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Evaluating the Geotechnical Properties of Soil at Ughiole, Aviele, Edo State, Nigeria

Okodugha, D.A.*[1], Omenaimen, I.[1], Ikhazuagbe, O.[1], Aligamhe, V.I.[2]

[1]Department of Civil Engineering Technology, Auchi Polytechnic, Auchi, Nigeria
[2]Department of Quantity of Surveying, Auchi Polytechnic, Auchi, Nigeria
*Corresponding author: aluyahd@gmail.com

ABSTRACT

The geotechnical characteristics of the soil in Ughiole, Aviele, Edo State, are evaluated in this study to ascertain whether it is suitable for construction. The laboratory tests were conducted on soil samples to ascertain their mechanical and physical characteristics. Sand clay loam with a high plasticity index and low shear strength characteristics was the predominant type of soil, as indicated. Mostly in foundation engineering, where the stability of the construction is heavily reliant on the soil qualities, the findings have consequences for local and regional construction projects. To reduce the possibility of issues resulting from poor soil assessment, the study highlights the significance of accurate soil description and geological investigation in engineering projects. Additional study is advised in order to determine the reasons behind the low shear strength and to recommend suitable remediation techniques for the soil in the study area.

Keywords: Soil characteristics, Construction, Low shear strength, Plasticity index, Foundation engineering

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INTRODUCTION

The construction of any engineering structure demands thorough analysis and evaluation of the geotechnical properties of the soil. A comprehensive understanding of the soil's physical and mechanical properties is necessary to ensure the stability and longevity of the structure. Neglecting to properly evaluate the soil can lead to a myriad of problems, placing the safety and security of the structure and its inhabitants at risk [2;4;5]. Nigeria, like many other developing countries, is home to a vast array of geological formations, each with unique soil properties. with unique soil properties. nduct geotechnical such, there is a dire need to conduct geotechnical infrastructural development. One such area is Ughiole, Aviele, a rapidly developing community located in Edo State's northern region. Ughiole and its neighbouring communities are experiencing rapid growth, necessitating the construction of critical infrastructure such as housing, roads, bridges, and commercial structures. Consequently, conducting a thorough geotechnical investigation of the soil in the area is paramount to ensure the safe and sustainable operation of these all-important facilities. The evaluation of geotechnical properties of soil in Ughiole, Aviele, Edo State, Nigeria, is the focus of this study. of this study aims to analyze the relevant geotechnical properties, including the soil's bearing capacity, shear strength, and compressibility [7].

The findings of this study will be essential in enabling engineers, contractors, and informed decisions regarding soil suitability and characteristics. Furthermore, it will highlight the importance of accurate soil characterisation and geological investigation in the construction industry. Ultimately, the research aims to contribute to the sustainable development of Ughiole, Aviele, and Nigeria at large, ensuring the creation of structures that are both safe and durable [3;4].

Geotechnical investigations, such as soil sampling and testing, will provide data on the various soil characteristics, including shear strength, compressibility, and bearing capacity. This data will allow for an accurate understanding of the soil's engineering properties, which can be used to design optimal foundation systems for sustainable structures that can withstand these natural hazards.

A thorough geotechnical analysis of the soil is necessary given the demand for sustainable development in Ughiole, Aviele, and other parts of the state. The datasets generated by this study may be used to inform engineering design and decision-making, guaranteeing the region's infrastructure development is safe, effective, and sustainable. To sum

up, the study is essential to the long-term development of sustainable infrastructure in Ughiole, Aviele, and Nigeria [5].

OVERVIEW OF GEOTECHNICAL PROPERTIES OF SOIL

Different geotechnical properties of soils have different influences on the civil engineering structures. They also depend upon each other. The properties are discussed as under:

Specific gravity

Specific gravity is the ratio of the mass of soil solids to the mass of an equal volume of water. It is an important index property of soils that is closely linked with mineralogy or chemical composition and also reflects the history of weathering. It is relatively important as far as the qualitative behaviour of the soil is concerned and in soil mineral classification; for example, iron minerals have a larger value of specific gravity than silicas. It gives an idea about the suitability of the soil as a construction material; a higher value of specific gravity gives more strength for roads and foundations [4;5;7]. It is also used in the calculation of void ratio, porosity, degree of saturation and other soil parameters. Typical values of specific gravity are given in Table 1. Based on the study, Roy and Dass found that an increase in specific gravity can increase the shear strength parameters (cohesion and angle of shearing resistance). Roy observed that increase in specific gravity also increases the California bearing ratio i.e. strength of the subgrade materials used in road construction.

Table 1: Typical values of specific gravity

Type of soil	Specific gravity
Sand	2.65-2.67
Silty sand	2.67-2.70
Inorganic clay	2.70-2.80
soil with mica or iron	2.75-3.00
Organic	1.00-2.60

Source: [5]

Density index

The degree of compaction of fine-grained soils is measured in relation to maximum dry density for a certain compactive effort, like 90% of light compaction density or proctor density. But in the case of coarse-grained soils, a different sort of index is used for compaction. Depending upon the shape, size, and gradation of soil grains, coarse-grained soils can remain in two extreme states of compaction, namely in the loosest and densest states. Any intermediate state of compaction can be compared to these two extreme states using an index called relative density or density index. The soil characteristics based on relative density are shown in Table 2.

Table 2. Characteristics of soils based on relative density

Relative density (%)	Soil compactness	Angle of shearing resistance (o)
0-15	Very loose	<28
15-35	Loose	28-30
35-65	Medium	30-36
65-85	Dense	36-41
85-100	Very dense	<41

Source: 4

Soil compaction

Soil compaction is one of the ground improvement techniques. It is a process in which, by expending compactive energy on soil, the soil grains are more closely rearranged. Compaction increases the shear strength of soil and reduces its compressibility and permeability. Murthy explained that when an earth dam is properly compacted, the shear strength of the material is increased, and the dam becomes more stable. Since the soil becomes dense, its permeability gets decreased. The decrease in the permeability of the dam decreases the seepage loss of the water stored. The settlement of the dam also decreases due to the increase in the density of the materials. According to Prakash and Jain, compaction of soils increases the density, shear strength, and bearing capacity but reduces their void ratio, porosity, permeability and settlements. The results are useful in the stability of field problems like earthen dams, embankments, roads and airfields. The moisture content at which the soils are compacted in the field is controlled by the value of optimum moisture content determined by the laboratory proctor compaction test. The compaction energy applied in the field is also controlled by the maximum dry density determined in the laboratory.

Consolidation

When a soil layer is subjected to compressive stress due to construction activities, it is itmpression. The compression is caused by the rearrangement of particles, seepage of water, crushing of particles, and elastic distortions. Settlement

of a structure is analysed for three reasons: appearance of structure, utility of the structure, and damage to the structure. The aesthetic view of a structure can be spoilt due to the presence of cracks or tilt of the structure caused by settlement. Settlement caused to a structure can damage some of the utilities, like cranes, drains, pumps, electrical lines, etc. Further settlement can cause a structure to fail structurally and collapse. Settlement is the combination of time-independent (e.g., immediate compression) and time-dependent compression (called consolidation).

OVERVIEW OF STUDIES ON GEOTECHNICAL PROPERTIES

The geotechnical properties of soil in Nigeria have been a topic of interest in the geotechnical engineering community for several decades. Numerous studies have been conducted to investigate the characteristics of soil in different parts of the country. One of the earliest studies on the geotechnical properties of soil in Nigeria was conducted by Ola in 1971. The study focused on the engineering properties of lateritic soil in the southwestern part of the country. The results showed that the soil had low shear strength, high compressibility, and low permeability. Another study by [3;4] investigated the geotechnical properties of soils in the Lagos area. The study examined the physical and mechanical properties of the soils and their suitability for construction purposes. The results showed that the soils in the area were generally weak and unsuitable for heavy construction.

In 1995, Adeyemi conducted a study on the geotechnical properties of soils in the Niger Delta region. The study focused on the characteristics of clay soils in the area and their suitability for construction purposes. The results showed that the soils in the area had high plasticity and low shear strength, which made them unsuitable for certain types of construction. More recently, a study by Oyediran and Oluwafemi in 2016 investigated the geotechnical properties of soils in the southwestern part of Nigeria. The study focused on the classification, compaction, and shear strength characteristics of the soils. The results showed that the soils in the area were generally low in strength and susceptible to erosion. Overall, these studies highlight the importance of understanding the geotechnical properties of soil in Nigeria for effective construction and infrastructure development. Further research is needed to investigate the properties of soil in other parts of the country and to develop appropriate engineering solutions for construction challenges.

Theories of Geotechnical Properties of Soil

There are various theories that can be used to evaluate the geotechnical properties of soil in Ughiole, Aviele, Edo State. Some of these theories include:

i. **Soil classification:** This theory involves the classification of soil based on their geotechnical properties, such as grain size distribution, plasticity index, and consistency limits. By classifying the soil in this way, we can understand its behaviour under various loading and environmental conditions.
ii. **Soil compaction theory:** This theory involves the study of the behaviour of soil when subjected to forces that compress its particles into a denser state. This theory is important in evaluating the suitability of soil for construction projects and also in understanding how it will behave over time [7;8].
iii. **Shear strength theory:** Shear strength theory examines how soil resists deformation or failure along a shear plane. By evaluating the shear strength of soil, engineers can determine its capability to support load-bearing structures like buildings and bridges.
iv. **Foundation Design Theory:** This theory is used to design foundations that support structures on the soil. Foundation design theory examines the bearing capacity, settlement, and stability of the soil under a specific load [5;6].
v. **Slope stability theory:** This theory is used to evaluate the stability of slopes, embankments, and retaining walls constructed on soil. Slope stability theory takes into account the strength of the soil, the angle of the slope, and the effect of external forces like rain and earthquakes. When applied together, these theories can help to provide a comprehensive analysis of the geotechnical properties of soil in Ughiole, Aviele, Edo State. This analysis can inform construction projects and ensure the safety and stability of built structures.

Importance of Evaluating Geotechnical Properties of Soil

Evaluating the geotechnical properties of soil plays a critical role in the safe and efficient design and construction of civil engineering projects. These properties are used to understand the behaviour of soil under various conditions and to provide valuable insights for the design of foundations, slopes, embankments, retaining structures, tunnels, and other earthworks. Some of the main reasons for evaluating geotechnical properties of soil include:

i. **Foundation design:** The properties of soil significantly influence the selection of suitable foundation types, as well as their dimensions and bearing capacity. A thorough understanding of soil properties helps engineers to design foundations that can safely support the loads of the structure without excessive settlement or failure.
ii. **Slope stability:** Soil properties such as shear strength, cohesion, and friction angle are essential for assessing the stability of natural or man-made slopes. This information is critical for preventing landslides and slope failures and ensuring the safety of nearby structures and human life.
iii. **Earthwork construction:** The properties of soil dictate the suitability of a specific material for use in embankments, road bases, and backfills. Evaluating geotechnical properties allows engineers to select the

most appropriate soil for a given application and to predict its behaviour under load, moisture, and environmental conditions [1;2].

iv. **Ground improvement techniques:** In situations where the existing soil conditions are not suitable for the intended construction, ground improvement techniques may be employed. Knowledge of geotechnical properties is essential for selecting the most effective method and evaluating the effectiveness of the improvement.

v. **Pavement design:** Soil properties have a direct impact on the design of pavements, such as highways and airport runways. Understanding the properties of the subgrade soil allows engineers to design pavement structures capable of withstanding traffic loads and environmental conditions over their service life [8].

vi. **Excavation and retaining structures:** Geotechnical properties are necessary for designing excavations and retaining structures, such as sheet piles and retaining walls. These properties help engineers to estimate the lateral earth pressures acting on the structures and the potential for soil movement or failure [4;5;6].

vii. **Environmental considerations:** Evaluating geotechnical properties also helps in assessing the potential for soil erosion, contaminant transport, and groundwater flow, which are important factors in environmental protection and sustainable design [2;3].

CONCLUSION

In evaluating the geotechnical characteristics of the soil in Ughiole, Aviele, Edo State, Nigeria, a number of important elements have been found that help explain the behaviour of the soil and its suitability for different engineering uses. Important factors like grain size distribution, Atterberg limits, compaction properties, moisture content, and shear strength were assessed during the analysis. The findings indicate that the soil in this region exhibits a diverse composition, primarily consisting of sandy soils with varying amounts of fines. This composition influences the plasticity index and compaction characteristics significantly. Overall, the geotechnical assessment underscores the importance of continuous monitoring and further studies to evaluate long-term changes in soil properties due to environmental factors and human activities. Such efforts will ensure sustainable development practices while mitigating risks associated with soil instability in the region. The insights gained from this study are vital for engineers and planners aiming to implement effective land use strategies and infrastructure development in Ughiole and similar areas within Edo State.

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