in the area. Uniosun has BC of 187.17 KN/M2 at an average depth of 0.8m and Oke-Baale with BC of 340.5 KN/M2 at an average water level depth of 1.9m.

KEYWORDS: AASHTO (American Association of State Highway and Transportation Officials), Halloysite (Aluminosilicate Clay Mineral), L.L (Liquid Limit), P.L (Plastic Limit), P.I. (Plasticity Index), SPT (Standard Penetration Test), Montmorillonite (Red Clay), SBC (Soils bearing Capacity), SC (Clayey Sand), SG (Specific Gravity), SM (Silty Sand), SW (Well-graded Sand), Uniosun (Osun State University), USCS (Unified Soils Classification System).

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I. INTRODUCTION

It is important and essential to note that no civil engineering works, especially construction can be done without soil being an integral part of the assessment. Nearly all structures are built into the ground and for the construction to stand the test of time; it must stand on a good foundation footing based on the load-bearing capacity of the soil. Virtually all structures are supported by soil or rock at the base. The structure may be a dam, a highway, a tunnel a bridge, building etc.; the nature of the soil at that location is of great importance to the civil engineer or constructor [2].

To the Civil Engineer, soil is any un-cemented accumulation of mineral particles formed by weathering of rocks. Soils are generally used as foundation or construction material. A class of soil known as expansive soil, when used as foundation material, is usually affected by environmental conditions and undergoes detrimental volumetric and hydraulic conductivity changes because of the variation in moisture contents; this has a potential for shrinkage or swelling under changing moisture conditions [1]. These types of soils can cause damage to structure particularly light building and pavements than any other natural hazards [6].

Soil is a mixture of solid particles, moisture and air; soil can be of many types such as clayey soil or expansive, sandy or loose soils etc. The soil near surface is called top soil and below a depth of 300mm is referred to as sub soil. Generally subsoil is used as base for foundation for small buildings. However, soil investigation should be carried out to know the nature of soil, depth of water table, type of soil, depth of different layers of soil and to know the bearing capacity of soil at different levels for large structures [7]. When the load is transferred from the structure to soil through foundations, the soil tends to consolidate and settlement of foundation occurs; this consolidation process can be quick in case of non-cohesive soils such as sand and can even take years for other soils. The complete settlement of foundation in sandy soil may occur even before the building construction has been completed. Clayey soil can hold water for longer time and thus settlement is very slow and can take years. Clayey soils hold large amount of water, and thus settlement of foundation is large in such soils [3].

A foundation on the other hand is that part of a building/structure which is in direct contact with the ground and its primary aim is to transmit and spread the loads (dead and live) from the building/structure over a sufficient area of soil to avoid undue settlement because of the failure of the underlying soil [5]. Foundations of engineering constructions are systems that act like interface elements to transmit the loads from superstructure to, and into, the underlying soil or rock over a wider area at reduced pressure [4]. One very important and equally serious problem often neglected by experts is the issue of foundation failure. The failure of foundation leads to the failure of whole structure, loss of life as well as economical loss. Foundations are affected not only by design errors but also by foundation inadequacies such as sitting them on incompetent earth layers. So it is important to determine the best soil on which a foundation can be based for its stability. Hence, the aim of this study is to assess the load-bearing capacity of soils in Osun State adequately suitable for foundation construction. This will assist foundation design engineers, home-owners, developers and other stakeholders in arriving at a save foundation type suitable for the study areas in Osun State, Nigeria.

II. METHODOLOGY

Laboratory tests were carried out to determine the following soil parameters of the study soils;

1. Specific gravity;
2. Liquid limit;
3. Plastic limit;
4. Plasticity Index;
5. Particle Size distribution;

Also, field work was carried out to determine the load- bearing capacities of the various soils using Standard Penetrometer Test (SPT) boreholes. The soil samples were collected and prepared in accordance with the procedure

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highlighted in BS 1377 part 1 (1992). The method entails digging three SPT boreholes each at distances apart and to various depths. The readings were recorded and plotted as graphs for easy understanding.

III. RESULTS AND DISCUSSION

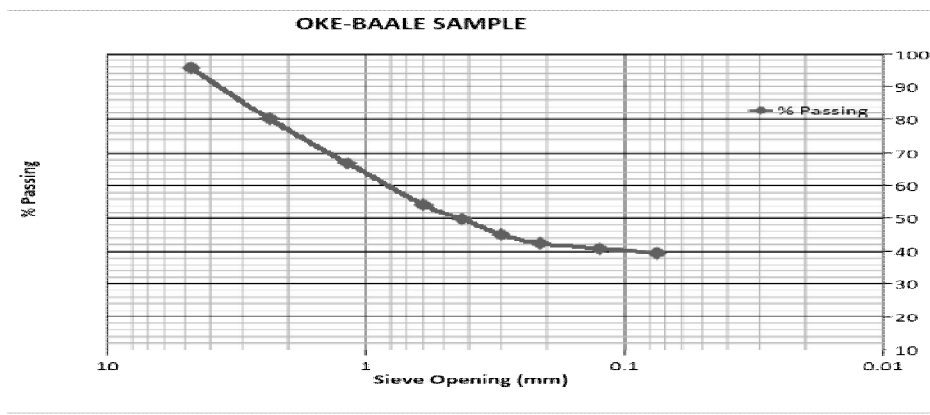


Fig. 1. Particle Size Distribution for Oke-Baale Soil Sample

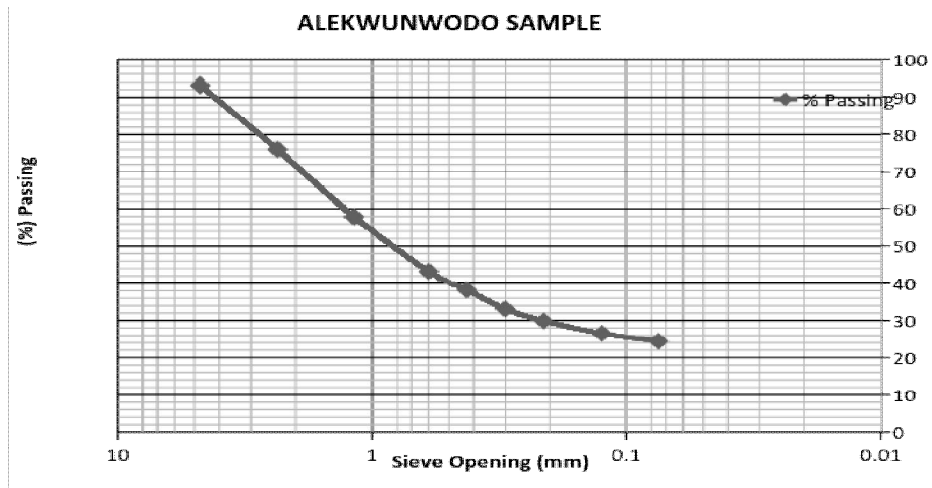


Fig. 2 Particle Size Distribution for Alekunwodo Soil Sample

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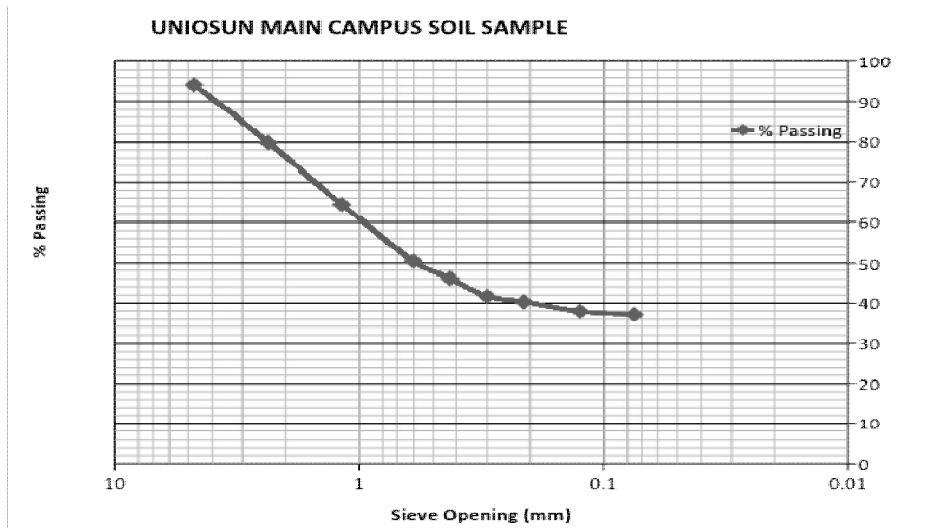


Fig. 3 Particle Size Distribution for Uniosun Main Campus Soil Sample

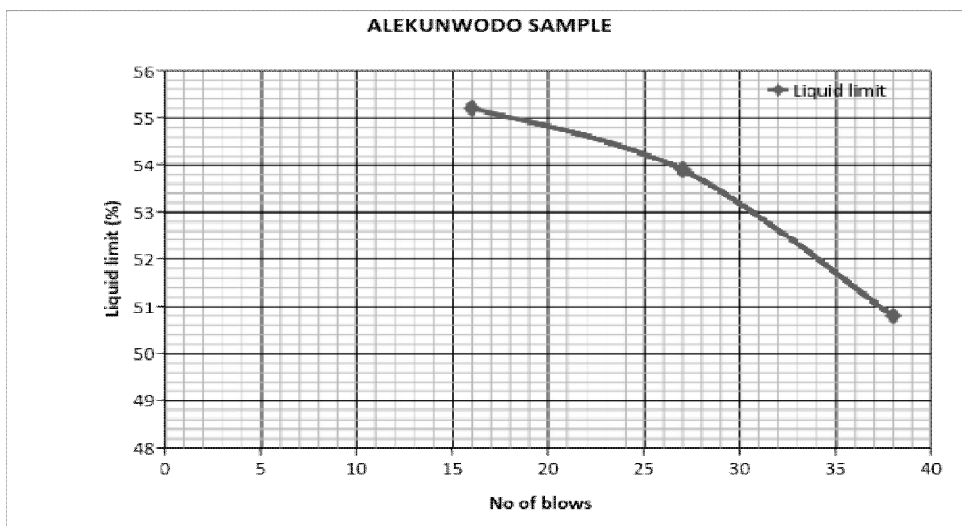


Fig. 4 Graph of Liquid Limit corresponding to 25 Blows for Alekunwodo Soil Sample

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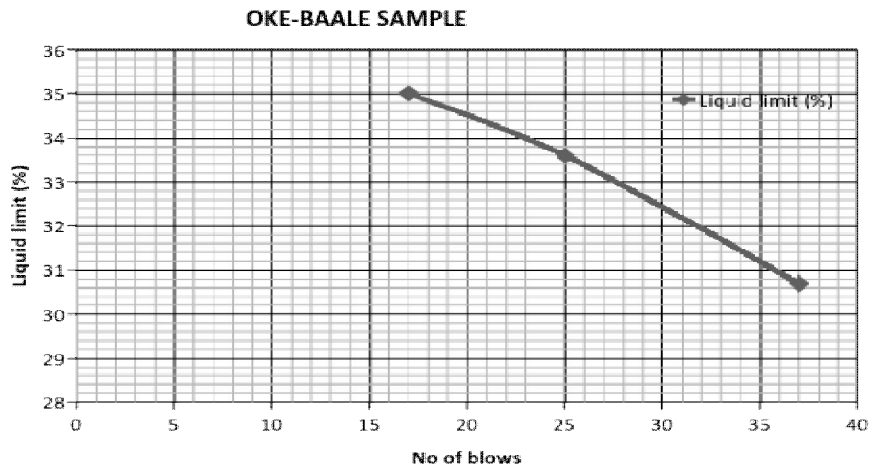


Fig. 5 Graph of Liquid Limit corresponding to 25 Blows for Oke-Baale Soil Sample

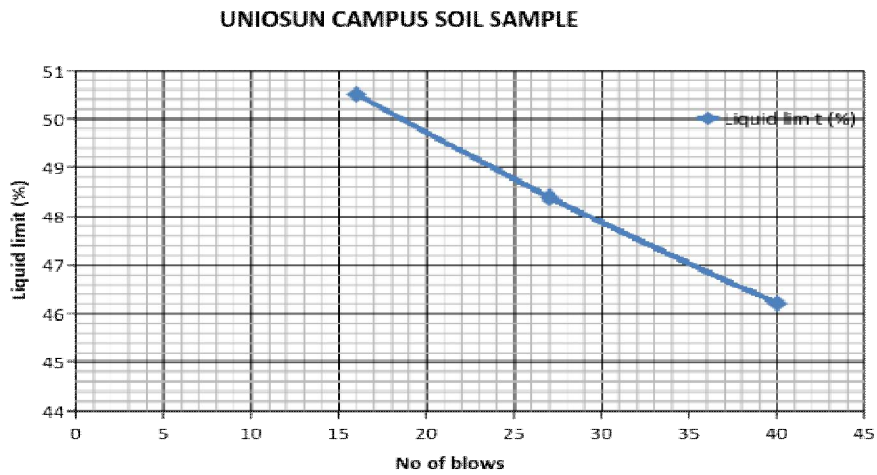


Fig. 6 Graph of Liquid Limit corresponding to 25 Blows for Uniosun Campus Soil Sample

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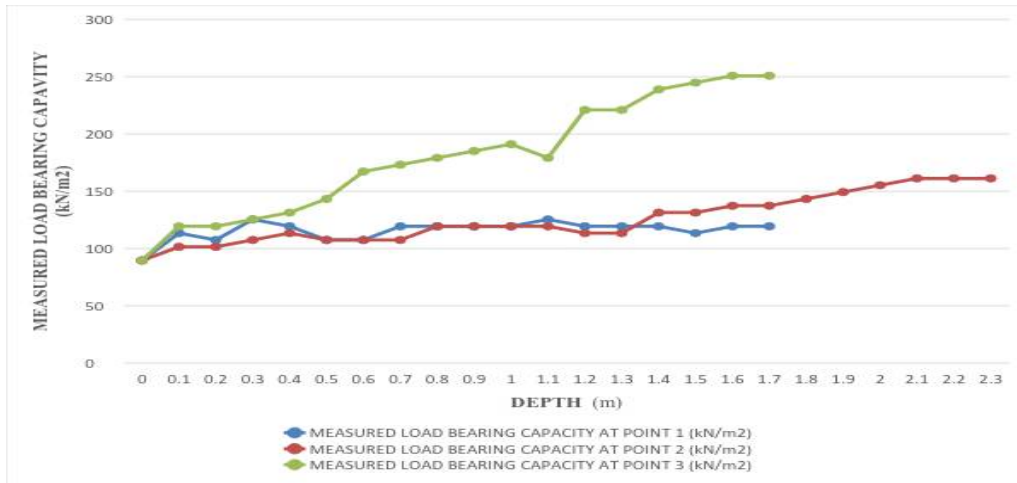


Fig. 7 Chart showing the Load-Bearing Capacity for Alekunwodo Soil at Different Test Points

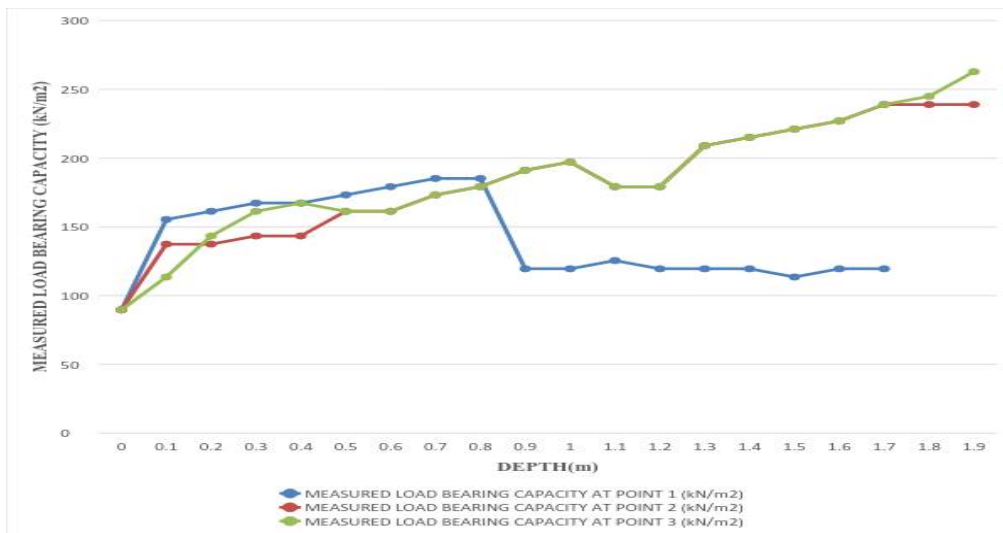


Fig. 8 Chart showing the Load-Bearing Capacity for Uniosun Campus Soil at Different Test Points

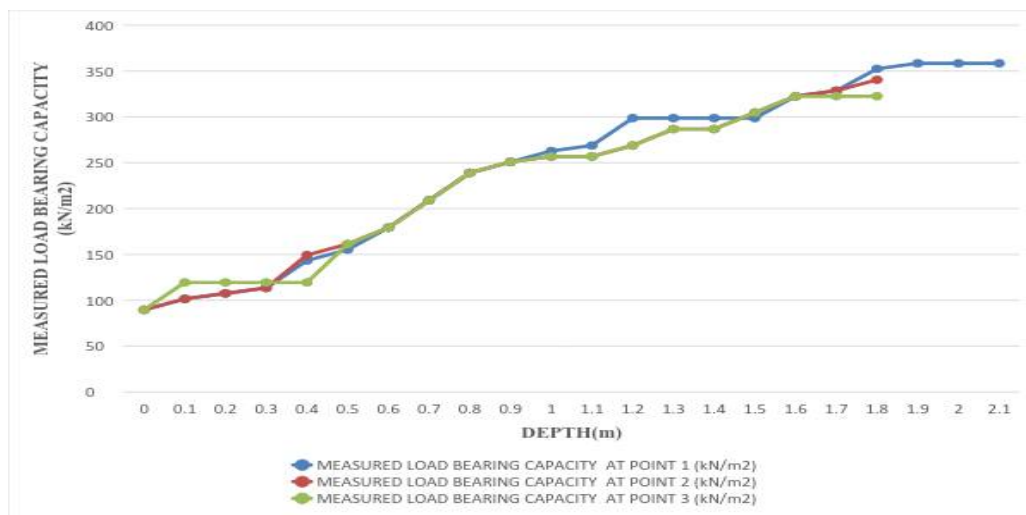


Fig. 9 Chart showing the Load-Bearing Capacity for Oke-Baale Soil at Different Test Points

From this study finding, the SG for Alekunwodo soil is 1.9 and composes of Montmorillonite mineral; Uniosun and Oke-Baale soils have SG of 2.03 and 2.37 respectively and contain Halloysite mineral. The result also, shows the L.L, P.L, and P.I for Alekunwodo, Uniosun Campus and Oke-Baale as; 53.3%, 39.3%, 14%; 48.4%, 26.3%, 21.6% and 33.1%, 17.3%, 9.8% respectively (figures 1-6). Similar study, finds that SG for Osun State soils range from 2.02 – 2.6 using AASHTO Classification A-2-4, A-2-6, A-4, and A-6. This study also, indicates that the L.L of soils range from 27%-40% which supports the current study.

The particle size distribution (PSD) for Alekunwodo, Uniosun and Oke-Baale are show in figures 1-3 above. AASHTO classification system (1986) was used to classify the soil samples; Alekunwodo sample belongs to A-2-5 group with granular soil being the major constituent material since less than 35% passes through sieve No 200. Oke-Baale sample belongs to class A-7-5 group with Silty-clay being the constituent material since more than 35% passes through sieve No 200. Uniosun sample belongs to class A-6 group with Silty-clay being the major constituent material since more than 35% passes through sieve No 200.

Also USCS classification system was used to classify the soil samples; Alekunwodo sample belongs to SW class under coarse-grained soil group since less than 50% passes through sieve No 200. Oke-Baale sample belongs to SC class under coarse-grained soil group since less than 50% passes through sieve No 200. Uniosun campus sample belongs to SM class under coarse-grained soil group since less than 50% passes through sieve No 200. Figures 4-6 depict the graph for the L.L of Alekunwodo, Uniosun and Oke-Baale soils respectively. The Liquid limit for Alekunwodo, Oke-baale and Uniosun campus samples are 53.3%, 33.1% and 48.4% respectively. Also, the graph of liquid limits corresponding to 25 numbers of blows for Alekunwodo, Oke-baale and Uniosun campus samples accordingly.

The cone penetrometer test (CPT) provides valuable information in geotechnical investigations when used in conjunction with other equipment and procedures. Cone penetrometer testing (CPT) is a fast, effective, and relatively inexpensive system for collecting important soils parameters during a geotechnical site investigation; for this study, the penetrometer test was carried out using the 2.5ton testing equipment. The test was terminated when the end resistance and the side friction on both the cone and the rods respectively hindered further penetration.

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Standard penetration test carried out at various selected points revealed that the three soil samples possess adequate strength with a load-bearing capacity value exceeding 100kN/m². Alekunwodo sample has an average load-bearing capacity of 137.42kN/m² at an average depth of 0.5m which coincides with the minimum water level at 0.5m depth. Uniosun sample has an average bearing capacity of 187.17kN/m² at an average water level depth of 0.8m. Oke-Baale sample has an average load-bearing capacity of 340.5kN/m² at an average depth of 1.9m; consequently, Oke-Baale soil has the most adequate bearing capacity, compared to others.

IV. CONCLUSION

It is recommended that structures can be built on the three samples analysed since they possess adequate strength to support structural load thereby providing additional support for any selected foundation. This study therefore, recommends raft foundation as more appropriate foundation type for Alekunwodo soil with load-bearing capacity of 137.42kN/m² than strip foundation that requires a higher load-bearing capacity soil for stability. Strip/Pad foundation type is recommended for soil around the Uniosun Campus Osogbo with 187.17 kN/m² load-bearing capacity. Strictly Strip foundation will be sufficient for the Oke-Baale area of Osogbo with 340.5 kN/m² load-bearing capacity soil.

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