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GEOTECHNICAL AND GEOCHEMICAL CHARACTERISATIONS OF KAOLINITIC CLAY SOILS FROM SOME SELECTED AREAS IN EKITI STATE, NIGERIA

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ABSTRACT: *Kaolinitic clay soils from Ikere, Isan, and Ijero in Ekiti State, southwestern Nigeria, were investigated to evaluate their geotechnical and geochemical characteristics relevant for stabilisation requirements and engineering applications. Representative samples obtained at multiple depths were subjected to index testing, direct shear, permeability, dynamic cone penetration tests, and microstructural analysis using SEM–EDS. The soils exhibit relatively uniform index properties, with clay contents of approximately 48%, but show weak strength characteristics, including low cohesion (4.9 – 5.3 kPa) and moderate friction angles (13° – 15°), alongside low permeability with an average coefficient of 4.7×10^{-9} m/s. Despite similar bulk properties, notable spatial variability in engineering performance was observed. Ikere clay demonstrated fair bearing capacity at depth (CBR = 16.2%), whereas Ijero and Isan clays exhibited weak subgrade conditions near the surface with CBR of 11% and 12%, respectively. Geochemical and microstructural analyses confirm kaolinite dominance (Si = 45 – 50 wt%, Al = 10 – 15 wt%), with Ijero clay exhibiting optimal Si/Al ratios and dense microstructure. Ikere and Isan clays presented elevated organic content, higher microstructural porosity, moisture retention, and strength behaviour. Weak correlations between bulk composition and strength parameters highlight the governing role of soil fabric and microstructure rather than mineralogical composition alone. Based on these findings, site-specific stabilisation strategies are proposed: lime treatment for Ijero clay, compaction-based improvement for Ikere clay, and combined lime–cement stabilisation for Isan clay to mitigate drainage and settlement risks. This study provides new regional data and demonstrates the importance of integrating microstructural analysis with geotechnical testing to improve subgrade design and enhance infrastructure durability in tropical lateritic environments.*

KEYWORDS: Geochemical characterisation, Geotechnical properties, Kaolinitic clays, Soil stabilisation, Southwestern Nigeria, Subgrade performance.

INTRODUCTION

Clay soils are residual deposits formed through intense tropical weathering of Precambrian Basement Complex rocks, including granites, gneisses, migmatites, and charnockites (Elueze et al. 2004; Adeola 2015). Examples of clays include kaolinitic clays, montmorillonite, bentonite, and fuller's earth (Adeniyi et al., 2023). Nigeria has a resource of around three billion metric tons of kaolinitic clay deposits spread across more than 40 locations (Akinyele et al., 2017). The map in Fig. 1a presents the various locations of kaolinitic clay in Nigeria. Kaolin is a kind of clay that is extracted from the earth, having the chemical formula $Al_2Si_2O_5(OH)_4$. The distinct mineralogy, geotechnical, and geochemical characteristics of Kaolinitic clays make them useful in various industrial applications (Adeniyi et al., 2023). Clays from Ikere, Isan, and Ijero in Ekiti State, Southwestern Nigeria, exhibit predominantly kaolinitic mineralogy with minor illite and halloysite phases characteristic of hydrothermal and in-situ weathering processes under the region's high rainfall regime (annual > 1500 mm). These clays display high plasticity (PI = 25-40%), low permeability (10^{-8} to 10^{-10} m/s), and excellent water retention capacity that underpin diverse industrial applications, including fired clay bricks, ceramics, traditional pottery, refractory materials, and compacted landfill liners. These are attributed to their chemical stability, moderate firing temperatures (900 - 1200°C), and proven heavy metal sorption capacity for contaminants like Pb, Cd, Cu, and Cr (OlaOlorun et al., 2010; Adeniyi et al., 2020; Daramola et al., 2024). Geochemical signatures consistently show SiO_2 (47 - 75 wt%) and Al_2O_3 (20-36 wt%) dominance with Fe_2O_3 content of 5 - 17.6 wt%, which is typical of mature lateritic profiles derived from feldspar-rich parent materials.

However, these near-surface clays (0 - 1.5 m depth) present formidable engineering challenges for road construction, building foundations, embankments, and flexible pavements across Southwestern Nigeria's humid tropics. Critical limitations include low undrained shear strength (cohesion 4.9 - 5.3 kPa), high compressibility, poor surface bearing capacity (CBR = 11 - 12%), and significant moisture-induced volume changes during wet-dry cycles that precipitate recurrent pavement failures, longitudinal cracking, and foundation heaves, particularly during the June-September rainy season (Das, 2016; Oyelami, 2016). Although kaolinite confers moderate cation exchange capacity (5 - 12 cmol kg^{-1}) and limited shrink-swell potential compared to smectitic clays, geochemical variations, particularly elevated Fe_2O_3 in Ikere (up to 17.6 wt%) and trace elements (Ti, Mn, Zn) profoundly influence Atterberg limits, compaction characteristics, permeability, and long-term durability, which are essential for site-specific geotechnical design (Tunbosun, 2022; Grim, 1968).

Despite established industrial viability, comprehensive integrated geotechnical-geochemical characterisation data remain limited for kaolinitic clays in Ekiti State. Existing research is predominantly confined to basic index properties, ceramic firing trials, or isolated landfill permeability studies (Osinubi & Eberemu, 2005). This study systematically addresses the regional knowledge gap through multi-method analysis encompassing Scanning Electron Microscopy (SEM) equipped with Energy Dispersive Spectrometer (EDS) for microstructural examinations. Direct shear strength parameters, DCPT-derived California Bearing Ratios, falling head permeability, and comprehensive index properties of Ikere, Isan, and Ijero clays were also investigated. By evaluating their performance across construction subgrades, stabilised embankments, agricultural soil amendments, ceramics production, and environmental barrier applications, the research provides actionable engineering parameters

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and site-specific stabilisation protocols to support resilient infrastructural development in Ekiti State and similar tropical lateritic terrains.

Geology of the study area

The study areas are Ikere, Isan, and Ijero, which lie within Ekiti State, southwestern Nigeria. They are part of the Precambrian Nigerian Basement Complex, dominated by metamorphic and igneous rocks including migmatites, gneisses, quartzites, schists, and granitic intrusions formed during Pan-African orogenic events (~600 Ma) that shaped the West African Shield (Rahaman, 1988; Obaje, 2009; Ocan et al., 2012). Intense tropical weathering of these feldspar-rich parent rocks produces lateritic, clay-dominated soils enriched in kaolinite, iron, and aluminium oxides. The Ikere's migmatite-gneiss complexes yield silica- and alumina-rich profiles of variable iron content, while Isan and Ijero exhibit similar characteristics influenced by local structures and drainage patterns (Fatoba et al., 2018; Olorunfemi et al., 2016). Fractured bedrock enhances weathering depth, significantly affecting soil thickness, permeability, and geotechnical properties critical for engineering. Tectonic shear zones from the Pan-African orogeny introduce geochemical variability that necessitates detailed investigation of these soils' engineering characteristics within this complex terrain (Akinmosin & Akinoso, 2017; Oyedele et al., 2022).

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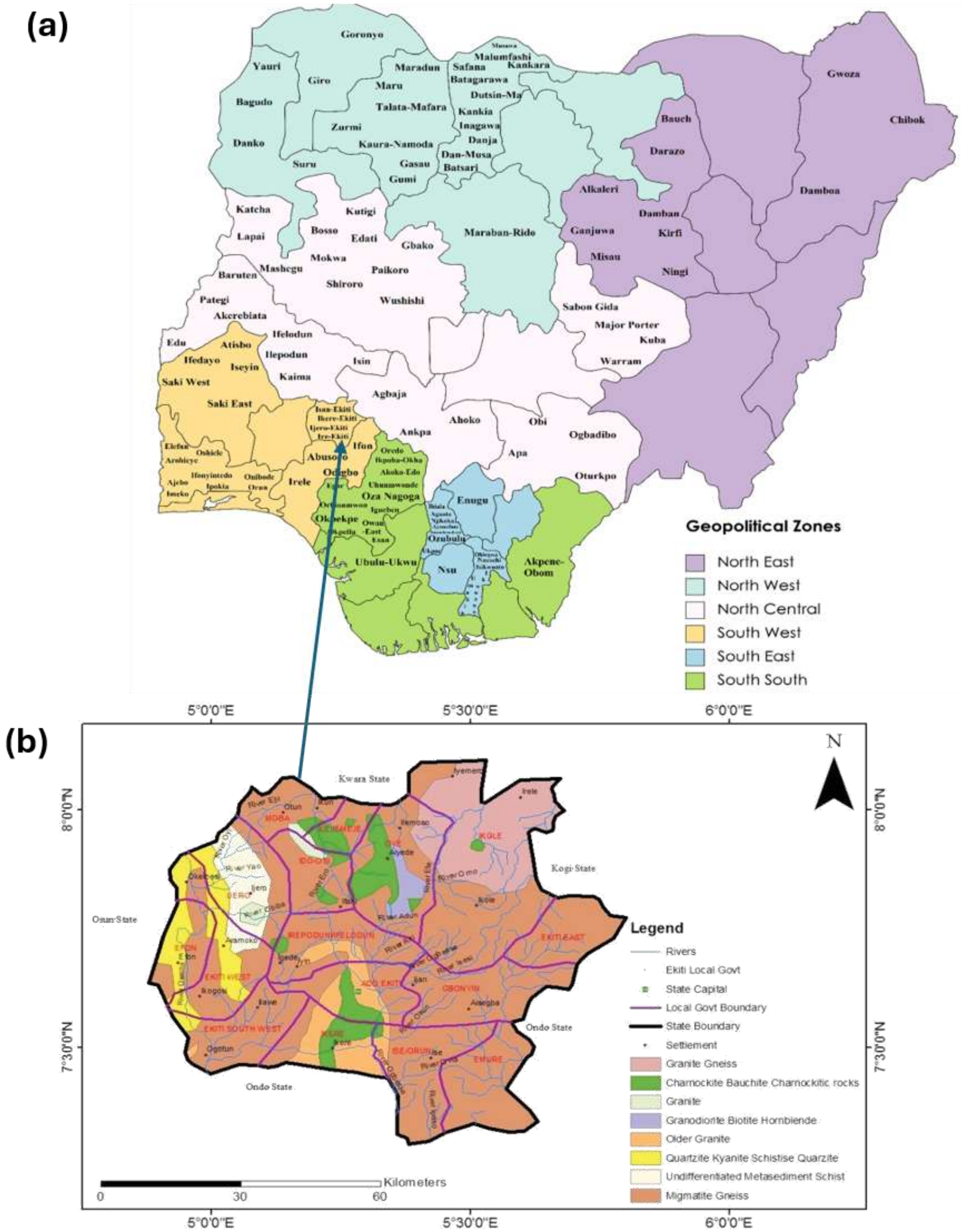
Figure 1. (a) Map of Nigeria showing the major locations of kaolin deposits (b) Geological map of Ekiti State (Adeniyi et al., 2023; Ademilua, 1997).



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MATERIALS AND METHOD

Twelve (12) clay soil samples were systematically collected from three sites in Ekiti State, south-western Nigeria, with details of the GPS readings and soil descriptions shown in Table 1. Ikere, Ijero, and Isan were chosen as typical towns in the Precambrian Basement Complex of southwestern Nigeria, where weathering of metamorphic and granitoid rocks results in thick fine-grained, clayey soils of engineering geologic interest in the region. Shallow depths (0.25 – 1.0 m) were selected because this layer is the most impacted by weathering and they represent the majority of shallow foundations, roads and utilities, thus capturing the range of variation encountered by engineers. The design comprised four depth measurements (0.25m, 0.5m, 0.75m, and 1m) at each of the three sites, and this provides a small but representative sample of the soil variability across the region and within each soil profile. The samples were immediately sealed in labelled polythene bags, and the depth, date, and location ID were recorded. Air-dried samples were crushed with a mortar and pestle and sieved through a 2 mm mesh for uniformity. The sub-portions were pulverised to 75 µm and stored in air-tight containers for SEM-EDS analysis at the Materials laboratory, University of Ibadan. Chemical composition analysis via SEM-EDS quantified the major elements (Si, Al, Fe) and trace elements (Ca, Mg, K, Na, Ti) influencing soil behaviour. Geotechnical testing included in-situ Dynamic Cone Penetration Test (ASTM D6951-09) and laboratory assessments based on ASTM D3080-11 (direct shear test), ASTM D422 (particle size analysis), and BS1377 (1990) for moisture content, specific gravity, and permeability (falling head). The retention of older standards guaranteed consistency with the existing geotechnical practice in Nigeria, regional legacy data sets, and project specifications, at the same time ensuring technically valid results for the tests performed. The resulting datasets were analysed to obtain the mean, standard deviation, and coefficient of variation (CV = SD/mean × 100%), which were required to evaluate tropical residual clay variability for reliable geotechnical design.

Table 1. Summary of sample locations, GPS co-ordinates and soil descriptions

Location	Latitude / Longitude	Soil Type
Ikere	5.23°N, 7.50°E	Dark bulky clay
Ijero	5.17°N, 7.35°E	Reddish plastic clay
Isan	5.32°N, 7.92°E	Reddish plastic clay

RESULTS AND DISCUSSION

Key Index Properties

Table 2 revealed that the samples exhibit consistently low variability (CV <12%) typical of uniform residual profiles from weathered Precambrian Basement Complex rocks. The Natural moisture content ranges between 13.6 – 19.0% (CV 6.8–11.1%), with Isan clay showing the highest retention (19.0%) and settlement risk, while Ijero clay displays the lowest values (13.6%). Specific gravity of the samples varies from 2.13 (Isan, organic influence) to 2.71 (Ikere, dense inorganics) with a CV of 0.2–5.0%. The clay content remains steady at 47.9–49.2% (CV ~5%), increasing with depth in Ikere. These characteristics align with migmatite-gneiss-derived lateritic soils under tropical weathering, where extreme uniformity supports reliable geotechnical design but the clay content gives rise to high fines content, which necessitates compaction control to address depth-dependent plasticity, shrinkage, and low

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permeability challenges in construction and agricultural applications (Olorunfemi et al., 2016; Oyedele et al., 2022).

Table 2. Summary of Key Index Properties

Property	Location	Mean	SD	CV (%)	CV Classification	Remarks
Natural Moisture Content (%)	Ikere	14.05	1.56	11.1	Low	Uniform; minor depth increase
	Ijero	13.62	1.24	9.1	Low	Very uniform; lowest retention
	Isan	18.98	1.30	6.8	Low	Highly uniform; elevated settlement risk
Specific Gravity	Ikere	2.71	0.005	0.2	Low	Extremely uniform; dense inorganic
	Ijero	2.48	0.065	2.6	Low	Uniform; slight weathering trend
	Isan	2.13	0.106	5.0	Low	Uniform; organics influence
Clay Content (%)	Ikere	48.3	2.44	5.1	Low	Uniform; increases with depth
	Ijero	47.9	2.45	5.1	Low	Uniform
	Isan	49.2	2.45	5.0	Low	Uniform; highest fines, compressibility risk

Direct Shear Strength, Permeability, and CBR Analysis

Table 3 shows the direct shear test results with moderate cohesion values of (4.9 – 5.3 kPa) having moderate to high variability (CV = 33 – 46%) across Ikere, Ijero, and Isan, reflecting depth-dependent compaction effects in these Basement Complex-derived clays. Friction angles remain uniformly low, ranging from 13.4° to 14.8° (CV = 3 - 13%) and constraining overall shear resistance (Olorunfemi et al., 2016). Ikere clay exhibits the highest frictional resistance (14.8°) despite cohesion variability, Ijero clay shows a consistent intermediate friction angle suitable for averaging in design, and Isan displays the lowest shear reliability, which requires conservative safety factors as suggested in a previous study (Oyedele et al., 2022).

Table 3. Summary of Direct Shear Strength Parameters

Parameter	Location	Mean	SD	CV (%)	CV Classification	Interpretation / Implication
Cohesion, c (kPa)	Ikere	5.25	2.42	46.1	High	Significant variability; depth compaction effect
	Ijero	4.88	1.63	33.4	Moderate	Moderate; acceptable with averaging
	Isan	4.90	1.72	35.1	Moderate	Moderate; lower overall shear reliability

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Parameter	Location	Mean	SD	CV (%)	CV Classification	Interpretation / Implication
Friction Angle, φ (°)	Ikere	14.75	1.84	12.5	Low	Uniform; highest frictional resistance
	Ijero	14.1	0.92	6.5	Low	Very uniform
	Isan	13.35	0.45	3.4	Low	Extremely uniform; friction-limited

Table 4 shows the permeability coefficients of an average 4.7×10^{-9} m/s (CV ~53%) across sites, indicating consistently low but highly variable drainage, which is prone to pore pressure build-up under loading, which is most severe in Isan due to poor drainage characteristics.

Table 4. Permeability coefficients (Falling head test) of the selected clay samples

Location	Mean k ($\times 10^{-9}$ m/s)	SD	CV (%)	CV Classification	Remarks
Ikere	4.67	2.48	53.1	High	High variability; low but inconsistent flow
Ijero	4.76	2.56	53.8	High	High-depth compaction trend
Isan	4.68	2.49	53.2	High	High; poor drainage, pore pressure risk

Table 5 shows the DCPT-derived California bearing ratio (CBR) values. Ikere clay demonstrates depth competency with a mean CBR of 16.2% (CV = 15%) from subgrade, while the mean CBR of Ijero clay is 11% (CV 13%) and Isan clay is 12% (CV 29%), displaying uniformly weak surface conditions necessitating stabilisation (Fatoba et al., 2018). These patterns underscore site-specific compaction and drainage mitigation essential for foundation stability in tropical lateritic soils (Adephelumi et al., 2020).

Table 5. DCPT-Derived California Bearing Ratio (CBR) of the soil samples

Location	Mean CBR (%)	SD	CV (%)	CV Classification	Remarks
Ikere	16.3	2.45	15.0	Fair	Fair variability
Ijero	10.6	1.35	12.7	Low	Uniformly low; consistent weak subgrade
Isan	11.6	3.33	28.7	Moderate	Moderate variability; overall weak

Microstructures based on Scanning Electron Microscopy (SEM) of the clay samples

SEM micrographs of the clay samples taken at magnification of 8000 – 9000 times and the corresponding EDS spectra are presented in Fig. 2 – 5. The figures revealed different morphological features with significant differences in grain distribution within the microstructures and compositional variation. In general, the grain size and edge surface of kaolinite appear differently in various samples. Ikere clay presents relatively large plates of

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kaolinite with dense, interlocked grains and low porosity correlating to enhanced cohesion (4.9 – 5.3 kPa). Ijero clay displays intermediate compacted plate-like kaolinite particles with moderate pores. The kaolinite in Isan clay exists as porous, loosely packed flakes, which reflect organic weakening and elevated moisture retention (19%). It has been reported that the morphology of kaolinitic clays is influenced by the kind of parent-rock materials and the degree of chemical weathering they undergo (Akinyemi et al, 2014).

Figure 2. SEM-EDS micrograph of Ikere clay

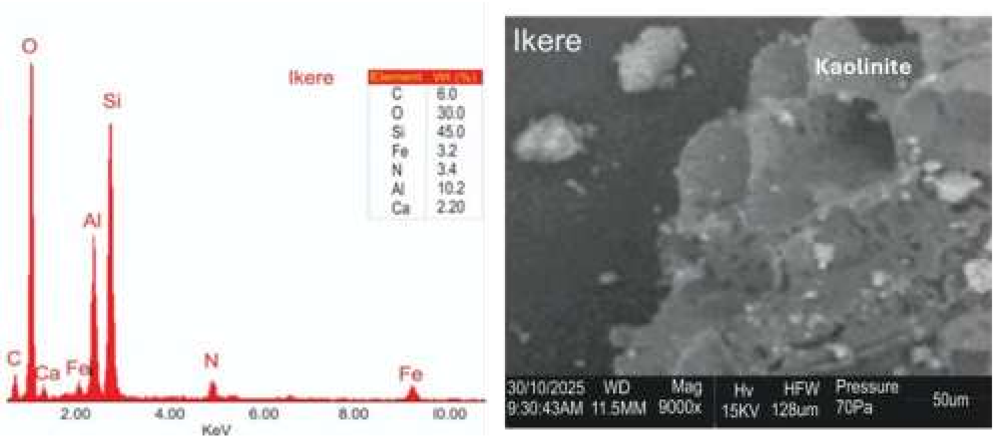


Figure 3. SEM-EDS micrograph of Ijero clay

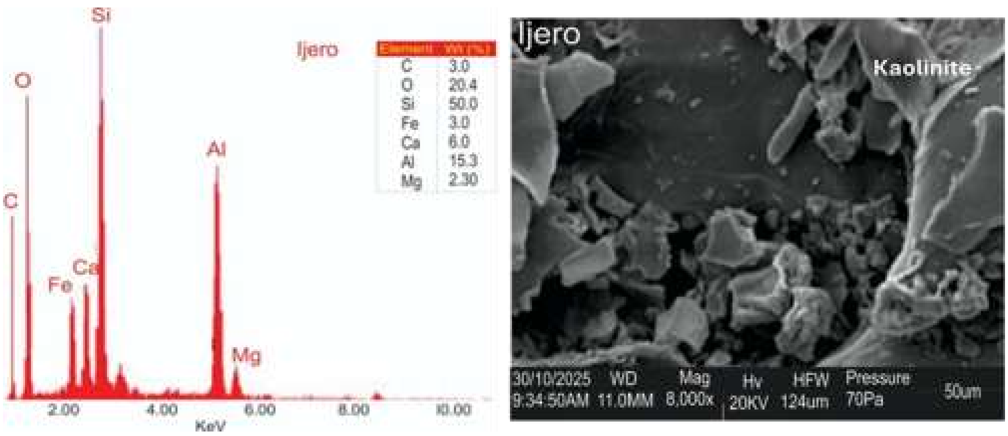
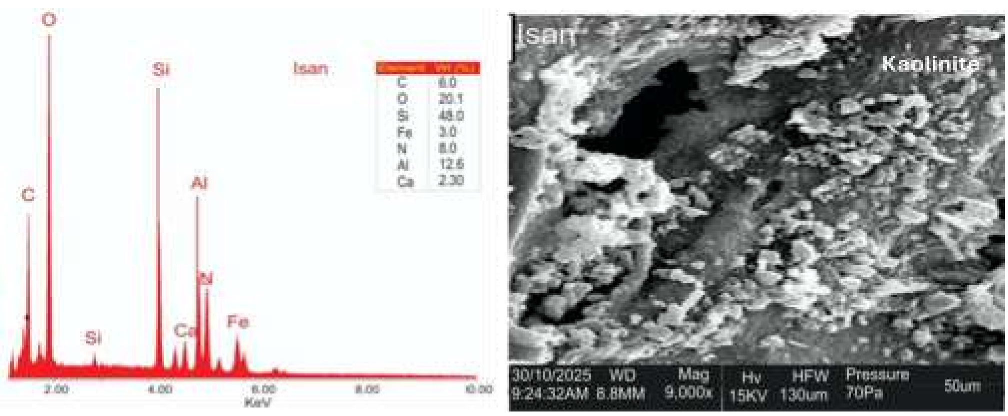


Figure 4. SEM-EDS micrograph of Isan clay



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Energy Dispersive Spectrometry (EDS) analysis of the selected clay samples

Table 6 shows the EDS elemental composition of the selected clay samples, which reveals a high Si content of 45.0 – 50.0 wt%, Al content of 10.2 – 15.3 wt%, and oxygen content of 20.1 – 30.0 wt%. These compositions are characteristic of kaolinite-rich alumino-silicates from Basement Complex weathering, with the Ijero sample exhibiting the highest Si and Al content of 50.0% and 15.3%, respectively, indicative of optimal mineral structure (Fatoba et al., 2018). The presence of Mg in Ijero clay, which is not found in clay samples from other locations, suggests compositional variation in the different samples. Ikere and Isan samples display organic matter signatures (C = 6.0 wt%, N = 3.4 – 8.0 wt%). The traces of Ca and Fe in all the samples across the sites indicate the presence of impurities, which is consistent with lateritic profiles in southwestern Nigeria (Oyedele et al., 2022; Yunusa et al., 2024). High Si/Al ratios in Ijero clay support high-load applications, Isan clay requires stabilisation for foundation use, while the Ikere clay performance depends on compaction control. These fabric-composition relationships guide site-specific soil improvement strategies (Olorunfemi et al., 2016). On comparing the composition of the studied samples with previously studied kaolinitic clay samples from Ire-Ekiti, it is similarly observed that the major elemental composition that is most abundant is silicon, aluminum, and oxygen, with percentage weight content of 53%, 18.2%, and 16.2%, respectively. This composition closely agrees with that of the clay sample from Ijero-Ekiti. A kaolinitic clay sample having these chemical properties can be used as a pozzolana and industrial adsorbent for the remediation of contaminants during wastewater treatment (Adekeye et al., 2019).

Table 6. Elemental compositions of the studied kaolinitic clay samples based on EDS analysis compared with the reference sample from Ire-Ekiti.

Elements	Ikere (Wt.%)	Ijero (Wt.%)	Isan (Wt.%)	Ire (Wt.%) Adekeye et al., 2019
Si	45.0	50.0	48.0	53.00
Al	10.2	15.3	12.6	18.15
C	6.0	3.0	6.0	4.45
N	3.4	-	8.0	-
Ca	2.2	6.0	2.3	0.74
Fe	3.2	3.0	3.0	3.86
Mg	-	2.3	-	-
O	30.0	20.4	20.1	16.20
Na	-	-	-	3.60
Ti	-	-	-	1.52

Correlation Analysis

Table 7 and Figure 5 are correlation data and plots, respectively, which reveal weak negative relationships between clay content and cohesion (r = -0.285, $p > 0.05$) and aluminium content versus friction angle (r = -0.389, $p > 0.05$), confirming limited predictive power from bulk composition alone. The regression equation: Cohesion = 36.8 - 0.27 × Clay_% explains only 8.1% of variance ($R^2 = 0.081$), with clay averaging 31.3% (16.5 - 58.3%) and cohesion 28.2 kPa (10.4 -55.6 kPa). These non-significant correlations (both p-values exceed 0.05) emphasise

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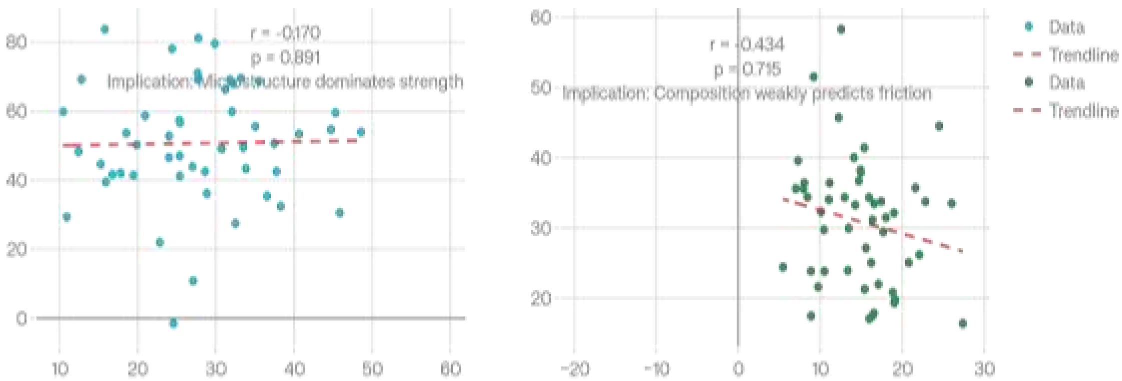
microstructural fabric, compaction, and cementation over grain size or oxide content in controlling strength for these low-permeability kaolinitic clays (k ≈ 4.7×10^{-9} m/s). Ikere clay with CBR (16.2%), despite the presence of organics, demonstrates depth competency. Ijero clay is suitable for stable subgrades, while Isan clay requires stabilisation to address drainage and settlement risks (Oyedele et al., 2022). Multi-parameter models incorporating SEM-derived Si/Al ratios and Atterberg limits are recommended for improved prediction ($r > 0.6$ expected). The provided correlation data for soil properties shows weak negative relationships with non-significant p-values, indicating limited predictive power from composition alone.

Table 7. Correlation data

Pair	r	p-value	Implication
Clay% vs. Cohesion	-0.285	0.891	Microstructure dominates strength
Al% vs. Friction φ	-0.389	0.715	Composition weakly predicts friction.

Fig. 5. Plot of clay% vs. cohesion. Plot of Al% vs. friction angle



CONCLUSION

Clay soils from Ikere, Isan, and Ijero in Ekiti state demonstrate uniform index properties (CV < 12%) derived from consistent weathering of Precambrian Basement Complex rocks, confirming their predictable geotechnical behaviour across sites. Ijero clay exhibits optimal engineering potential with the highest Si/Al ratio (3.27), dense microstructure, and stable subgrade characteristics, requiring minimal lime stabilisation targeting reliable CBR > 25%. This clay is also suitable as pozzolana and for wastewater treatment. Ikere clay reveals depth competency (CBR 16.2%), suitable for foundations. Isan clay requires the most intervention of quicklime and cement to counter elevated organic matter content, moisture content, and poor drainage, achieving the required CBR for subgrade reliability. Weak compositional correlations (Clay-cohesion $r = -0.285$; Al-φ $r = -0.389$) underscore microstructural dominance over bulk chemistry in strength development. These findings address critical regional data gaps, enabling site-specific design strategies that enhance infrastructural resilience while promoting sustainable material utilisation in ceramics, agriculture, and environmental applications throughout southwestern Nigeria.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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REFERENCES

Adekeye D., Popoola O., Ibigbami O., Asaolu S., & Olatoye R. (2019). Physicochemical Characterization and Mineralogical Evaluation of Ire-Ekiti Clay Deposit in Southwestern Nigeria. *International Journal of Engineering Applied Sciences and Technology*, 4 (8), 94 - 99.

Ademilua O. L (1997). A geoelectric and geologic evaluation of groundwater potential of Ekiti and Ondo States, Southwestern Nigeria. Unpublished M.Sc. Thesis, Dept. of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria. pp. 1- 67.

Adeniyi, A.G., Iwuozor, K.O., & Emenike, E.C. (2023). Material Development Potential of Nigeria's Kaolin. *Chemistry Africa*, 6, 1709–1725.

Adeniyi, A. O., Adebayo, A. S., & Ojo, A. O. (2020). Geotechnical properties of kaolinitic clays from Ekiti State for ceramic production. *Journal of African Earth Sciences*, 170, Article 103923.

Adeola A.J. (2015). Mineralogy and geochemistry of residual clay occurrences in Idi-Ayunre and Akure areas, Southwestern Nigeria. *J Geogr Geol*, 7(4), 23 – 32.

Adephelumi, A. A., Ojo, A. O., & Oladapo, M. I. (2020). Geophysical investigation of subsurface anomalies in Ekiti State, southwestern Nigeria. *Geophysics*, 85(4), B145-B156.

Akinmosin, A., & Akinoso, O. (2017). Fracture characterization of basement rocks in Ekiti State. *Journal of African Earth Sciences*, 134, 102-110.

Akinyele J, Odunfa S, Famoye A, Kuye S (2017) Structural behaviour of metakaolin infused concrete structure. *Niger J. Technol*, 36(2), 331 – 338.

Akinyemi S.A., Ogunniyi, S. O., Ojo, A. O., Gitari, W. M., Momoh, A., Akinola, O.O., Talabi, A.O., Afolagboye, L. O., Olaolorun, O. A. & Ayodele, O. S. (2014). Mineralogy, Physicochemical Characteristics, and Industrial Potential of Some Residual Clay Deposits within Ekiti State, Southwestern Nigeria. *Journal of Environment and Earth Science*, 4 (17), 70 – 88.

ASTM D6951/D6951M-09 (2015). Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications. Report GL-92-3, Department of the Army, Washington, DC, p. 19.

ASTM D422-63 (2007). Standard method for determining soil particle size distribution using sieve analysis (particles >75 µm) and hydrometer analysis (particles <75 µm). Report GL-92-3, Department of the Army, Washington, DC, p. 19.

ASTM D3080/D3080M- (2023). Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.

Article DOI: 10.52589/AJENSR-F90EJJNT
DOI URL: https://doi.org/10.52589/AJENSR-F90EJJNT

BSI 1377 (1990). Methods of testing soils for civil engineering purposes. British Standards Institution, London.

Daramola, O. S., Adeyemi, G. O., & Oladipo, A. A. (2024). Heavy metal sorption capacity of Ekiti kaolinitic clays for landfill liner applications. *Environmental Geotechnics*, 11(3), 145-156.

Das, B. M. (2016). *Principles of geotechnical engineering* (9th ed.). Cengage Learning.

Elueze A.A., Bakare C., & Bolarinwa A.T. (2004). Mineralogical, chemical, and industrial characteristics of residual clay occurrences in Iwo and Ijebu districts, Southwestern Nigeria. *J Mining Geol*, 40 (2), 119 – 126.

Fatoba, B. O., Oluwajana, O. A., & Adeyemo, I. A. (2018). Geochemical characterization of lateritic soils from migmatite-gneiss terrains in southwestern Nigeria. *Applied Clay Science*, 160, 78-89.

Grim, R. E. (1968). *Clay mineralogy* (2nd ed.). McGraw-Hill.

Obaje, N. G. (2009). *Geology and mineral resources of Nigeria*. Springer.

Ocan, O. O., Adebayo, S. I., & Oladipo, M. O. (2012). Pan-African orogeny signatures in the Nigerian Basement Complex. *Precambrian Research*, 204-205, 1-14.

OlaOlorun, A. O., Adeyemi, G. O., & Oladipo, A. A. (2010). Geochemistry of residual clay soils from Ekiti State Basement Complex. *Journal of Mining and Geology*, 46(2), 113-124.

Olorunfemi, M. O., Fasuyi, S. A., & Akinluyi, F. O. (2016). Engineering geological mapping of Ekiti State. *Bulletin of Engineering Geology and the Environment*, 75(3), 1025-1037.

Osinubi, K. J., & Eberemu, A. O. (2005). Compressibility behaviour of compacted lateritic soil. *Geotechnical and Geological Engineering*, 23(6), 627-638.

Oyedele, A. O., Oladapo, M. I., & Adeyemi, G. O. (2022). Geotechnical implications of weathering profiles in Ekiti State. *Engineering Geology*, 298, Article 106534.

Oyelami, C. A. (2016). Pavement failures in expansive clay terrains of southwestern Nigeria. *Transportation Geotechnics*, 8, 1-12.

Rahaman, M. A. (1988). Recent advances in the study of the basement complex of Nigeria. In P. O. Oluyide (Ed.), *Precambrian geology of Nigeria* (pp. 11-43). Geological Survey of Nigeria.

Tunbosun, O. A. (2022). Geochemical signatures of Ekiti State residual soils. *Journal of Earth System Science*, 131(2), Article 45.

Yunusa, A., Hong, H., Salim, A., Amam, T., Liu, C., Xu, Y., Zuo, X., Li, Z. (2024). Mineralogical Characterization and Geochemical Signatures of Supergene Kaolinitic Clay Deposits: Insight of Ropp Complex Kaolins, Northcentral Nigeria. *Minerals*, 14 (869), 1 – 20.

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