

Geotechnical Index Properties of Soils in Abua and Environs: A Case Study of Obedum-Anyu-Emelago Road

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Abstract

The frequent collapse of engineering structure and incessant cracks witnessed on walls of buildings within the Obedum-Anyu-Emelago axis of Abua/Odual Local Government Area of Rivers State prompted the need for geotechnical investigation to assess the suitability of soils and characterize their engineering properties as a guide to foundation designs. Soil samples were obtained between 0 and 30 metres depth and used in the study. The field boring and laboratory results shows that the stratigraphy is predominantly of medium with soft to firm brown mottle grey salty peaty clay and soft to firm grey mottle brown salty peaty clay in shallow borings of 2 m. The organic peaty clay layers are very poorly suited to support foundations due to very high compressibility compared to other materials. Laboratory analyses showed that the clays are characterized by moderately high moisture content and compressibility and fairly low undermined strength. CBR values between 5.7 percent to 8.5 percent, liquid limit between 38.8 percent and 50.6 percent, plasticity limit 18.8 percent and 25.5 percent. Comparison of these ranges of geotechnical properties with Bench Mark for sub grade indicated that they are of low standard. Recommendation includes the need for stabilization with lime and cement to avoid the collapse of structure or buildings within the study area.

Keywords: Geotechnical; Index Properties; Abua; Engineering Structures

Introduction

The Obedum-Anyu-Emelago Axis in the Abua/Odual Area has witnessed mirage of creeks in buildings and collapse of structures. In recent times; this has been attributed to differential settlement, to wrong types and positions is foundation on incompetent strata.

Therefore, the need for adequate and reliable geotechnical characterization of sub-soil is very important. This is because the compact of the composed load is exacerbated by the thickness and consistency of the compressible layer. These in additions to other intrinsic factors contribute to the failure of civil engineering structures [1].

Consequently, it becomes imperative to carry out through site investigation and laboratory analysis to obtain geotechnical information on the sub-oil of the area at different depths. It is this information that engineers sought for in the construction of engineering works. Geotechnical information are useful in ensuring that the effects of projects on the environment and natural resources are properly evaluated and mitigated where necessary [2]. Soils have been found to develop in different sub climates and drainage environments with each often exhibiting unique set of physical, chemical and geotechnical properties of soils which are closely related to the physical conditions of the materials, that include particles size distribution (DPS), Atterberg Limits, Plasticity Limits and liquidity Limits, shear strength, parameters of undrained cohesion, angle of shear resistance of soils, these properties determine the instability of material for construction purposes.

The Geotechnical properties of soil can be grouped into two major categories:-

Index properties and mechanical/design properties

Whereas the first group are used for identification and classification of soil materials, the second group are used basically for the design of foundation. Apart from quantifying these properties, it is also important to know the extent and the means by which they can be

altered or modified [3]. The study area is characterized by the fresh water swamp, ecology of the reaches of the Orashi Rivers within the Niger Delta. It lies within the outcropping Benin formation made up of continental deposits of flat to sub-horizontal elevation. The fresh water swamp and seasonal flooding of the study area growth hampered the city of structure and therefore, insight from this study will show the actual properties of soil in the area and their influence on road and structures in the area.

Geomorphology and Geology of the Study Area

The study area is situated within the Niger Delta that is located in the latest Africa continental Margin. The knowledge of the geomorphological units of the Niger Delta today is derived mainly from the works of Allen, Weber [4,5]. The study area has a flat topography, sloping, seaward gently; the area is a lowland area within the range of 0-30 m above sea level and is drained and criss-crossed by the network of distributaries [6]. The area has equatorial tropic rain forest types. Two seasons are observed in within the area; the dry season and wet seasons. The dry season is actually from November to March, and the wet season from April to October [7].

The annual rainfall within the study area varies from 23.855 mm to 27.635 mm [8]. The high rainfall is due to proximity to sea and location on the path rain bearing wind. The rain to emerge in water table as high 1.5 m in some area and this has a negative effect on the geotechnical properties of the soils in the study area.

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Consequently, there is emerge increase moisture content, hence reduction in geotechnical strength of the soils. The Niger Delta is a coarsing upward regressive sequence of tertiary classics that prograde over the passivecontinental margin sequence of mainly cretaceous sediments. Variation form of Morphological units are depositional environments have been recognized in the study area, ranging from coastal feats, sand bars, ancient / modern sea, rivers and lagoons beaches, flood plains, seasonal flooded depressions, swamps, ancient creeks and rivers channels [9].

The formation of the recent day Niger Delta started during the Eocene from the building up of the fine grain sediments eroded and transported by the river Niger and its tributaries.

The subsurface geology is made up of the three tertiary lithostratigraphic units namely Benue Agada and Akata formation from top to bottom.

Lithologically, the Benue formation consists of over 90% sand and sand stones with shale intercalation. It extends from West across, the entire Niger Delta area and southward beyond the present coastline [10]. On the surface it is oligocene in age while in general, the Benin formation range from Miocene to Recent in age. The underling of Agbada formation is a sequence of sand stones and shale with predominantly sand units at the upper part and minor shale intercalations, the shale units become thicker towards the boundary between it and the Akata formation. It ranges from Eocene to Pliocene. The Akata formation consists of shale deposits, dark sandy silt with plant remain ontop; particular at contact the overlying Agbada formation.

Generally, this unit ranges from Eocene to recent in age and it covers 1,200 m the Benin formation, which is the youngest, is overlying by varioustypes of Quaternary to Recent deposits.

Hydrogeology and Structure of Niger Delta

Studies on the hydro geological conditions of the Niger Delta by notable scholars have share shown irregular, lenticular and lateral discontinuous layers of clay aquifers which partially subdivided the regional aquifers into two unites [11-13]. According to Akpokodje [3], structurally, the Niger Delta is divided into two surface and subsurface structures. The surface structures are produced by surface process such as water, wind and gravitational settlement. The most common features including gushed, slumping and sand weights of over burden of these are diapers; roll over anticline and growth fault.

Hydrogeologically, the principal source of ground water within the Niger Delta is the infiltration of rain fallinto the ground water table, changes in relation to the climatic and tidal conditions, more so the level of surface water contamination in conjunction with ground water would contribute greatly to the probable behavior of the soil in the Delta Region in respect to its engineering properties.

Location of the Study Area

The study area in along Obedum Anyu-Emelago Road in Abua/Odual local Government Area of Rives State, Nigeria. The study area lies between longitudes 5°30'E and 5°50'E and latitude 4°45'N and 5°0'N. The study area is located in the Niger Delta rain forest vegetation region and is accessible by road and 23 km away from the Degema Haulk Jetty via SombreiroRiver. The study area is also bounded by Brass, and Ogbia Local Government Area in Bayelsa State and Ahoada-East and West, as well as Degema Local Government Areas of Rivers State (Table 1).

| Geologic Unit | Lithology | Age |
|-------------------------------------------|----------------------------------------------------------|------------------|
| Alluvium (general) | Gravel, sand, clay silt | Quaternary |
| Freshwater back swamp and meander belt | Sand, clay, some silt and gravel | Quaternary |
| Saltwater mangrove swamps and back swamps | Medium fine sand, clay and some silt | Quaternary |
| Active/abandoned beach ridges | Sand, clay and some silt | Quaternary |
| Sombreiro Warri deltaic plain | Sand, clay and some silt | Quaternary |
| Benin formation | Coarse to medium sand: subordinate silt sand clay lenses | Miocene – Recent |
| Akata Formation | Clay | Paleocene |

Table 1: Geological units of the Niger Delta.

| N-16 | Mins. | Max | Ave |
|----------------------------|-------|------|------|
| Natural moisture (%) | 25.5 | 69.2 | 47.4 |
| Liquid limit (%) | 35.1 | 74.8 | 33.2 |
| Plasticity Index (%) | 13.3 | 42.8 | 27.4 |
| Liquidity index (%) | 0.27 | 0.89 | 0.62 |
| Bulk unit weight (KN/M3) | 13.4 | 15.8 | 14.3 |
| Dry unit weight (KN/M3) | 7.1 | 12.5 | 9.9 |
| Find validation | 0.72 | 1.70 | 1.18 |
| Final porosity (%) | 42.2 | 63.0 | 52.7 |
| Specific Gravity | 2.25 | 2.60 | 2.45 |
| Degree of saturation (%) | 87.8 | 97.5 | 92.2 |
| Drained friction Angle (%) | 2.8 | 39 | 34 |
| Undrained straight (Kpa) | 19 | 28 | 23 |

Table 2: The range of variations in the index and engineering perimeters of the study area.

Materials and Methods

In the course of the investigation of the sub soil of the area under study ten (10) geotechnical borehole were sank at bridge sites, soil samples were collected, water tables were measured. Both the Auger method and percussion Rig methods were employed in the collection of samples at various intervals. The percussionrig boring was terminated at 30 m while the hard auger was executed to adoption of 2.0 m respectively. Disturbed sample were collected at regular international of depth and also physical and systematic observation of also was done. Samples obtained from the field were taken to the laboratory for analysis to carry out detailed laboratory investigation for the purpose for identification and classifications. The laboratory analyses were carried out on representative samples in evidence with the American society for testing and materials (ASTM) detailed and qualification information conveying the soil nature.

Results and Discussion

Engineering properties

The major geotechnical properties of the soil are discussed and summaries

Peator peaty clay layer: The peaty clay extends from the formed surface to the depth of about (5.5 m below top soil. The clays are characterized by moderately high moisture content and compressibility and a fairly low undrained strength. The range of variations in the index and engineering perimeters of the study area are shown in Table 2.

The natural moisture content to these organic clays are in extra of 100%. This may be attributed to the high void ratio created by the Organic and Clay nature of the material. The preserve of high water contents are characterized by soils which in high organic content and

clay [14]. From the analysis gotten, it shows that, the lowest liquid limit and plastic unit occur in Anyu averaging 35.1 and 21.8% respectively. Relatively, from the results, it indicated that the highest values of liquid and plastic units were obtained from Obedum where the average value were 95.2 and 46.50% respectively. Emelago samples gave values of liquid and plastic liquid of 74.8 and 32.0 respectively. The consistency units of soil are dependent on moisture content, grain size distribution and the properties of the fine-grained fraction [14].

The peaty clays in the various locations (Odum, Anyu and Emelago) had overall medium high value of consistency limits because of the presence of medium high clay content. Majority of the sample plots below the A-line of the Casagrande plasticity limit chart as ML and MC clay and organic material of low to medium plasticity alluding to the unified soil classification scheme.

The engineering properties of peat are quite different from those of mineral soils. The composition of Chicoco has been highlighted in the aspect of the ratio of organic content to mineral fraction.

For example NEDECO [15] gave the ratio of 1:1 with mineral fraction comprising 14% clay, 35% silt and 10% sand. This type of soil is referred to as Chicoco. However, Akpokodjie [16] used the term Dark Organic/Peaty Clay to refer to the same soil types but reported average composition 66% clay, 21% silt and 2% sand [17].

From the result obtained, it shows that the underlined shear straight parameters give ranges of cohesion and angle of internal friction as 71-12.5KN/M² and 28-39 respectively. This value falls in the range of soft to fairly hard clayed soils allowing to the BS 5930 classification. The classification refers to the shear straight of soils which either exudes between fingers when sequenced, or can be molded light pressure [18].

Loose to medium dense and medium dense to dense sands: The loose, to medium and medium dense to dense sand is encountered from the depth of about 5.5 m to 30 m table.

Generally, from the studied locations, the sand are in the range of fine to medium grained, loose to dense and medium dense sand. The column ranges from brown to grey and white [19]. However, the upper part of the sand is interlaminated with silt and clayed 6 m. In the lower part (Layers), the sands are mainly fine to medium grained whitish, medium dense to dense. The effective size particle size d₁₀ (mm) and mean practice size d₅₀ (mm), averages 0.068 and 0.153 respectively.

The coefficient of uniformity of the sand averages 2.685 which indicate that the sands are fine in nature. The percentage of the fine fraction range from 6.06% to 17.40% for uncompressed sample in general, the percentage of fine for the range forms 4.20% 17.40% for Obedum, Anyu between 7.61 to 21.99% and for Emelego between 9.61 to 21.20%. The soil from the percentage of fine result can serve for the purpose but except for the Obedum location which cannot serve as a good seal material [20,21].

Conclusion

A study of the area geotechnical index properties of Obedum-Anyu Emelego axis of Abua / Odual Local Government Area in Rivers State, Nigeria was carried out. The soil stratigraphy reveals that the axis is predominantly underlain with soft to firm brown mottled grey silt clay peat in shallow boring of 2.0 m depth.

Deep boring showed predominantly a sequence of soft to firm peaty clay beneath top soil, overlying loose fine sand, beneath the fine sand is loose to medium dense fine to the medium sand overlying

medium that extend to the borehole. The peaty clays have moderately high compressibility with fairly low bearing capacity values and appreciate switching properties.

From the results of the laboratory analysis, the clays obtained from the borehole has liquid limits between 38.8% and 50.70% and plasticity index between 18.8.6 and 25.50%, with predominantly more than 35% passing No 200 sieve.

The above properties of the soil material place it in A-7 of the AASHTO soil. The area is unsuitable for use as base course they need to be stabilized

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