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Estimation of Poisson's Ratio of Ozizza Subsurface Layers

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Abstract : *A geophysical survey aimed at determining the Poisson's ratio of subsurface earth materials have been carried out. Knowledge of the Poisson's ratio of materials is important since it gives information about the quality of such materials with respect to construction works. The study area is Ozizza (lat. 5.8^0-5.9^0N; long. 7.8^0-7.9^0E) situated within the Afikpo sedimentary basin in south - eastern Nigeria. The geophysical method employed was the seismic refraction method and both P - and S - waves were utilized. The major equipment used was a MOD.S79 seismograph and its accessories including P- and S- wave sources and detectors. The result shows that the P- waves delineated three layers with average velocities of 420m/s, 1745m/s and 2620m/s for the first, second and third layers from the earth's surface respectively whereas the S-waves revealed only two layers with average velocities of 310 m/s and 1100 m/s for the first and second layers accordingly. The result indicates that the first and second layers of Ozizza (probably made up of sandy clay and sand with gravel have Poisson's ratio of 0.22 and 0.28 respectively.*

Keywords – *Basin, Poisson, Sedimentary, Seismograph*

I. Introduction

When a force is applied to a material, it deforms. This implies that particles of the materials are displaced from their original positions [1-2]. As long as the applied force is not greater than a certain threshold value the particle displacement can be reversed. The reversal takes place when the applied force is removed so that no permanent change (size or shape) occurs. Materials which exhibit this behavior are said to be elastic. Materials in the earth's interior also exhibit elastic behavior. The stresses subsurface materials undergo due to the passage of seismic waves or otherwise cause corresponding strains of the materials. Whereas, stress, is defined as the ratio of the applied force to the cross- sectional area of a material, strain, ε is the ratio of extension to original length. There are various kinds of stresses (e.g. tensile/compressive, bulk, shear/tangential, etc) which produce corresponding kinds of strains. Tensile/compressive stress produces longitudinal strain. In two dimensions, this longitudinal strain involves an extension in one direction, say x (the direction of application of force) and contraction in the other direction, say y (see Fig. 1).

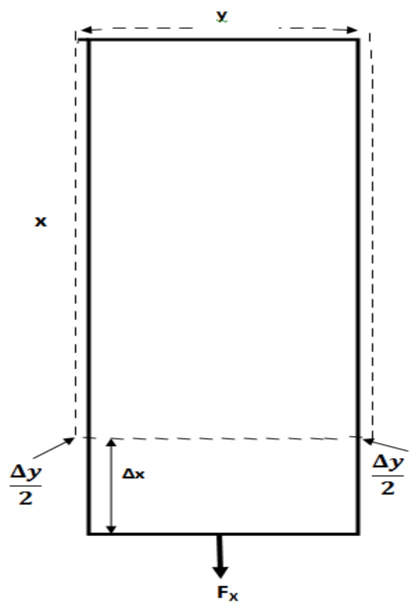

Fig. 1. Shape deformation of a rectangular bar due to the action of a tensile force.

We define the Poisson's ratio, V of a material acted upon by a force F_x as the ratio of longitudinal extension to lateral contraction. From Fig. 1, V is given by;

$$V = \frac{\Delta y / y}{\Delta x / x} = \frac{sYY}{sXX} \tag{1}$$

However, it should be noted that the description of longitudinal strain can also be expanded to three dimensions. Poisson's ratio, V is one of the elastic constants of materials. It is related to other elastic constants such as Bulk modulus, K, shear modulus, μ and Young's modulus, E by the following:

$$K = \frac{E}{3(1-2V)} \tag{2}$$

$$\mu = \frac{E}{2(1+V)} \tag{3}$$

If there is no volume change where a unidirectional stress is applied, V becomes 0.5; the maximum value it can have. For highly consolidated, unweathered rocks, V ranges from 0.2 to 0.3, while for most non-indurated elastic sedimentary rocks, it ranges from 0.05 to 0.02, depending on degree of porosity and weathering [2-5]. Estimate of the Poisson's ratio values of an area is very useful as it furnishes the engineer with knowledge of the quality of the subsurface materials with respect to building construction and other related works requiring foundation making. The Poisson's ratio's of subsurface materials at Ozizza (latitude 5.8^0-5.9^0N; longitude 7.8^0-7.9^0E) were estimated using seismic compressional waves generated from a mechanical source. Ozizza has an area of about $25km^2$ and is located at the western part of Afikpo basin - a sedimentary basin in southeastern Nigeria. Some geophysical works have been carried out within the basin. Research has been done by Okeke et al [6] on gravity survey along Afikpo –Amasiri axis. Their result gave an overall estimated average thickness of the pre-santonian sediments as 5.9km. In the literature, Selemo [7], carried out a research work on the aeromagnetic study of the basement relief of Afikpo basin. His objective was to study critically the basement relief with a view of understanding properly the intra-basement and supra-basement anomalies that may be responsible for the geological structures in the area. In this study, the Poisson ratio of Ozizza subsurface layers is reported for the first time.

II. Materials And Method

The equipment used in the work comprises an MOD S79 seismograph and its accessories including compressional (P) wave and shear(S) wave geophones as sensors; a hammer and a metal plate as wave source. The method employed was the seismic refraction method. Single line profiling was adopted and the traverse length for each profile line was 60 m. Compressional waves and shear waves were generated and utilized. Both P-and S- waves were propagated along the same profile line in the study area. The seismic data obtained were the travel times, T(ms) of the refracted signals (P and S) and the shot-detector distance, X(m).The arrival times were plotted against offsets and seismic velocities of underlying layers were determined from the T-X curves.

III. Results And Discussion

Sample T-X curves obtained at the study area are shown in Figs. 2 and 3. In each of the locations in the study area, the P-waves clearly defined a 3-layer case (Fig. 2). The mean seismic velocities of the layers were 420 m/s, 745 m/s and 1720 m/s which probably indicate sandy clay, sand with gravel and a saturated layer respectively. The average thicknesses of the first and second layers were 2.7m and 2.5m respectively.

On the other hand, the S-wave showed a 2-layer case (Fig. 3) with velocities of 510m/s and 1400m/s for the first and second layers respectively. The Poisson's ratios for the first two layers from the surface were estimated as 0.22 and 0.28 respectively.

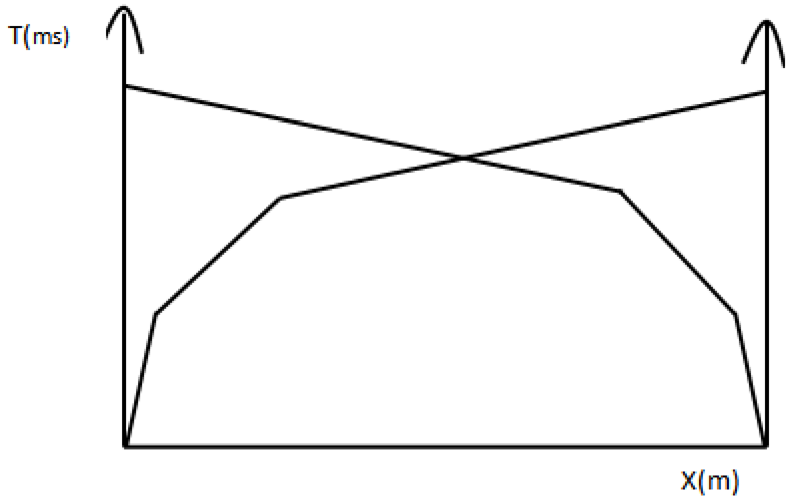

Fig. 2: Typical P-wave T-X curve obtained at the study area

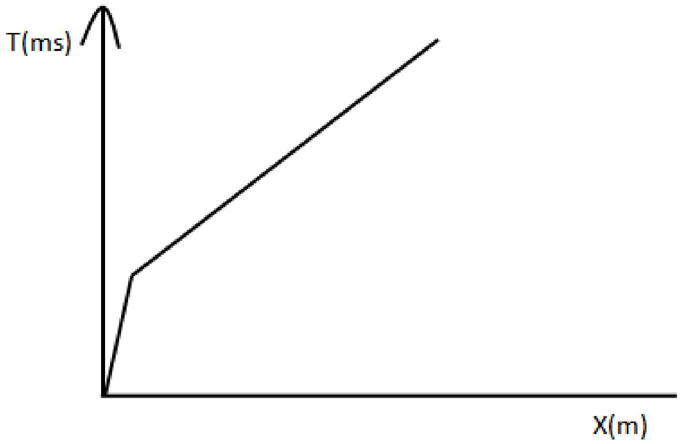

Fig. 3: Typical S-wave T-X curve obtained at study area.

IV. Conclusion

For highly consolidated unweathered rocks, the Poisson's ratio V ranges from 0.2 to 0.3 [1, 4]. The estimated values of Poisson's ratio for the first and second layers of Ozizza are 0.22 and 0.28.These layers which have average thicknesses of 2.7m and 2.5m (top and bottom) and which were interpreted to be probably sandy layer and sand with gravel respectively are likely be consolidated and unweathered.

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