range from 0.0 to 4.5 m. The middle layer was characterized by fairly competent soil and rock quality, V_P and V_S range from 650.00 m/s to 1500 m/s and 625.00 m/s to 1460.00 m/s respectively. Allowable bearing capacity range from $(1.37 \text{ to } 3.70) \times 10^5 \ N/m^2$ and the ultimate bearing capacity ranged from $(4.32 \text{ to } 10.21) \times 10^5 \ N/m^2$.

The concentration index, material index, stress ratio and density gradient of the middle layer ranged from 0.90 – 1.80, 0.91 – 2.18, 0.60 – 7.0 and -0.85 – 4.43 respectively. The depth of the bedrock ranged from 5.0 to 12.5 m while its thickness ranged from 5.0 to 7.5 m. The lower (third layer) layer which is characterized by good competent soil and rock quality, the V_P ranged from 1730.00 m/s to 2450 m/s while V_S ranged from 1525.00 m/s to 2230.00 m/s. The allowable and ultimate bearing capacity the third layer ranged from $(2.18 \text{ to } 4.57) \times 10^5 \ N/m^2$ and $(6.10 \text{ to } 12.32) \times 10^5 \ N/m^2$ respectively. The engineering parameters (concentration index, material index, stress ratio and density gradient) calculated give values ranging from 1.30 – 6.25 for concentration index, 1.15 – 2.57 for material index, 4.61 – 10.31 for stress ratio and 2.60 – 11.70 for density gradient. The depth and thickness of the bedrock in this layer ranged from 13.0 to 25.2 m and 12.2 m respectively. No construction material has more variable engineering and physical parameters than the ground's soil. In order to evaluate the competence of the subsurface for construction, engineering parameters were integrated with bearing capacity.

The dependence of the engineering parameters with bearing capacity has been desirable through the various plots of the three layers; 1, 2 and 3 as shown in Figures 4 to 7. The slope of the plots shows a linear relationship between the plotted parameters which vary both laterally, vertically and often the variations are strong. The 2-D contour map in Figures 8 and 9 shows a continuous increment in the Stress ratio and material index in the south-east trend in layers 3 and 2 respectively. The contour map (Figure 10) shows the variation of the allowable bearing capacity which increases towards the eastern part of the study area in layer 1. This trend shows low allowable bearing and engineering parameters regions which is associated with zone that has weak and fair incompetent soil, rock quality and highly drained with water while high bearing and engineering regions reflected good competent soil, rock quality and unsaturated with water. However, in 3-D contour map (Figure 11), the region of high values of allowable bearing in the layer 2 conforms to the location noticed in layer 1.

These results demonstrate uniform consolidation trends from low to high values of engineering and bearing capacity with depth in layers 1 to 3. This conformity reveals the uniqueness of the method used in integrating the shallow subsurface structures. Compare the results of engineering and bearing parameters of upper, middle and lower layers with the standard geologic and engineering equivalence for engineering stability. The engineering and bearing parameters of lower layer indicates good competent soil and rock quality, therefore, the lower layer is recommended as the most eligible layer for stability engineering works for construction purposes.

4. Conclusion

Seismic refraction technique is a reliable geophysical technique for subsurface investigation. The refracted arrival time of P and S waves were measured and their velocities along with bearing capacity and engineering parameters were calculated. The result of the interpreted data reveals the variation of thickness across the three layers delineated. The bearing capacities estimated were allowable and ultimate; the allowable bearing capacity is one of the important parameters used in deciding the engineering foundations. The ability of the foundation to carry a load depends on the bearing capacity. The bearing capacity depends on the shear wave velocity, the values of the bearing capacity increases with high values of shear wave velocity. The shallow engineering parameters (concentration index, material index, stress ratio and density gradient) were also calculated to assess the subsurface bedrock. These parameters were contoured and the resulting maps show their variations across the study area and the plots show the relationships between the calculated parameters. The integration of the bearing capacity and engineering parameters indicate that the lower layer (third layer) has a good competent soil and rock quality. Therefore, the lower layer is recommended as the most appropriate layer for engineering and foundation stability.

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