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Investigation of incessant road failure in parts of Abeokuta, Southwestern Nigeria using integrated geoelectric methods and soil analysis

- S. A. Ganiyu,
- M. A. Oladunjoye,
- M. O. Olobadola,
- A. P. Aizebeokhai &
- B. S. Badmus

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Abstract

A flexible pavement devoid of discontinuities allows for smooth movement of a vehicle load on the roadway. This study involved the use of integrated geoelectric methods comprised of 1D and 2D Electrical Resistivity Tomography (ERT) as well as soil analysis to investigate causes of unceasing road failures along busy Camp—Alabata Road, Abeokuta, Southwestern Nigeria. Four road sections (two failed portions and one fair section and one good section) were identified along which four resistivity traverses were established along the investigated roadway. Four 1D Vertical Electrical Sounding (VES) points were also carried out on the 2D ERT lines. Apparent resistivity data were measured along the four traverses using Schlumberger and Wenner arrays with the aid of a Campus Ohmega resistivity meter. The VES and 2D resistivity data were processed and inverted using WinResist and

RES2DINV softwares, respectively. Twenty soil samples at a sampling depth (0–1.0 m) with an interval of 0.2 m were also collected on all designated road sections and analyzed for selected hydraulic/geotechnical properties related to pavement durability. Penetration resistance (PR) was measured in situ by a penetrologger while other subgrade soil properties were evaluated in the laboratory. The VES results delineate three geoelectic layers comprising topsoil, weathered basement (clayey), and fractured/fresh basement with their corresponding resistivity values ranging between 71 and 282 Ωm, 12–76 Ωm, and 261–10,094 Ωm. The thicknesses range between 0.9 and 3.2 m for topsoil and 4.5–19.1 m for weathered basement. 2D resistivity inverted sections delineate two lithologic layers: topsoil with resistivity values > 200 Ωm, devoid of linear geological structures as competent topsoil on a stable road section while incompetent topsoil on failed road sections were characterized by resistivity values < 200 Ωm. The weathered layers as depicted by 2D inverted resistivity sections were generally of resistivity less than 100 Ωm while fractured/fresh basement were not depicted in the 2D model. Failed road sections are underlain by topsoil with a resistivity (< 200 Ωm), shallow weathered (clayey) layer, and differential settlement of saturated subgrade materials. Soil analyses results showed that the stable portion depicts lowest mean values of plasticity index (5.12%) and liquid limit (22.21%), uniform sandy-loam textural class, highest mean value (1.24 cm/h) of saturated hydraulic conductivity (K_{sat}); % sand content (73.2%) and Penetration Resistance (PR) values that increased within the sampling depth (0–40 cm). However, one of the failed sections had lowest mean value (0.81 cm/h) of K_{sat}, % sand content (64.9%) and PR values that decreased within the sampling depth (0–40 cm). Analysis of variance (ANOVA) showed that there were significant differences at the 5% level among all designated road sections with respect to percent silt and moisture content (MC). Adequate engineering construction approaches should be adopted considering the thick layer of incompetent formation (clay) observed across the area investigated. Integrated interpretations present a better resolution and detailed characterization of the substratum underlying the pavement.

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Author information

Affiliations

1. **Department of Physics, Federal University of Agriculture, Abeokuta, Ogun, Nigeria**
   S. A. Ganiyu, M. O. Olobadola & B. S. Badmus
2. **Department of Geology, University of Ibadan, Ibadan, Ogun, Nigeria**
   M. A. Oladunjoye
3. **Department of Physics, Covenant University, Ota, Ogun, Nigeria**
   A. P. Aizebeokhai

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