



Landslide Susceptibility Assessment using Geotechnical Index Properties of Soils in Ibam Edet and Odorokpe Villages, Ini LGA, Akwa Ibom State, Nigeria

Dickson, Justus O.¹ and Ehibor, Imo-Owo U.^{2*}

Abstract

Susceptibility assessment of a landslide was carried out using the geotechnical index properties of soils in Ibam Edet and Odorokpe villages Ini LGA of Akwa Ibom State. The aim was to identify, characterize and evaluate the index properties of the soils in order to assess the susceptibility of the soils to a landslide. Soil samples were retrieved from three locations in Ibam Edet and one location in Odorokpe village using a hand auger from the ground surface to 4.0m depth. The samples were analysed in the laboratory to determine their index properties such as moisture content, Atterberg limits and particle size distributions. The stratigraphy consists of fine-medium grained clayey sand from 0-2m underlain by a medium-coarse grained sand from 2-4m depth in locations L1 and L2. In location L3, a fine-grained sand occurred from 0-4m. While in location L4 a fine-medium grained silty sand occurred from 0-2m underlain by a medium-coarse grained sand from 2-4m. The average moisture content percentages across locations L2 (37.3%), L3 (34.5%) and L4 (39.7%) showed a general decline in water content with depth. While the liquid limit percentages increased with depth in locations L1 (29.6%) and L2 (26.5%). The presence of clays and silts in the sands between 0-2m in locations L1, L2 and L4 will limit the flow of water through the soil as shown in the higher percentages of moisture content and Atterberg limits in the clayey sand and silty sand layers. The particle size distribution plots of the sands show poorly /uniformly graded fine, medium to coarse grained sands that are free draining because of their high porosity and lack of cohesion. An increased water saturation within the pores of the clayey sand and silty sands during prolonged and heavy rainfall reduces the friction and shear strength of the soil which may lead to landslides. This study therefore recommends the drilling and collection of soil samples at depths greater than 4m. Also, an analysis of the soils shear strength to evaluate the angle of internal friction of the clays and sands in order to quantitatively determine the slope stability, estimate the factor of safety and ascertain the degree of susceptibility of the soils to a landslide is recommended.

✉ Ehibor, Imo-owo U.: imohuyanga@gmail.com

¹ Akwa Ibom State University, Ikot Akpaden, Department of Geology, Faculty of Physical Sciences, Mkpata Enin LGA, Akwa Ibom State, Nigeria

^{2*}University of Port Harcourt, Faculty of Science, Department of Geology, Port Harcourt, Rivers State, Nigeria.

Keywords: Landslide Susceptibility; Geotechnical Index Properties; Water saturation; Shear strength; Slope stability

Article history

Received: January 5, 2026

Received in revised form: March 3, 2026

Accepted for publication: March 6, 2026

Available online: March 8, 2026

1.0 Introduction

Landslides are geologic hazards which happen suddenly or more slowly over long periods of time and can be generated by interaction of several factors such as intense rainfall, water level change, storm waves, stream erosion, geology, slope geometry, vegetation cover and anthropogenic activities. In Nigeria, different studies (Okogbue, 1994, Igwe & Una, 2019, Egboka et al., 2019, Ayodele et.al. 2020 and Effiong et al., 2021) show that landslides occur more frequently in the southern part of the country than in the north, especially within the south eastern states. Some key occurrences in Nigeria include: Nanka, Anambra state in 1988 (Igwe and Una, 2019), Calabar and the Obudu mountain resort in 2013 in Cross Rivers state (Akpan et al., 2016), (Effiong et al., 2021), Akovolwo mountains and Ogbajala hills Benue State (Okogbue, 2003) and Okemesi town in Ilesha, Osun state (Ayodele et al., 2020.) Landslide susceptibility evaluation has become a major concern in areas prone to heavy rainfall, widespread gully erosion, deforestation activities and loose sedimentary rocks. One of the most critical aspects in understanding and preventing landslides is the investigation of the geotechnical properties of subsoil conditions that influence slope stability. Geotechnical index properties provide valuable insights into landslide risks by providing information on the instability associated with high plasticity and low permeability soils and their effects on the shear strength or friction of soil particles. However, inadequate or poorly conducted subsoil investigations often lead to insufficient understanding of the geotechnical properties and structural behaviour of soils within landslide-prone areas. Subsoil index characteristics such as soil stratification, moisture content, Atterberg limit (Plasticity) and particle size distribution play a significant role in slope failure mechanisms. Variations in these properties can create weak zones that serve as slip surfaces thereby increasing the susceptibility of slopes to

failure, in many landslide occurrences, failure has been attributed to insufficient knowledge of subsurface soil conditions prior to construction Kim et al. (2016) and Situmorang et al. (2022). Furthermore, complex geological formations, seasonal changes in groundwater levels and weathering processes can significantly alter subsoil properties over time. Surface observations alone are often inadequate for identifying these subsurface variations. Without subsoil investigations, landslide assessments may be unreliable. An evaluation of the index properties of the sub soils in the study of landslides is very important in the design of slope stabilization structures and effective land-use planning for safety of civil engineering structures in landslide prone areas.

In November 2019, a landslide occurred in Ibam Edet and Odorokpe Villages in Ini Local government area of Akwa Ibom State. Although no life was lost, property worth millions of naira and other invaluable assets of the communities such as streams that are sources of drinking water for the community were affected and people were displaced from their homes. Several landslide studies exist in south eastern Nigeria including in Akwa Ibom state where other analytical methods including Geophysical and GIS based analysis have been used to study or predict landslide susceptibility such as Udosen et al. (2014) and Ibanga (2021), but no analysis using the geotechnical index characteristics of the soils has been conducted in Ini LGA following the 2019 landslide event, This study fills this gap by identifying, characterizing and evaluating the index properties of the soils to provide valuable insights on the soils stratigraphy, water content, consistency and particle size distribution of the soils. These properties amongst others determines and affects the plasticity, porosity and permeability of the soils which in turn determines to a large extent the strength of soil particles ultimately affecting the slope's stability and the soils susceptibility to landslides.

2.0 Location of Study

The study areas: Ibam Edet and Odorokpe villages in Ini local government area of Akwa Ibom state are located within longitude $7^{\circ} 40' - 7^{\circ} 50'E$ and latitude $5^{\circ} 20' - 5^{\circ} 30'N$ (Figure 1) in

the north-eastern part of Akwa Ibom State, Nigeria. The soil sample locations and their elevation above mean sea level (msl) are presented in Table I.

Table 1: Soil Sample Location Coordinates and Their Elevations

Sample location	Coordinates Northings	Coordinates Eastings	Elevation (m)
Location 1 (Ibam Edet)	N $04^{\circ} 50'' 17.1'$	E $007^{\circ} 47' 35.7'$	109
Location 2 (Ibam Edet)	N $05^{\circ} 21'' 33.4'$	E $007^{\circ} 45'' 11.7'$	100
Location 3 (Ibam Edet)	N $05^{\circ} 21'' 34.5'$	E $007^{\circ} 45'' 22.0'$	117
Location 4 (Odorokpe Village)	N $05^{\circ} 21'' 26.9'$	E $007^{\circ} 44'' 35.1'$	113

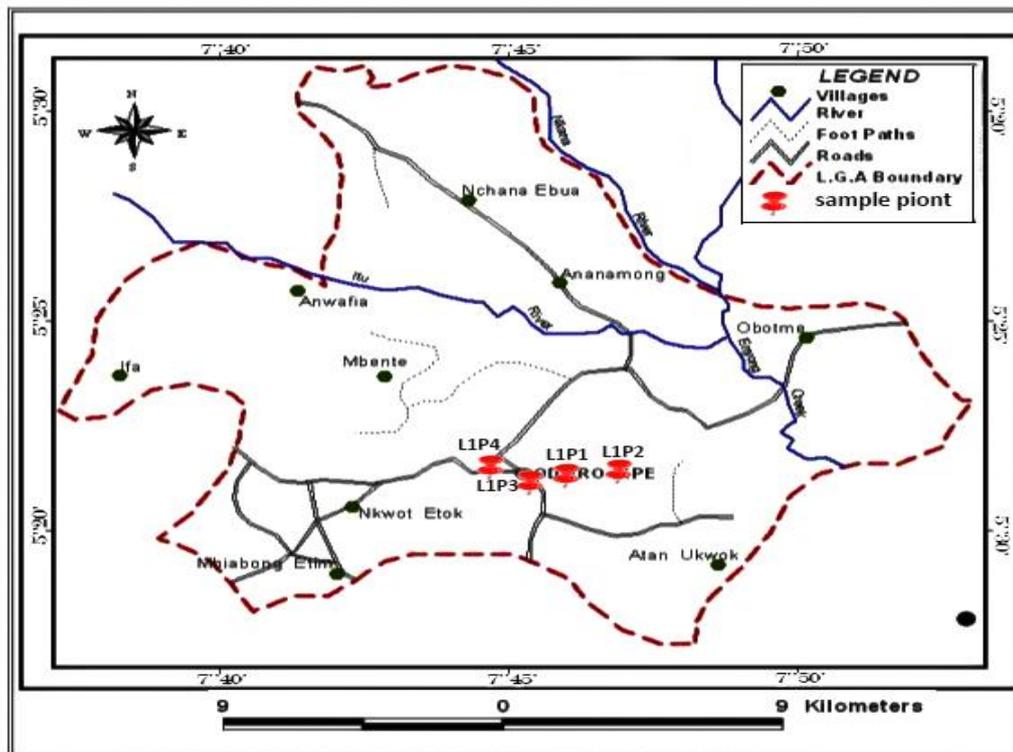


Figure 1: Map of the study areas Ibam Edet and Odorokpe villages in Ini LGA showing the sampling collection points

2.1 Geology of the Study Area

The Niger Delta is divided into three stratigraphic sequences, Benin, Agbada and Akata formation (Short & Stauble, 1967). The Benin Formation (Miocene-Recent age) has been described as “coastal plain sand” which outcrops in so many places in the Niger Delta. It

consists of sands and gravels with thickness ranging from 0 – 2000 m. The sand and sandstones are coarse to fine grained and commonly granular in texture and can be partly unconsolidated. The Benin Formation is the main source of groundwater in the Niger Delta area.

The Agbada Formation underlies the Benin Formation and forms the second of the three strongly diachronous Niger Delta complex Formations. It is characterized by the alteration of sandstone and sand bodies with shale layers. The upper part consists of sandstone-shale intercalation with the former predominating over the later. In the lower part, the shale units become more prominent and thicker than the intercalation sandstone or sand bodies. The Akata Formation (Paleocene to Holocene in age)

at the bottom, is the basal major transgressive lithologic unit in the Niger Delta complex. This is a marine pro-delta mega facies, comprising mainly of shales with occasional turbidities sandstone and siltstone. In some areas, it is sandy or silty in the upper part of the formation where it grades into Agbada Formation. The Stratigraphy of the Tertiary Niger Delta formation modified by Reyment, 1965 is presented in Table II

Table II: Stratigraphy of the Tertiary Niger Delta formation (modified by Reyment, 1965)

Age	Surface Formation	Subsurface Equivalent	Depositional Environments
Pliocene – Recent	Coastal Plain Sands	Benin Formation	Continental
Miocene - Recent	Ogwashi – Asaba Formation	Benin Formation	Continental
Eocene – Recent	Ameki Formation	Agbada Formation	Paralic
Paleocene – Recent	Imo Formation	Akata Formation	Marine

2.2 Drainage and Relief

The drainage pattern in the study area is dendritic with the streams draining into the Cross-River waters. The study area has an undulating topography with hills, valleys and gullies. These gullies are stream channels or flood paths.

2.3 Climate and Vegetation

The study area falls within the tropical climatic region of Nigeria. The study area is characterized by two seasons namely, the wet and the dry seasons. The wet or rainy season starts from mid- March and ends in November, slightly decreasing in the month of August (August break) and the dry season start from November and lasts till early March. The August break in the rainy season makes it possible to recognize four seasons in the area: the long rainy season (March – early August), the short dry season (August), the short rainy season (September – October), and the long dry season (November – February). The total amount of rainfall in Akwa Ibom state is about 2,500mm (98.43 in) per annum (Ekanem, 1994). A higher

number of days (174) and volume of rainfall per annum (3914mm) was recorded in 2019 when the landslide occurred than in the year 2020 which recorded 141 days of rainfall and a volume of 1,224mm per annum as shown in Table III. According to Udo-Inyang & Edem (2012), there is a gradual increase in rainfall trend from the northern highlands to the coastal parts of the south of Akwa Ibom state and this increase was more pronounced in the months of March, July and September.

3.0 Materials and Methods

A detailed field mapping was undertaken to study the area, the method adopted in this project involved reconnaissance survey of the area to determine the failed sections. The soil was drilled using a hand Auger from the ground surface to 4.0 m depth. The soil samples were collected at 1m intervals, bagged, labelled and logged for easy identification and classification before being transported to the laboratory where the percentage of natural moisture content in the soil was determined immediately. The soil samples were then air-dried before carrying out

the Atterberg limit, while for the particle size analysis, the soils were washed through a sieve with mesh size 0.15mm to remove the fine fraction, air-dried and sieved. These tests were conducted according to British standard 1377 of 1990.

4.0 Results and Discussion

4.1 Stratigraphy

Table III: Summary of the temperature and rainfall per month in 2019 & 2020. (source: Meteorological department Akwa Ibom international Airport, Akwa Ibom state)

Month	2019				2020			
	Maximum (°C)	Minimum (°C)	Total volume of rainfall per month in (mm)	No. of rainy days	Maximum (°C)	Minimum (°C)	Total volume of rainfall per month in (mm)	No. of rainy days
JAN	33.4	22.7	15.9	4	33.4	21.1	34.0	1
FEB	33.6	22.8	76.2	2	35.7	20.4	0.0	0
MAR	32.1	23.5	249.9	14	34.3	23.9	46.6	7
APR	32.2	23.5	278.8	16	32.1	23.8	80.1	12
MAY	31.3	24.1	398.9	16	32.0	24.2	133.7	16
JUNE	29.4	23.8	552.7	18	30.1	22.9	226.4	22
JULY	28.6	23.3	685.5	25	28.4	22.7	198.2	20
AUGT	28.7	22.7	534.3	19	29.2	22.5	37.5	12
SEPT	29.2	22.7	470.8	21	28.6	22.8	221.4	28
OCT	29.7	22.7	327.6	24	30.1	22.6	151.5	13
NOV	31.5	22.9	327.6	13	32.1	23.2	94.6	10
DEC	33.0	22.6	47.7	2	32.8	23.0	0.0	0
Total volume of rainfall each year			3913.8	174			1224.0	141

In location L4 Odorokpe village, a fine to medium, light brown silty sand occurs from 0-2m depth. This unit is underlain by a reddish-brown, medium to coarse sand at 2-4m depth where the drilling was terminated in this location. The clayey sand and silty clays that form the top soils between 0-2m in locations L1,

L2 and L4 will limit the flow of water through the soil, increasing water saturation within the soils. A summary of the soil sample description at different depths in the landslide locations in Ibam Edet and Odorokpe villages is presented in Table IV.

Table IV: Summary of the soil sample description at different depths in the Landslide locations in Ibam Edet and Odorokpe villages

Sample Location	Depth (m)	Lithologic Description
Location 1	0 - 2	Fine to medium grained, dark brown, clayey sand

(Ibam Edet)	2 - 4	Medium to coarse grained, reddish brown, sand
Location 2 (Ibam Edet)	0 - 2	Fine to medium grained, brown clayey sand
Location 3 (Ibam Edet)	2 - 4	Medium to coarse-grained, reddish-brown sand
Location 4 (Odorokpe)	0 - 2	Fine to medium grained, light brown, silty sand
	2 - 4	Medium to coarse-grained, reddish-brown sand

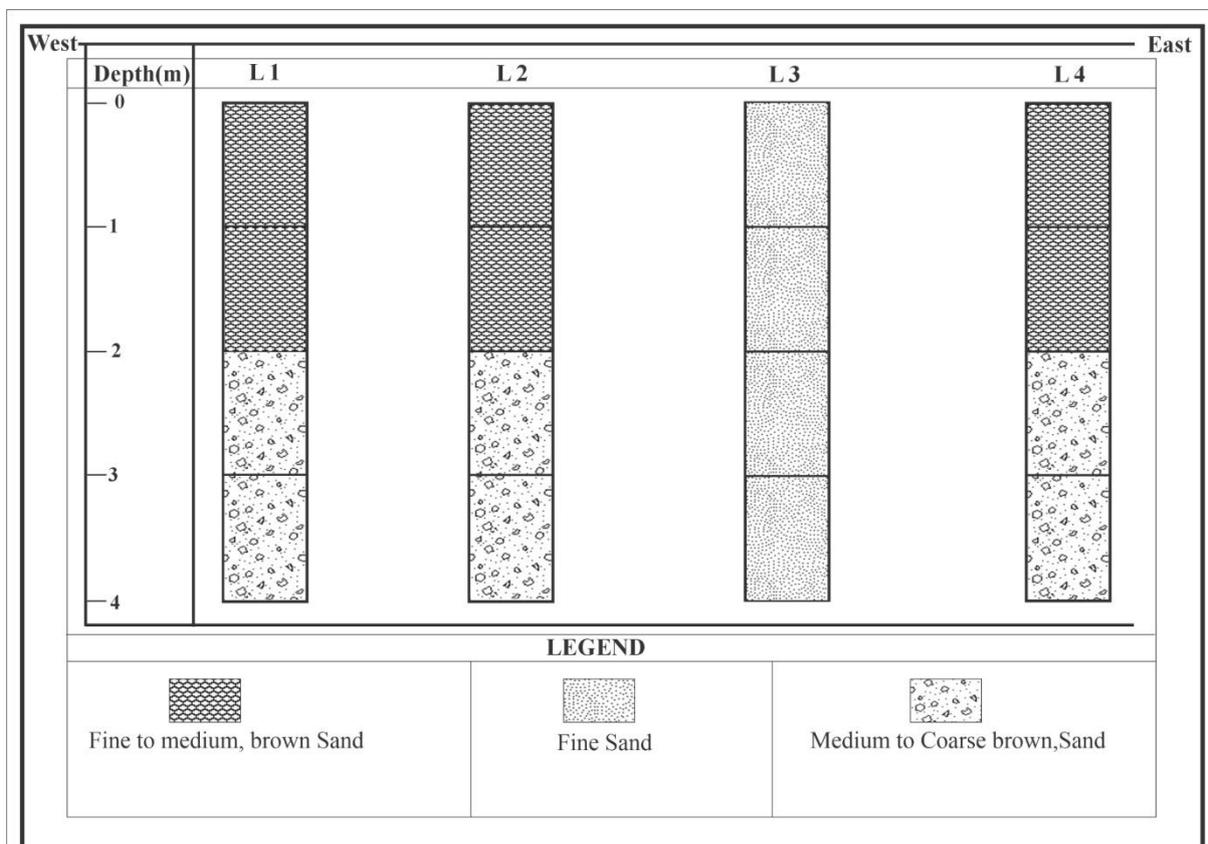


Figure 2: Subsoil Stratigraphic profile of a landslide site at Ibam Edet and Odorokpe Villages in Ini LGA, Akwa Ibom State.

4.2 Moisture Content and Atterberg Limit Results

The moisture content and Atterberg limit percentages of the soils at different depths in locations L1, L2, L3 and L4 are presented in Table V. Moisture or water content percentages of the soils in all the locations fall below 50%. Similar results have been obtained for Abija et al. 2020 in Calabar, Cross River state. At a depth of 1-2m, across the four locations, the moisture

content percentages range from 33.6% in location L1 to 39.7% in location L4, while at 2-4m depth, the moisture content percentages range from 29.5% in location L3 to 42.5% in location L1. Average moisture content percentages across the four locations L1, L2, L3 and L4 are 38.05%, 33.75%, 32% and 38.7% respectively. There is a general decline in the water content percentage with depth in locations L2, L3 and L4. The presence of water between

pore spaces reduces friction and compaction between the soil particles, thereby reducing the strength of the soil. While clays become soft and slippery when saturated because they do not allow water to drain easily making it easier for the soil mass to slide downslope, silts and sands which have a higher permeability than clays transmit and drains water quicker than clays and maintains strength better than the clays when wet.

The liquid limit values across the four locations (Table V), range from 19.7% in location (L3) to 40.4% in location (L4). Liquid limit percentages increase with depth in locations L1 and L2, while it reduces with depth in locations L3 and L4. Plasticity plots of the clays in Figures 3 and 4 showed that all the clays fell below the 50% liquid limit mark. Soils in locations L1 and L2 are classified as inorganic clays of low plasticity because they plot above the activity line (A-line) in the region of clay soils and their liquid limit

values are greater than 20% but less than or equal to 35%. Soils in location L3 are described as cohesionless soils because their liquid limit values are less than 20% ($LL < 20\%$), while soils in location L4 are described as inorganic silts of intermediate plasticity because they plot below the activity line (A-line) in the region of silts and their liquid limit values are greater than 35% but less than or equal to 50%. Similar results of the Atterberg limits have been obtained by Akpan et al. (2016) and Aigbadon et al. (2021). Clay soils are typically more susceptible to landslides especially during heavy rainfall, prolonged saturation or weathering of clay minerals. Some clay minerals expand when wet and shrink when dry. The volume changes create cracks and zones that can trigger landslides. Clays also have high cohesion, thus when rainfall infiltrates clay soils, water is trapped in the pores of the soil; because clays have a low permeability, the pore pressure increases and the shear strength reduces between the soil particles.

Table V: Moisture content and Atterberg limit characteristics of the soils

LOC	Depth of Soil (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	USCS Soil
L1	1-2	33.6	22.6	11.0	11.6	Inorganic clays of low plasticity
L1	2-4	42.5	29.6	12.9	17.0	Inorganic clay soil of low Plasticity
L2	1-2	37.3	24.9	12.4	12.5	Inorganic clays of low plasticity
L2	2-4	30.2	26.5	11.5	15.0	Inorganic clays of low plasticity
L3	1-2	34.5	19.7	16.4	3.3	Cohesionless soils
L3	2-4	29.5	18.6	12.5	6.1	Cohesionless soils
L4	1-2	39.7	40.4	26.7	13.7	Inorganic silts of intermediate plasticity
L4	2-4	37.7	39.7	25.8	14.0	Inorganic silts of intermediate plasticity

L1-Ibam Edet, L2-Ibam Edet, L3-Ibam Edet, L4-Odoroikpe, USCS- Unified Soil Classification System

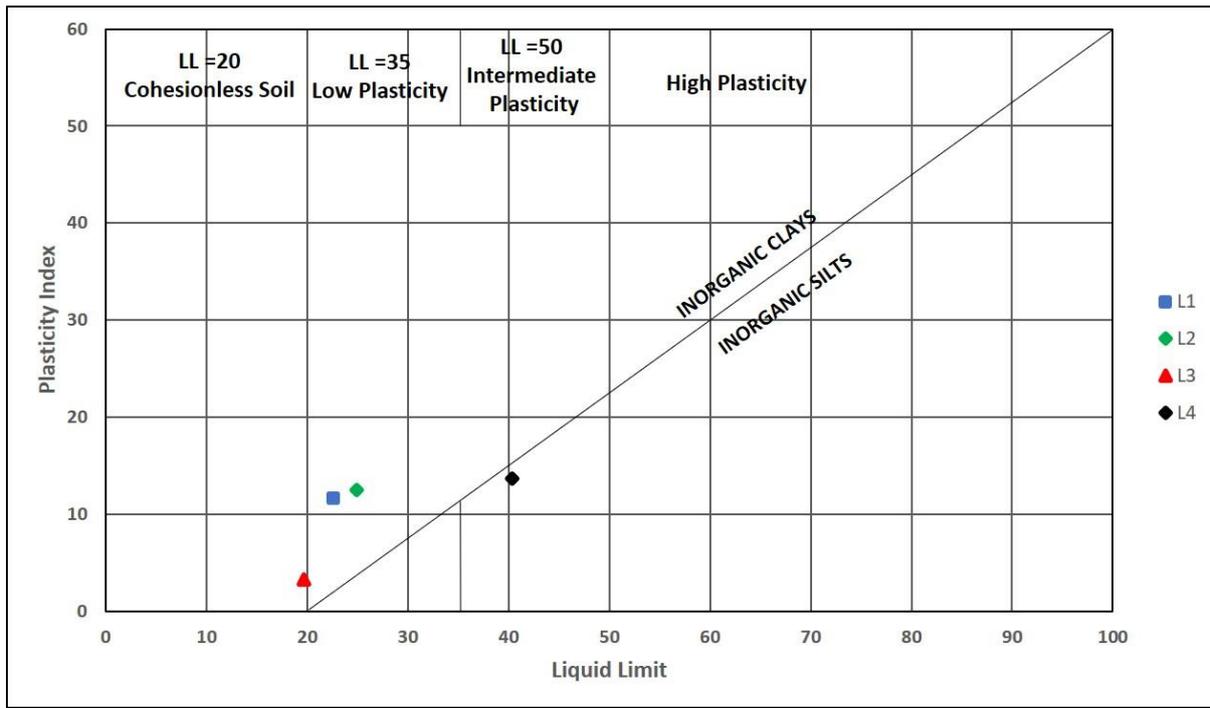


Figure 3: Soils at a depth of 1-2m from the different locations showing their classifications on the plasticity plot

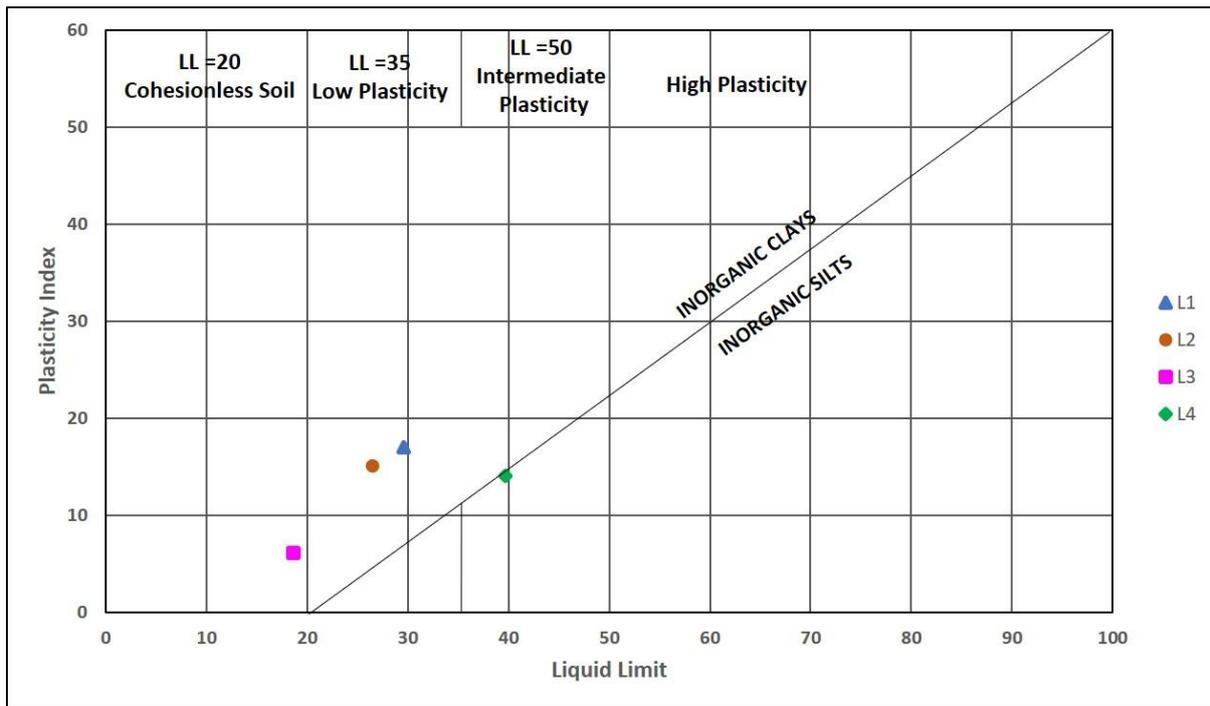


Figure 4: Soils at a depth of 2-4m from the different locations showing their classifications on the plasticity plot

Particle size distribution of the analysis of the sands shows a poorly /uniformly graded fine to medium to coarse sand with a very minimal percentage of the fine fraction passing through D^{50} and D^{60} and the absence of a soil fraction finer than D^{10} (Figure 5). The medium sand

fraction has a higher percentage than the fine and coarse sand fractions as shown in Table VI. Similar results of the particle size distribution have been obtained by Ogbonnaya et al. (2015) and Ayodele et al. (2020). The sands are free draining because of their high porosity and lack

of cohesion. The stability of the soil mainly depends on friction between soil particles thus, during heavy and prolonged rainfall or saturation, water occupies the pore spaces

reducing friction between the soil particles. The particles lose contact with one another resulting in a reduction in the strength of the soil or its failure.

Table VI: Particle size distribution analysis of the soils

LOC	D ¹⁰	D ⁵⁰	D ⁶⁰	CU	% fine sand fraction	% medium sand fraction	% coarse sand fraction	USCS SOIL
L1	0	0.14	0.28	0.28	6	27	12	Poorly/ Uniformly graded soil
L1	0	0.12	0.22	0.22	18	23	15	Poorly/ Uniformly graded soil
L2	0	0.11	0.21	0.28	14	23	13	Poorly/ Uniformly graded soil
L3	0	0.21	0.30	0.22	20	27	11	Poorly/ Uniformly graded soil
L4	0	0.19	0.31	0.31	16	36	12	Poorly/ Uniformly graded soil
L4	0	0.19	0.25	0.25	24	26	16	Poorly/ Uniformly graded soil

USCU- Unified Soil Classification System

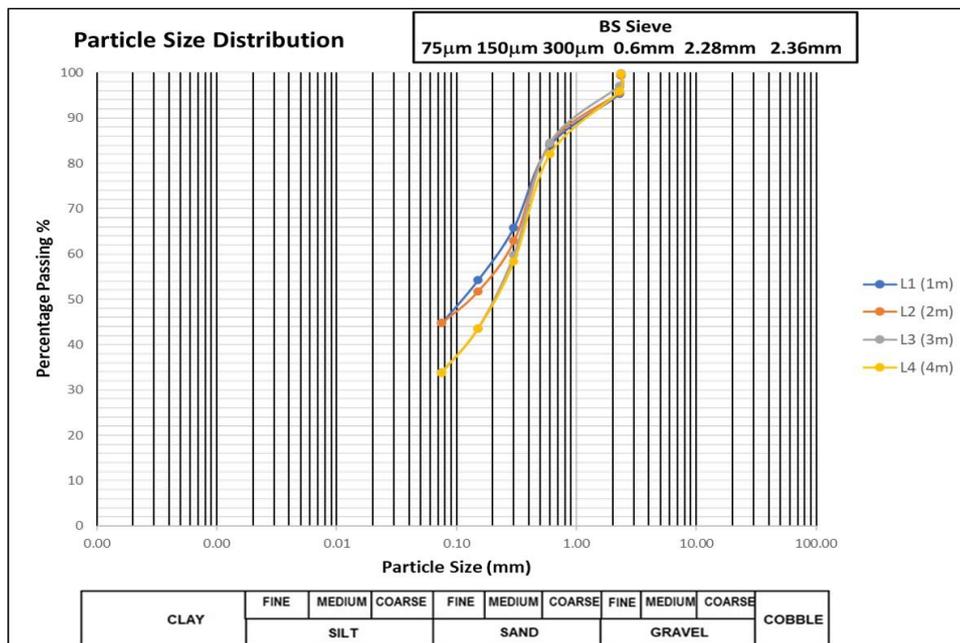


Figure 5: Typical Particle size distribution plots in locations L1 (1m), L2 (2m), L3 (3m) and L4 (4m) showing poorly/uniformly graded soils.

5.0 Conclusion

The subsoil stratigraphy at Ibam Edet consists of a fine to medium grained clayey sand from 0 - 2 m, underlain by a medium to coarse sand from 2 - 4 m in Locations L1 and L2 in Ibam Edet; while in Location L3 in Ibam Edet, a fine sand occurs from 0 - 4 m depth where the drilling was

terminated. In location L4 Odorokpe village, a fine to medium, silty sand occurs from 0 - 2 m depth. This unit is underlain by a medium to coarse sand at 2 - 4 m depth where the drilling was terminated in this location. Average moisture content percentages across the four locations L1, L2, L3 and L4 show a general

decline in the water content percentage with depth in locations L2, L3 and L4. Liquid limit percentages across the four locations show an increase in liquid limit with depth in locations (L1 and L2) and a decrease with depth in locations (L3 and L4). The soils in locations L1 and L2 are classified as inorganic clays of low plasticity, soils in location L3 are described as cohesionless soils and soils in location L4 are described as inorganic silts of intermediate plasticity because they plot below the activity line in the region of silt. In conclusion, the presence of clays and silts in the sands between 0 – 2 m in locations L1, L2 and L4 limit the flow of water through the soil because of their low permeability, increasing water saturation within the soil. Fine grained soils such as clays and silts are typically more susceptible to landslides especially during heavy rainfall, prolonged saturation or weathering of clay minerals. As recorded in 2019, a higher number of days (174) and volume (3914mm) of rainfall per annum occurred in 2019 when the landslide occurred than in the year 2020. Although clays have a high cohesion, when rainfall infiltrates clay soils, water is trapped in the pores of the soil. The pore pressure within the clay soils increases and their shear strength reduces which may lead to failure of the soil and a landslide. Particle size distribution analysis of the sands shows poorly/uniformly graded, fine to medium to coarse sands with the medium sand fraction having a higher percentage than the fine and coarse sand fractions. Sands lack cohesion thus, during prolonged and heavy rainfall or saturation, water reduces friction between the soil particles leading to instability of the soil and in extreme cases failure or a landslide.

References

- Abija, F. A, Nwosu, J. I, Ifedotun, A. I. & Osadebe, C. C. 2020. Landslide susceptibility of Calabar, Nigeria using Geotechnical, Remote sensing and Multi-criteria Decision Analysis: Implications for Urban planning and Development. *Journal of Earth Sciences and Environmental studies*, Vol. 4, No. 3, Pp. 774-788.
- Akpan, A. E, Ekwok, S. E & Ebong, D. E. (2016). Seasonal reversals in groundwater flow direction and its role in the recurrent Agwagune Landslide problem: a geophysical and geological approach. *Environmental Earth Science*, Vol 75. No. 429, Pp. 1-17.
- Aigbadon, G. O, Ocheli, A. & Akudo, E. O. (2021). Geotechnical evaluation of gully erosion and landslides materials and their impact in Iguosa and its environs. Southern Nigeria. *Environmental Systems Research*, Vol. 10. No. 36, Pp. 1-17.
- Ayodele, O. S, Olayanju, G. M. & Adeosun, O. E. (2020). Geological Assessment of Landslide occurrences in Okemesi Area, Southwestern Nigeria. *American Journal of Environmental Engineering*. Vol. 10. No. 1, Pp. 13-19.
- Effiong, J., Eni, D. I, Obiefuna, J. N. & Etu, S. J. (2021). Geospatial modelling of Landslide susceptibility in Cross River State of Nigeria. *Scientific Africana*. Vol. 14. Pp. 1-14.
- Egboka, B. C, Orji, A. E. & Nwankwoala, H. O. (2019). Gully Erosion and Landslides in South eastern Nigeria: Causes, Consequences and Control measures. *Global Journal of Engineering Sciences*. Vol. 2 No. 4. Pp. 1-11.
- Ekanem, E. M. (1994). Urban Sedimentation problems in the Humid tropical city of Uyo. *Ibom Journal of Social Science Uyo*. Faculty of Social Sciences. Vol. 1. No.2. Pp 8-17.
- Ibanga, M. (2021). Geophysical investigation of Landslide occurrence in Northern Akwa Ibom state. *Unpublished B.Sc. Thesis*.

- Department of Geology, Akwa Ibom state University*. Pp 1-33.
- Igwe, C. & Una, C. (2019). Landslide impacts and management in Nanka area, South east Nigeria. *Geo environmental Disasters (science Direct)*. Pp 1-12.
- Kim, M. S, Onda, Y, Uchida, T, Kim, J. k (2016). Effects of soil depth and subsurface flow along the subsurface topography on shallow landslide predictions at the site of a small granitic hillslope. *Geomorphology (Science Direct)*. Vol. 271. Pp. 40-54.
- Ogbonnaya, I, Brooks, A. E, Maduka, R. I and Oha, I. A. (2015). Landslide Investigation of Ikwette, Obudu Local Government Area of Cross River State, Nigeria. *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)*. Vol. 3, No.3. Pp 1-12.
- Okogbue, C. O. (1994). Classification and distribution of recent landslides in Southern Nigeria. *Engineering Geology*. Vol. 37. No. 3-4, Pp. 263-270.
- Okogbue, C. O. (2003). A landslide in a quasi-stable slope. *Engineering Geology*. Vol. 25, No. 1. Pp 69-82.
- Reyment, R. A. (1965). Aspects of Geology of Nigeria. *University of Ibadan Press*. P. 145.
- Short, K. C and Stauble, A. J. (1967). Outline of the Geology of the Niger Delta. American Association of Petroleum Geologists. Vol. 56. Pp. 761-799.
- Situmorang, H, Nurhasan, N, Rusdiana, R, Viridi, S and Fitriani, D (2022). Subsurface Structure Analysis of Landslide Potential Areas Based on Electrical and Physical properties of soil. *Journal of Physics: Conference Series 2377 012044*.
- Udo-Inyang, U. C. & Edem, I. D. (2012). Analysis of rainfall trends in Akwa Ibom State. *Journal of Environment and Earth Science*. Vol. 2. No.8, Pp 60-70.
- Udosen, C., Etok, A. & Essien, A. (2014). Predictive Analysis of Landslide Susceptibility with GIS-DEMs in Uyo, South Eastern Nigeria. *Journal of Geology and Geomatics Engineering*. Vol.1 Pp 42-50.