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Determination of Incompressibility (Bulk Modulus), Elasticity (Young's Modulus) and Rigidity (Shear Modulus) of Uyo and Its Environ, Southeastern Nigeria

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Abstract

In this work, seismic refraction was used to obtain elastic properties (shear modulus (μ), Young modulus (*E*), Bulk modulus (*K*) and lithological information in Uyo and its environ as an aid to engineering foundation. Using seismic refraction method, the top and weathered layer of the engineering foundation in the study area was investigated to determine the elastic parameters of top soil and also assess the strength of engineering foundation based on the parameter distribution. A 24-channel signal enhancement seismograph, geophones, sledge hammer and a metal plate (source) for generating seismic waves were used. The study area lies between latitudes 4˚45' and 5˚15'N and between longitudes 7˚45' and 8˚30'E in the Niger Delta region of southern Nigeria. Geologically, the area is located in the Tertiary to Quaternary Coastal Plain Sands (CPS) (otherwise called the Benin Formation) and Alluvium environments of the Niger Delta region of southern Nigeria. Shear Modulus had average values of 0.43×10^8 N/m^2 and 1.40×10^8 N/m^2 for layers 1 and 2 respectively. The average values of the Young Modulus for layers 1 and 2 were determined as 2.32×10^8 N/m^2 and 3.84×10^8 N/m^2 respectively. The average values of the bulk Modulus for layers 1 and 2 were estimated as 1.52×10^8 N/m^2 and 4.93×10^8 N/m^2 respectively.

Keywords

Uyo, Velocity, Seismic Refraction, Sediments, V_p/V_s

1. Introduction

Rock/soil elastic properties are sources of valuable information for most projects in rock/soil mechanics as the knowledge of deformational characteristics of rocks/soils are vital in locating and extracting mineral resources and designing and constructing any structure on the rock or soil. Geotechnical testing has increasingly been used for geotechnical investigation to identify subsurface irregularities, such as fill, cavities and variable strata (Budhu & Al-Karni, 1993). It can also be used to obtain quantitative information that is useful for foundation assessment and design.

Due to the incessant failure of roads and collapse of buildings in Nigeria and Uyo in Akwa Ibom State in particular, the need to find a lasting solution to these problems led to the undertaking of this research work. In this work, seismic refraction was used to obtain the elastic properties and lithological information as an aid to engineering foundation. The earth model is assumed to be spherically symmetric non-rotating, elastic and isotropic in nature (Ogagarue & Asor, 2010). Using seismic refraction method, the top and weathered layer of the engineering foundation in Uyo senatorial district of Akwa Ibom State, Nigeria was investigated to determine the elastic parameters of top soil and also assess the strength of engineering foundation based on the parameter distribution. The results obtained will help in the development of the geotechnical aspect of Geophysics.

2. Elastic Moduli and Their Characteristics

The application of external forces to an elastic body produces a balance in internal body focus within a body. The force in this case is elastic, produced by expansion or compression as the case may be when a wave propagates through the body. Therefore the whole elastic force arising from the passage of wave is given by $\Delta T_{xx}S$, where ΔT_{xx} is the change in stress. Thus,

$$\frac{\Delta T_{xx}\Delta X_s}{\Delta X} = \rho\Delta XS\frac{\mathrm{d}^2u}{\mathrm{d}t^2} \tag{1}$$

The equation of motion for the wave is

$$\rho\frac{\mathrm{d}^2u}{\mathrm{d}t^2} = \frac{\mathrm{d}T_{xx}}{\mathrm{d}x} \tag{2}$$

$$\rho\mathrm{d}^2u = \frac{\mathrm{d}T_{xx}}{\mathrm{d}Y_{xx}} = \frac{\mathrm{d}Y_{xx}}{\mathrm{d}x} \tag{3}$$

Substituting Equations (2) into (3) gives

$$\frac{\rho\mathrm{d}^2U}{\mathrm{d}t^2} = \frac{\mathrm{d}T_{xx}}{\mathrm{d}Y_{xx}} = \frac{X\mathrm{d}^2U}{\mathrm{d}x^2} \tag{4}$$

$$\frac{\mathrm{d}T}{\mathrm{d}Y} = \text{constant} \tag{5}$$

where $\mathrm{d}T$ is stress and $\mathrm{d}Y$ is strain. This quantity $\mathrm{d}T/\mathrm{d}Y$ for isotropic body is constant and is known as elastic modulus (parameter). The direct relationship between stress and strain in the elastic field is unique for any material by its different elastic moduli, each of which expresses the ratio of a particular type of stress to a particular strain (Domenico, 2012).

2.1. Young's Modulus (*Y*)

If the body is stretched with a lateral force from stress, the constant would be the Young's modulus. Mathematically, Young's Modulus (*E*) =

$$\frac{\text{Longitudinal Stress}\left(\frac{f}{A}\right)}{\text{Longitudinal Strain}\left(\frac{\Delta L}{L}\right)}$$ expressed in N/m^2.

Young's modulus (*E*) can be calculated using Equation (6) below

$$E = 2\mu(1+\sigma) \tag{6}$$

where μ is shear modulus and σ is the Poisson's ratio.

2.2. Bulk Modulus (*K*)

The bulk modulus (*K*) expresses the stress-strain ratio as in simple hydrostatic pressure *P*, the resultant volume strength being the change in volume ΔV divided by the original volume. That is

$$K = \frac{\text{Volume Stress}(\rho)}{\text{Volume Strain}(\Delta V)} \tag{7}$$

Bulk Modulus (*K*) can be calculated using Equation (8) below

$$K = \frac{2\mu(1+\sigma)}{3(1-2\sigma)} \tag{8}$$

where μ is shear modulus and σ is the Poisson's ratio.

2.3. Shear Modulus (μ)

It is the measure of an ability of an object to withstand or oppose the shape from being deformed under a tangential stress condition. The tangential forces due to seismic wave propagation in a medium produce an angle of shear (θ). Therefore shear modulus is defined as the ratio of shear stress to the resultant shear strain.

Mathematically, $\text{shear modulus}(\mu) = \frac{\text{shear stress}}{\text{shear strain}} = \frac{\text{Force/Area}}{\text{Extension/Original length}}$

The formula below is used to calculate the Shear Modulus (μ)

$$\mu = \rho V_s^2 \tag{9}$$

or

$$\mu = \frac{E}{2(1+\sigma)} \tag{10}$$

where *E*, μ and ρ are Young's modulus, Shear modulus and average density (2200 kg/m^3) respectively.

3. Location and Geology of the Study Area

The study area shown in **Figure 1**, lies between latitudes 4˚45' and 5˚15'N and between longitudes 7˚45' and 8˚30'E in the Niger Delta region of southern Nigeria. It covers an area of about 1110.1 km^2. It is located in an equatorial climatic region that is characterised by two major seasons: the rainy season (March-October) and dry season (November-February) (Evans et al., 2010; George et al., 2010a, 2010b). The dry season is a period of extreme aridity characterized by excruciating high temperatures that could climb to 35˚C. The area has been severely affected by the current global climatic changes in such a way that there have been shifts in both the upper and lower boundaries of these climatic conditions (Martínez et al., 2008; Rapti-Caputo, 2010; Riddell et al., 2010; Wagner & Zeckhauser, 2011; Farauta et al., 2012).

Geologically, the study area is located in the Tertiary to Quaternary Coastal Plain Sands (CPS) (otherwise called the Benin Formation) and Alluvium environments of the Niger Delta region of southern Nigeria as shown in **Figure 1**. The sediments of the Benin Formation consist of interfringing units of lacustrine and fluvial loose sands, pebbles, clays and lignite streaks of varying thicknesses while the alluvial units comprise tidal and lagoonal sediments, beach sands and soils (Emujakporue & Ekine, 2009; Reijers et al., 1997; Nganje et al., 2007) mostly found in the southern parts and along the river banks. The CPS is covered by thin lateritic overburden materials with varying thicknesses at some locations but is massively exposed near the shorelines. The CPS constitutes the engineering foundations in the area. It comprises poorly sorted continental (fine-medium-coarse) sands and gravels that alternate with lignite streaks, thin clay horizons and lenses at some locations (Essien & Akankpo, 2013; Essien et al., 2014). The coastal plain sand covers 80 percent of the area and forms the major aquiferous and foundation zones of the study area. Thin clay horizons and

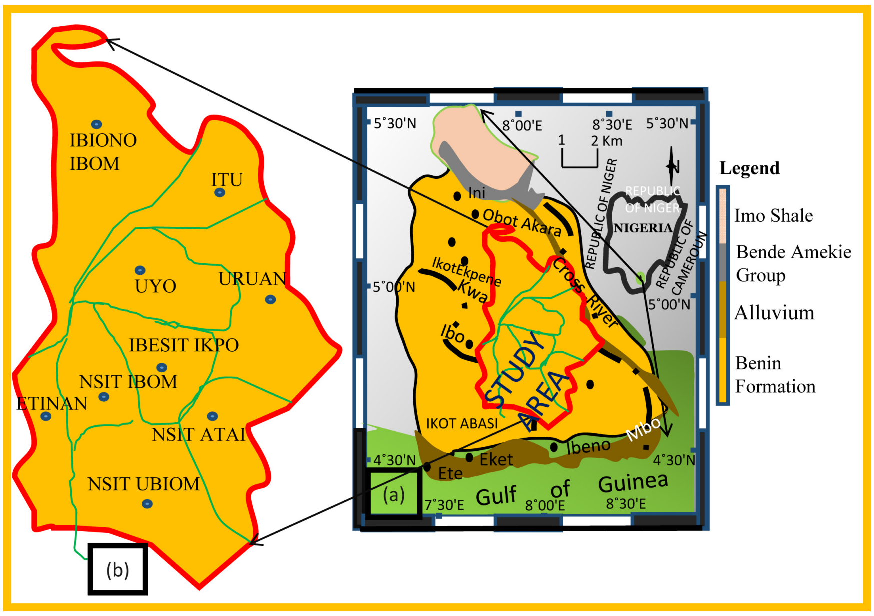


Figure 1. Map showing the study area location and general geology of Akwa Ibom State of Nigeria (a) and the nine (9) central Local Government Areas in Uyo Senatorial district that the study area situates (b).

lenses disturb the horizontal and vertical systems that make up the subsurface (Emujakporue & Ekine, 2009). The area is generally porous and permeable and this is usually interrupted by clay-sand sequence at different depths (Okwueze, 1991; Ekwueme & Onyeagoda, 1985).

4. Materials and Methods

In this study, a 24-channel signal enhancement seismograph, geophones, sledge hammer and a metal plate (source) for generating seismic wave were used. The electromagnetic geophone which were in direct contact with the earth, transformed the seismic energy generated by the source to electrical voltage which is a function of velocity. The mechanically generated seismic disturbances sensed by the geophones were received and recorded by a seismograph cascaded with the geophones (Reynolds, 1997). The double seismic source, in which one of them was for shear wave source and the other, compressional wave source, has two set of geophones for the S-wave and P-wave respectively (Kesavula, 1993). The generated energy penetrated into the subsurface and refracted off at various interfaces corresponding to the geological boundaries and consequently returned to the surface at later time to be picked up by the geophone (Kearey & Brooks, 1991). The seismic wave received by the geophone was converted into electrical pulse and was amplified by the preamplifier.

This plot was printed out from the seismograph from which arrival times were obtained. The refraction time-distance measurement at the surface of the ground led to the determination of V_p/V_s ratio and other principal properties of the near surface rocks. P-wave and S-wave velocities were obtained from seismic refraction survey covering a spread line of 50 m, with 2 m geophones spacing in the foundation layer of Uyo and its environs of Akwa Ibom State, Southern Nigeria. The arrival times of recorded signal (seismogram) were picked and plotted against the offset distance using IX Refrax and Pickwin software programmes.

5. Results and Discussion

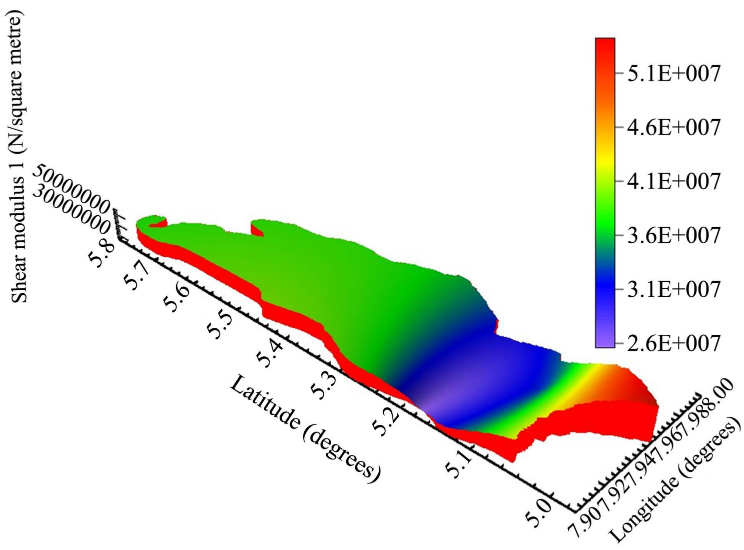
The summary of the geoelastic parameters such as shear modulus (μ), Young modulus (E), Bulk modulus (K) is presented in **Table 1**, while the detailed parameters and the geographic coordinates taken from global positioning system (GPS) radar are presented in Appendix **Table A1**. The estimation of these parameters was necessary in order to evaluate the geotechnical strength of the foundation layers. Shear modulus (μ) values ranged from 0.21×10^8 to 0.63×10^8

Table 1. Summary of layer parameters in the study area.

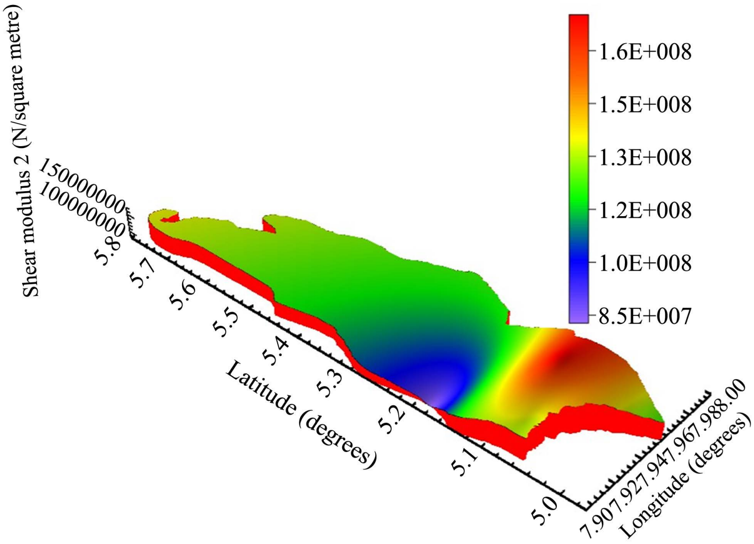
Layers	$\mu \times 10^8$ (N/m²)			$E \times 10^8$ (N/m²)			$K \times 10^8$ (N/m²)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
L_1	0.21	0.63	0.43	0.58	9.56	2.32	0.76	2.22	1.52
L_2	0.78	2.55	1.40	2.15	6.99	3.84	2.77	8.95	4.93

N/m² with an average of 0.43×10^8 N/m² for layer 1 and 0.78×10^8 to 2.55×10^8 N/m² with an average of 1.40×10^8 N/m² for layer 2. The higher values of Shear moduli increases the cohesion of the topsoil.

Using 3D contour maps in **Figure 2(a)** and **Figure 2(b)**, the distribution of the shear modulus or modulus of rigidity in the study area was examined. Generally, the topsoil under study has shear modulus ranging from 21,200 kPa - 255,000 kPa with an average value of 93,200 kPa. Comparing these to the table of shear modulus (**Table 2**) generated by Sawangsuriya (2012), the geoelastic parameters of the engineering foundation fall within dense sands and gravels as well as silty sands. The Ultimate Bearing capacity depends on the soil type, moisture content, compaction and the amount of uniformity of the formation.



(a)



(b)

Figure 2. 3-D blanked contour map of layer 1 shear modulus (a) and layer 2 shear modulus (b) showing their distributions in the study area.

Table 2. Typical ranges of values of shear modulus for different types of soil formations (after Sawangsuriya, 2012).

Soil Type	Shear Modulus, (kPa)
Dense Sands & Gravels	69,000 - 345,000
Silty Sand	27,600 - 138,000
Medium Stiff Clay	6900 - 34,500
Soft Clays	2750 - 13,750

Soils with high arenaceous formations have a higher bearing capacity than soil with high argillaceous materials (Atat et al., 2013). The range indicates that the topsoil under study can support load that is being subjected to shear stress, provided the materials within the layer are well compressed. The considered foundation layers are cohesionless, gritty and therefore not susceptible to creep, erosion and failures provided proper compaction is done during road construction.

Figure 3(a) and Figure 3(b) represent the 3D display of Young's modulus in the study area. The Young's modulus (E) values for layer 1 ranged from 0.58×10^8 to 9.56×10^8 N/m^2 with an average of 2.32×10^8 N/m^2 and 2.15×10^8 to 6.99×10^8 N/m^2 for layer 2 with an average of 3.84×10^8 N/m^2. The higher values of Young's modulus as seen increases the elasticity of the soil. The contour maps display of Young's moduli indicates that the topsoil has high degree of rigidity and cannot be subjected to creep and failure in a linearly compressed condition. On the average, Young modulus increases from the north towards the southern part of the study area. In this study, dense and silty sand formations characterised by physical and elastic properties that are nearly homogenous suggest that in many locations, the topsoil does not have the attribute of creeping or failing except compaction is not adequately uniform.

Figure 4(a) and Figure 4(b) represent the 2D blanked contour map of layer 1 and layer 2 bulk moduli in the study area. Bulk modulus (K) values for layer 1 ranged from 0.76×10^8 to 2.22×10^8 N/m^2 with an average of 1.52×10^8 N/m^2 while that of layer 2 ranged from 2.77×10^8 to 8.95×10^8 N/m^2 with an average of 4.93×10^8 N/m^2. The bulk modulus, describes the elastic properties of a solid or fluid when it is under pressure on all surfaces. The present topsoil in this work has in positive bulk modulus. This signifies that when pressure is imposed and then removed, the formation will not be deformed. The high value of Bulk modulus is very desirable because it will not deform the soil, instead increases the compaction of the soil.

In a similar study conducted in Eket, Akwa Ibom State the following results were obtained: Young's modulus E (-40.772×10^8 to 16.1481×10^8 N/m^2), Bulk Modulus K (-0.7964×10^8 to 7.6896×10^8 N/m^2) and Shear modulus μ (1.3751×10^8 to 7.0209×10^8 N/m^2) (Essien et al., 2016). The findings in Eket revealed that a reasonable thickness of the top layer was porous, swampy, air-filled and weak. From the findings, wildcat engineering use of the top soil and weathered soil for construction should be discouraged.

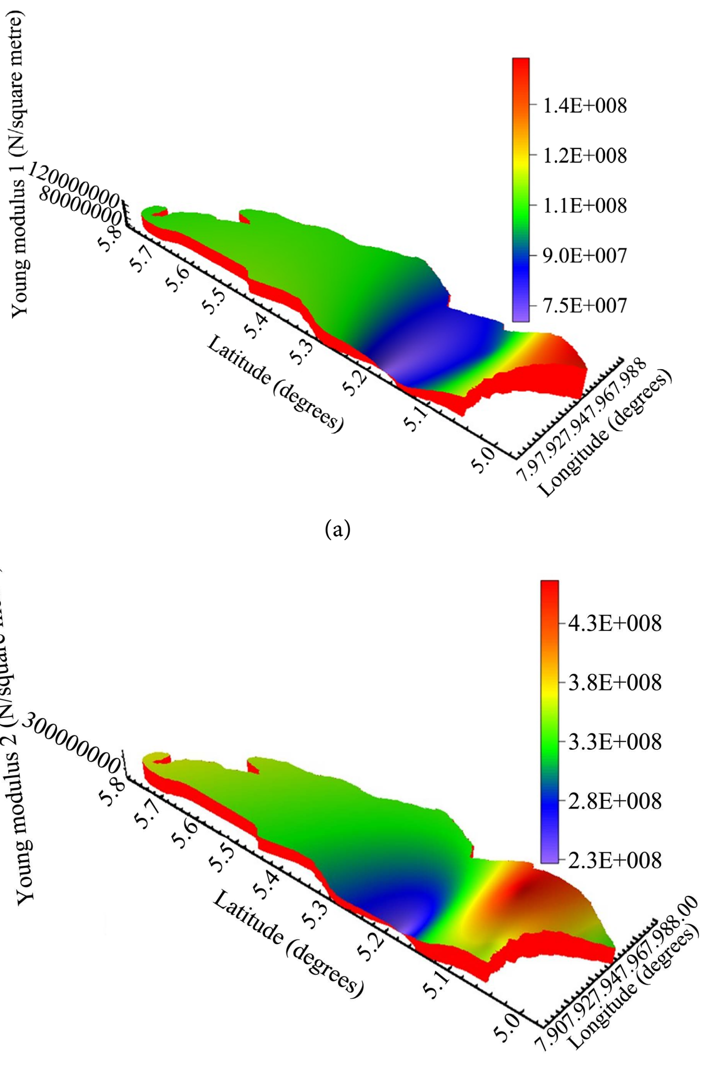


Figure 3. 3-D blanked contour map of layer 1 Young's modulus (a) and layer 2 Young's modulus (b) showing their distributions in the study area.

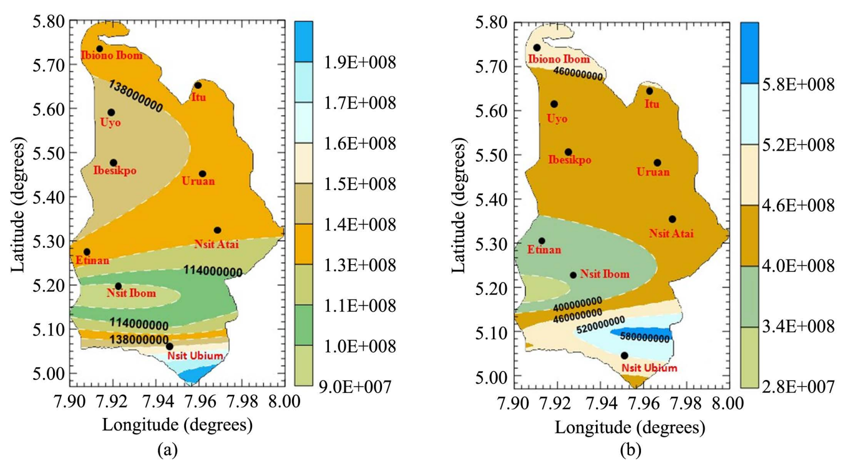


Figure 4. Blanked 2D contour map of layer 1 bulk modulus (a) and layer 2 bulk modulus (b), showing their distributions in the study area.

6. Conclusion

The results of refraction technique have been used to characterise the cohesionless (friable) topsoil in parts of Uyo and its environ, Akwa Ibom State, Nigeria. Parameters determined were: Shear Modulus whose averages and ranges for layers 1 and 2 were 0.43×10^8 N/m^2 and 1.40×10^8 N/m^2; 0.21×10^8 to 0.63×10^8 N/m^2 and 0.78×10^8 to 2.55×10^8 N/m^2 respectively. The averages and ranges of the Young Modulus for layers 1 and 2 were also determined as 2.32×10^8 N/m^2 and 3.84×10^8 N/m^2; 0.58×10^8 to 9.56×10^8 N/m^2 and 2.15×10^8 to 6.99×10^8 N/m^2 respectively. The averages and ranges of the bulk Modulus for layers 1 and 2 were estimated as 1.52×10^8 N/m^2 and 4.93×10^8 N/m^2; 0.76×10^8 to 2.22×10^8 N/m^2 and 2.77×10^8 to 8.95×10^8 N/m^2 respectively. The higher values of Shear moduli increase the cohesion of the topsoil. The higher values of Young's modulus as seen increase the elasticity of the soil. The high value of Bulk modulus is very desirable because it will not deform the soil, instead increasing the compaction of the soil.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Atat, J. G., Akpabio I. O., & George, N. J. (2013). Allowable Bearing Capacity for Shallow Foundation in Eket Local Government Area, Akwa Ibom State, Southern Nigeria. *International Journal of Geosciences, 4,* 1491-1500. https://doi.org/10.4236/ijg.2013.410146

Budhu, M., & Al-Karni, A. (1993). Seismic Bearing Capacity of Soils. *Geotechnique, 43,* 181-187. https://doi.org/10.1680/geot.1993.43.1.181

Domenico, S. N. (2012). Elastic Properties of Unconsolidated Porous Sand Reservoirs. *Geophysics, 4,* 1321-1563.

Ekwueme, B. N., & Onyeagoda, A. C. (1985). Metamorphic Isograds of Uwet Area Southeastern Nigeria. *Journal of African Earth Sciences, 3,* 443-454. https://doi.org/10.1016/S0899-5362(85)80087-7

Emujakporue, G. O., & Ekine, A. S. (2009). Determination of Rocks Elastic Constants from Compressional and Shear Wave Velocities for Western Niger Delta, Nigeria. *Journal of Applied Science and Environmental Management, 13,* 53-55. https://doi.org/10.4314/jasem.v13i3.55364

Essien, U. E., & Akankpo, A. O. (2013). Compressional and Shear Wave Velocity Measurement in Unconsolidated Topsoil in Eket, South-Eastern Nigeria. *Pacific Journal of Science and Technology, 14,* 476-491.

Essien, U. E., Akankpo, A. O., & Igboekwe, M. U. (2014). Poisson's Ratio of Surface Soils and Shallow Sediment Determined from Seismic Compressional and Shear Wave Velocities. *International Journal of Geosciences, 5,* 1540-1546. https://doi.org/10.4236/ijg.2014.512125

Essien, U. E., Igboekwe, M. U., & Akankpo, A. O. (2016). Determination of Incompressibility, Elasticity and Rigidity of Surface Soils and Shallow Sediments from Seismic Wave Velocities. *Journal of Earth Sciences and Geotechnical Engineering, 6,* 99-111.

Evans, U. F., George, N. J., Akpan, A. E., Obot, I. B., & Ikot, A. N. (2010) A Study of Superficial Sediments and Aquifers in Parts of Uyo Local Government Area, Akwa Ibom State, Southern Nigeria, Using Electrical Sounding Method. *E-Journal of Chemistry, 7,* 1018-1022. https://doi.org/10.1155/2010/975965

Farauta, B. K., Egbule, C. L., Agwu, A. E., Idrisa, Y. L., & Onyekuru, N.A. (2012). Farmers' Adaptation Initiatives to the Impact of Climate Change on Agriculture in Northern Nigeria. *Journal of Agricultural Extension, 16,* 132-144. https://doi.org/10.4314/jae.v16i1.13

George N. J., Akpan A. E. and Obot, I. B. (2010a) Resistivity Study of Shallow Aquifer in the Parts of Southern Ukanafun Local Government Area, Akwa Ibom State. *E-Journal of Chemistry, 7,* 693-700. https://doi.org/10.1155/2010/323969

George, N. J., Obianwu, V. I., Akpan, A. E., & Obot, I. B. (2010b). Assessment of Shallow Aquiferous Units and Coefficients of Anisotropy in the Coastal Plain Sand of Southern Ukanafun Local Government Area, Akwa Ibom State, Southern Nigeria. *Archives of Physics Research, 1,* 118-128.

Kearey, P., & Brooks, M. (1991). *An Introduction to Geophysical Exploration* (2nd ed., pp. 22-23, 96-115). Blackwell Scientific Publications Limited.

Kesavula, N. C. (1993). *Textbook of Engineering Geology* (pp. 73-101). Macmillan.

Martínez, A. G., Takahashi, K., Núñez, E., Silva, Y., Trasmonte, G., Mosquera, K., & Lagos, P. (2008). A Multi-Institutional and Interdisciplinary Approach to the Assessment of Vulnerability and Adaptation to Climate Change in the Peruvian Central Andes: Problems and Prospects. *Advances in Geosciences, 14,* 257-260. https://doi.org/10.5194/adgeo-14-257-2008

Nganje, T. N., Edet, A. E., & Ekwere, S. J. (2007). Concentrations of Heavy Metals and Hydrocarbons in Groundwater Near Petrol Stations and Mechanic Workshops in Calabar Metropolis, South-Eastern Nigeria. *Journal of Environmental Geosciences, 14,* 15-29. https://doi.org/10.1306/eg.08230505005

Ogagarue, D. O., & Asor, V. E. (2010). Application of Cross Correlation for Global Velocity Quantity Control in Seismic Imaging. *Australian Journal of Basic and Applied Sciences, 4,* 4995-4999.

Okwueze, E. E. (1991). Shear Wave Observation Seismic Refraction Prospecting. *Journal of Mapping and Geology, 24,* 61-65.

Rapti-Caputo,D. (2010). Influence of Climatic Changes and Human Activities on the Salinization Process of Coastal Aquifer Systems. *Italian Journal of Agronomy / River Agronomy*, 3, 67-79. https://doi.org/10.4081/ija.2010.s3.67

Reijers, T. J. A., Petters, S. W., & Nwajide, C. S. (1997). The Niger Delta Basin. In R. C. Selley (Ed.), *African Basins—Sedimentary Basins of the World* (Vol. 3, pp. 151-172). Elsevier Science. https://doi.org/10.1016/S1874-5997(97)80010-X

Reynolds, J. M. (1997). *An Introduction to Applied Environmental Geophysics* (p. 780). Wiley.

Riddell. E. S., Lorentz, S. A., & Kotze, D. C. (2010). A Geophysical Analysis of Hydro-geomorphic Controls within a Headwater Wetland in a Granitic Landscape, through ERI and IP. *Journal of Hydrology and Earth System Sciences, 14,* 1697-1713. https://doi.org/10.5194/hess-14-1697-2010

Sawangsuriya, A. (2012). Wave Propagation Methods for Determining Stiffness of Geomaterials. In M. Giovine (Ed.), *Wave Processes in Classical and New Solids* (pp. 157-200). http://dx.doi.org/10.5772/48562

Wagner, G., & Zeckhauser, R. J. (2011). Climate Policy: Hard Problem, Soft Thinking. *Climatic Change, 110,* 507-521. https://doi.org/10.1007/s10584-011-0067-z

Appendix

Table A1. Summary of layer parameters and elastic properties in the study area.

Location Name	Number	Latitude (˚)	Longitude (˚)	Elevation (m)	Layer	σ	$\mu \times 10^8$ (N/m^2)	$E \times 10^8$ (N/m^2)	$K \times 10^8$ (N/m^2)
Etinan	1	5.9833	7.8500	67.00	L1	0.3716	0.37	1.00	1.30
					L2	0.3701	1.41	3.86	4.95
	2	4.9500	7.8333	61.00	L1	0.3712	0.48	1.33	1.72
					L2	0.3702	1.15	3.15	4.04
	3	4.8333	7.8510	31.00	L1	0.3713	0.45	1.24	1.61
					L2	0.3703	1.11	3.04	3.91
Nsit Ibom	1	4.8166	7.8330	36.00	L1	0.3710	0.55	1.52	1.96
					L2	0.3698	1.96	5.36	6.87
	2	4.8667	7.9167	46.00	L1	0.3710	0.55	1.52	1.96
					L2	0.3700	1.66	4.53	5.81
	3	4.8510	7.9000	43.00	L1	0.3715	0.38	1.04	1.36
					L2	0.3697	2.53	6.92	8.85
Nsit Ubium	1	4.7833	7.9000	34.00	L1	0.3716	0.37	1.01	1.30
					L2	0.3705	0.83	2.28	2.94
	2	4.7833	7.9166	49.00	L1	0.3712	0.48	1.31	1.70
					L2	0.3702	1.23	3.36	4.31
	3	4.8167	7.9667	37.00	L1	0.3717	0.33	0.89	1.16
					L2	0.3703	1.06	2.90	3.73
Ibesikpo	1	4.8500	7.9667	49.00	L1	0.3710	0.55	1.52	1.96
					L2	0.3699	1.75	4.80	6.15
	2	4.9000	7.9833	133.00	L1	0.3725	0.21	0.58	0.76
					L2	0.3702	1.22	3.35	4.30
	3	4.9500	7.9667	72.00	L1	0.3712	0.48	1.31	1.69
					L2	0.3702	1.17	3.20	4.11
Uruan	1	4.9167	8.0167	52.00	L1	0.3715	0.39	1.07	1.39
					L2	0.3699	1.94	5.31	6.80
	2	4.9167	8.0333	52.00	L1	0.3711	0.50	1.38	1.79
					L2	0.3697	2.55	6.99	8.95
	3	4.9500	8.0000	57.00	L1	0.3713	0.42	1.16	1.50
					L2	0.3702	1.18	3.25	4.14

Continued

Nsit Atai	1	4.8667	8.0500	45.00	L1	0.3713	0.44	1.21	1.57
					L2	0.3701	1.41	3.87	4.97
	2	4.8000	8.0667	37.00	L1	0.3714	0.41	1.12	1.46
					L2	0.3703	1.14	3.12	4.01
	3	4..8333	8.0333	31.00	L1	0.3714	0.41	1.13	1.47
					L2	0.3704	0.98	2.68	3.45
Uyo	1	4.9833	8.0000	50.00	L1	0.3708	0.63	1.71	2.22
					L2	0.3701	1.41	3.87	4.97
	2	5.0000	7.9500	82.00	L1	0.3711	0.52	1.43	1.86
					L2	0.3701	1.29	3.54	4.55
	3	5.0333	7.9167	67.00	L1	0.3712	0.46	1.26	1.63
					L2	0.3701	1.43	3.91	5.02
Itu	1	5.0500	7.9167	65.00	L1	0.3717	0.33	9.15	1.19
					L2	0.3700	1.47	4.03	5.18
	2	5.0667	7.9167	68.00	L1	0.3714	0.41	1.11	1.45
					L2	0.3701	1.31	3.60	4.62
	3	5.1000	7.9500	57.00	L1	0.3717	0.32	8.88	1.15
					L2	0.3699	1.72	4.70	6.03
Ibiono Ibom	1	5.1833	7.9000	66.00	L1	0.3722	0.25	6.93	0.90
					L2	0.3706	0.78	2.15	2.77
	2	5.1832	7.8667	63.00	L1	0.3716	0.35	9.56	1.24
					L2	0.3703	1.07	2.92	3.76
	3	5.2000	7.8500	72.00	L1	0.3711	0.49	1.35	1.75
					L2	0.3703	1.10	3.00	3.87