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SPECIFIC GRAVITY OF THE EOCENE SEDIMENTS OF AMEKI FORMATION, NIGER DELTA BASIN, NIGERIA. CASE STUDY: OKPANAM, SOUTHERN NIGERIA.

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ABSTRACT

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 closely linked with mineralogy and/or chemical composition. It decreases with aluminium content but increases with iron content and grain size fraction. For the disturbed samples, the samples were collected at 0.5m and for the undisturbed samples, they were sampled at 1.0m intervals. If numerical values are given in a discussion where it may not be clear to what the specific gravity is referred, the magnitude of the values may indicate the correct usage since the of the soil particles will always be larger than the bulk specific gravity based on the soil voids in the computation {and either full of air (dry) or full, or partly full of water}. The results show the value of the specific gravity of de-aerated soil samples across the ten trial pits. The disturbed soil samples had a range of 2.59 - 2.87 with a mean on 2.68 while the undisturbed soil samples had a range of 2.61 – 2.87 with a mean value 2.67. Based on mineral contents found in sediments, the soils are majorly composed of quartz (2.65) and of feldspar (2.65 – 2.7). These results in the soil samples classified as sand, silty sand, inorganic clay and soils containing Mica or Iron. Other geotechnical index properties such as density index, consistency limits, particle size gradation, compaction, consolidation, permeability, shear strength help in stability of engineering structures on or below the earth.

Keywords: Specific gravity, density index, mineral content, silty sand, void ratio

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INTRODUCTION

Engineering structures like building, bridge, highway, tunnel, dam, tower, etc. are founded below or on the surface of the earth. For their stability, a suitable foundation soil is required. To check the suitability of soil to be used as foundation or construction materials there is the need to determine the engineering properties of the soils for different strata (Arora, 2008). One of such geotechnical index property is 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 closely linked with mineralogy and/or chemical composition (Oyediran and Durojaiye, 2011). It is therefore necessary to standardize the particle size for the determination of specific gravity. The specific gravity of grains of any soil is also significant in estimating its degree of weathering. A positive correlation between specific gravity and shear strength parameters (cohesion and angle of shearing resistance) also exists. Roy, 2016 also observed that an increase in specific gravity also increases the California bearing ratio i.e. strength of the subgrade materials used in road construction. The objective of this research is to determine the specific gravity of the soil, which will help in determining the soil type, particle size analysis and mineralogy of the soil at the location.

Rocks rich in heavy minerals weather to soils whose grains have high values of specific gravity. The value of the specific gravity of soils is useful in the identification and classification of Laterites. It is relatively important as far the qualitative behaviour of soil is concerned and useful in soil mineral classification, for example iron minerals have a larger value of specific gravity than silica. It gives an idea about suitability of the soil as a construction material; higher value of specific gravity gives more strength for roads and foundations. It is also used in the calculation of void ratio, porosity, degree of saturation and other soil materials. It decreases with aluminium content but increases with iron content and grain size fraction. It is therefore necessary to standardize the particle size for the determination of specific gravity. The specific gravity of grains of any soil is also significant in estimating its degree of weathering (Tuncer and Lohnes, 1977). Rocks rich in heavy minerals weather to soils whose grains have high values of specific gravity.

The value of the specific gravity of soils is useful in the identification and classification of Laterites. A positive correlation has been established between the specific gravity of soils and their degree of laterization (Gidigasu, 1976). It is relatively important as far the qualitative behaviour of soil is concerned (Raj, 2012) and useful in soil mineral classification, for example iron minerals have a larger value of specific gravity than silicas. It gives an idea about suitability of the soil as a construction material; higher value of specific gravity gives more strength for roads and foundations. It is also used in the calculation of void ratio, porosity, degree of saturation and other soil materials (Prakash and Jain, 2002). Roy and Dass, 2014 also have found out a positive correlation between specific gravity and shear strength parameters (cohesion and angle of shearing resistance). Roy, 2016 also observed that an increase in specific gravity also increases the California bearing ratio i.e. strength of the subgrade materials used in road construction. The knowledge of these properties as well as the effect of their interactions is recommended to assist in designing the foundations for different types of engineering structures.

This research will determine the specific gravity of the soil, which will help in determining the soil type, particle size analysis and mineralogy of the soil at the location. The specific gravity is a fundamental property of soils and other construction materials. This dimensionless unit is the ratio of material density to the density of water and is used to calculate soil density, void ratio, saturation and other soil properties.

Physical Settings

The study area is located at Okpanam town in Delta state, Nigeria. Its longitudes falls within the range of $N6^{0}12^{'}35.4''$ - $N6^{0}12'44.8''$ and its latitudes fall within $E6^{0}39'9.1''$-$E6^{0}39'13.7''$ (Fig. 1). It is easily accessible via the Benin - Asaba expressway. The outskirt of the location made reconnaissance survey and sampling easy. Figure 2 show pictures of exposed road cuts in the study area.

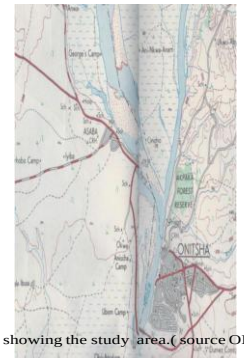


Fig 1: map showing the study area.(source ONITHSHA SHEET 300)



Fig 2: Exposed road cuts in the location

The Niger delta constitutes an extensive, typical deltaic plain with a monotonous and essentially flat topography. It attains a height of less than 40m above sea level inland and gently slopes seaward to a minimum level of 8m above sea level at the coast (Akpokodje, 1986). The elevation in the study area has a range of 96m – 109m above sea level. It is drained and criss-crossed by a network of rivers, tributaries, and creeks most of which drains into the sea. Asaba is well drained by the river Niger with tributaries like Amilimocha, Otogwu, Iyi abi and Obosi River**.** Temperatures in the Niger delta are fairly uniform ranging from $20^{o}C$ at night to $32^{o}C$ during the day. Humidity is equally high nearly all year round. The thick vegetation ranges from rain forest in the north dry lands to swamp forest seaward to the south. The geology of the Niger delta is relatively simple, consisting of various types of Quaternary deposits overlying thick Tertiary sandy and clayey deltaic deposits. In terms of subsurface lithostratigraphic units in the Niger delta, Short and Stauble (1967) confirmed three main units namely: Akata, Agbada and Benin Formations in order of age. Figure 2 shows a stratigraphic column showing the three main formations in the Niger delta. The three formations are believed to be laid down under continental, transitional and marine environments respectively.

Local Geology

The major formation at the location is capped by the Benin formation and underlying it is the Ameki Formation. The formation is made up of alternating coarse grained sandstone, light coloured clays and carbonaeceous shales within which are lignite seams (Fig 3 - 4). From exposed road cuts and geophysical investigations at the study area, the formation reveals a thick overburden layer of lateritic clay, shales, sands and sandstones.

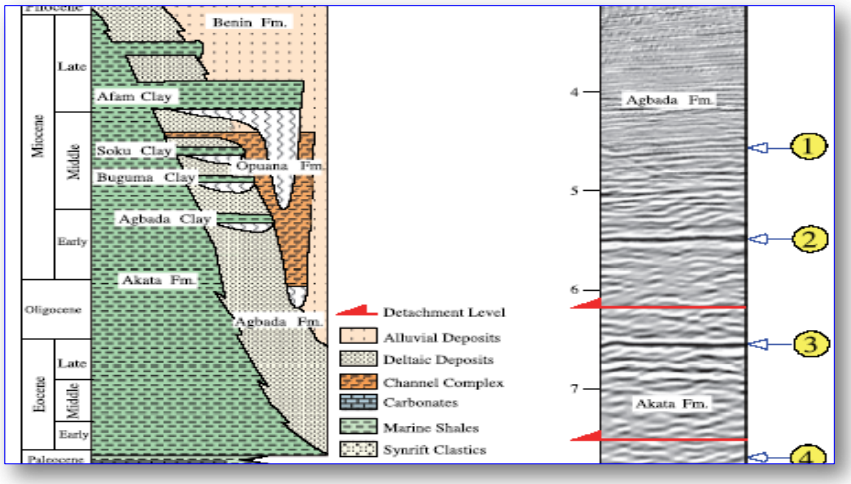


Fig 3: The Niger Delta stratigraphy (Short and Stauble, 1967 in the AAPG Bulletin, 2004)

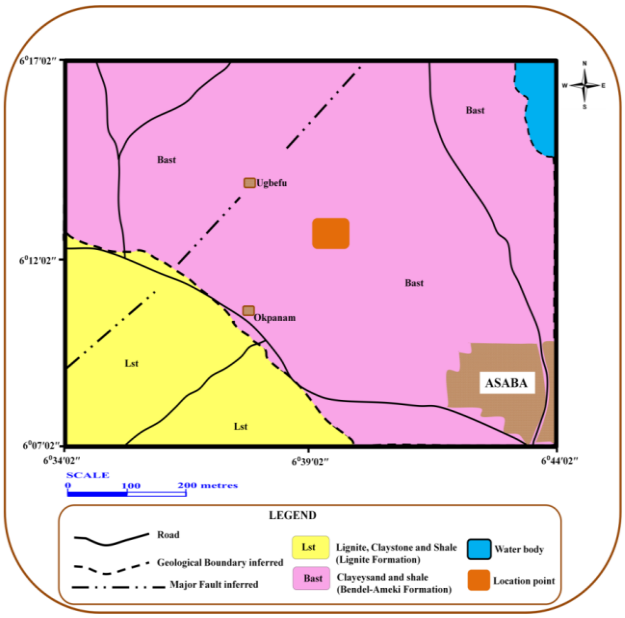


Fig. 4: Geological Map of the study area (source: NGSA, 2006)

MATERIALS AND METHODS

Specific gravity was tested at every metre to a depth of 3.0m. For the *disturbed* samples, the samples were collected at 0.5m and for the *undisturbed* samples; they were sampled at 1.0m intervals. The ASTM D-854 and the identical AASHTO T-100 are the standard test methods for specific gravity of soil solids by water pycnometer, vacuum pump, mortar and pestle, balances weighing 0.1g, supply of deaerated, temperature-stabilized water. The volume of a known mass of soil particles can be obtained by using a container of known volume of distilled water at 20^0C. At temperatures above this value, the volume will be slightly more;

below 20^0C, the volume will be slightly less. With a drying oven, the moisture is determined and final sieve sizes required for the samples to pass through is ASTM E11 (No.4). The soil sampling and analysis of specific gravity was tested at every metre to a depth of 3.0m. A value of specific gravity is necessary to compute the void ratio of a soil, hydrometer analysis and soil density. Figure 5 shows the geotechnical lithology of a geotechnical borehole where geophysical and geotechnical surveys where done to depths of 3.0m and 20.0m respectively.



Fig. 5: Showing a sampled Geotechnical borehole and a trial pit

RESULTS AND DISCUSSION

The specific gravity of a soil without any qualification is to be the average value for the soil particles. If numerical values are given in a discussion where it may not be clear to what the specific gravity is referred, the magnitude of the values may indicate the correct usage since the of the soil particles will always be larger than the bulk specific gravity based on the soil voids in the computation {and either full of air (dry) or full, or partly full of water}. Typical values of specific gravity are given in Table 1. The results (Tables 2 – 3) show the value of the specific gravity across the ten trial pits

Table 1: Soil Classification on the basis of Soil Gravity (Bowles, 2012)

Soil Type	Value of Specific Gravity
Organic Soils	< 2.00
Sand	2.65 – 2.67
Silty sand	2.68 – 2.70
Inorganic Clay	2.70 – 2.80
Soils containing Mica or Iron	> 2.80

Table 2: Specific gravity of *disturbed* soil samples in 10(ten) trial pits

Depth (m)	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG10	Mean
0.5	2.68	2.67	2.65	2.68	2.87	2.66	2.67	2.70	2.67	2.67	2.69
1.0	2.68	2.68	2.67	2.68	2.87	2.67	2.64	2.68	2.66	2.66	2.69
1.5	2.66	2.65	2.66	2.67	2.67	2.65	2.87	2.87	2.68	2.66	2.70
2.0	2.59	2.64	2.60	2.64	2.64	2.66	2.70	2.70	2.69	2.64	2.65
2.5	2.67	2.65	2.64	2.66	2.66	2.66	2.68	2.68	2.67	2.68	2.67
3.0	2.65	2.66	2.66	2.67	2.67	2.65	2.68	2.68	2.68	2.69	2.67

*Minimum value= 2.59 Maximum value= 2.87 Mean = 2.68

Table 3: Specific gravity of *undisturbed* soil samples in 10(ten) trial pits

Depth (m)	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG10	Mean
1.0	2.67	2.68	2.67	2.68	2.87	2.66	2.66	2.68	2.67	2.67	2.69
2.0	2.68	2.64	2.61	2.64	2.68	2.67	2.69	2.65	2.68	2.66	2.66
3.0	2.68	2.66	2.67	2.66	2.69	2.65	2.68	2.68	2.68	2.69	2.67

*Minimum value = 2.61 Maximum value = 2.87 Mean = 2.67

The disturbed soil samples had a range of 2.59 - 2.87 with a mean on 2.68 while the undisturbed soil samples had a range of 2.61 – 2.87 with a mean value 2.67.Based on mineral contents found in sediments, the soil are majorly composed of quartz (2.65) and of Feldspar (2.65 – 2.7). This results in the soil samples classified as *Sand, Silty Sand, Inorganic Clay* and *Soils containing Mica or Iron.* None of the soil samples exhibit specific gravity typical of *Organic* soils.

CONCLUSION

A value of specific gravity is necessary to compute the void ratio of a soil. It is used in the hydrometer analysis and it is useful to compute the soil density. Researchers have found out that different geotechnical properties of soils have different behaviour on structures. The higher the specific gravity, the higher the load carrying capacity of the soil

RECOMMENDATION

Other geotechnical index properties such as density index, consistency limits, particle size gradation, compaction, consolidation, permeability, shear strength help in stability of engineering structures on or below the earth. The knowledge of these properties as well as the effect of their interactions is recommended to assist in designing the foundations for different types of engineering structures.

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