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Geotechnical Evaluation of Lateritic Soil Index Properties in Ekiti State Districts, Southwestern Nigeria for Road Pavement Construction

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Abstract
Focusing on the three Senatorial Districts of Ekiti State, this research examines local soil properties to assess their suitability for construction and infrastructure development. The investigation starts by analysing samples from the Central District, Southern, and Northern with a sample size of 160 per district, the research utilized standard laboratory procedures to assess key physical properties. Specifically, tests were performed to evaluate moisture content, specific gravity, and grading, alongside an analysis of Atterberg limits. Based on the AASHTO classification system, the soils in the Central District were classified into four categories (A-2-4, A-2-6, A-2-7, A-7-5), while the Southern District contained eight categories (A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6, A-7-5), and the Northern District had six categories (A-2-4, A-2-5, A-2-6, A-2-7, A-6, A-7-6). Results show that while Central District soils meet the requirements for base and sub-base layers, those from the Southern and Northern Districts are more effectively utilized in sub-base and sub-grade construction. Although stabilization may be needed to enhance their performance. In conclusion, the soils of Ekiti State are generally suitable for civil engineering purposes, with the Central District offering the most reliable materials for foundational, pavement, and construction projects.

Keywords: *Consistency tests, Grain size analysis, Lateritic soils, Road pavement construction, Specific gravity tests.*

1.0 Introduction

Understanding the index characteristics of soil is fundamental to geotechnical practice, providing the necessary data to categorize materials and forecast how they will react to external pressures and environmental changes. Core parameters including Atterberg limits, specific gravity, moisture levels, and grain size variations serve as the primary metrics for determining if a soil deposit is appropriate for structural development.

Conducting proper site investigations is vital for the safe and cost-effective design of civil engineering structures. However, inadequate characterization of subsoil properties remains a significant issue in many developing countries, leading to structural failures and pavement issues. Recent research has highlighted the need for thorough geotechnical assessments to improve infrastructure durability and performance. Despite prior research indicating that lateritic soils in southwestern Nigeria have varying engineering properties, comprehensive evaluations across the three senatorial districts of Ekiti State are scarce. This study aims to provide an integrated assessment to aid in engineering design and contribute to the development of a geotechnical database.

1.1 Location of study area

Ekiti State is located in southwestern Nigeria within the tropical climatic zone. It is situated between 4°51'E and 5°45'E longitude, and 7°15'N and 8°05'N latitude. The state covers an area of approximately 6,353 km² and, according to the 2006 census, has a population of about 2.21 million. Ado-Ekiti is the state capital and administrative centre. Ekiti shares its northern boundaries with Kwara and Kogi. It's flanked by Osun to the west, and Ondo takes up the rest of the space to the east and south. The state is divided into sixteen Local Government Areas. Geologically, it lies within the Precambrian Basement Complex, which consists mainly of crystalline rocks. The region's drainage system includes rivers and streams flowing in a dendritic pattern, such as the Elemi, Ose, and Ogbese Rivers. The climate is typical of the humid tropics, with relative humidity ranging from 60% to 80% and an average annual rainfall of about 1,500 mm.

2.0 Materials and Methods

This study utilized geological maps of the area and a Global Positioning System (GPS) to accurately reference field locations. Other field equipment included field notebooks, data sheets, sample bags, trowels, spades, and scoops for to assess the state's geological resources, 480 disturbed samples were retrieved from borrow pits at a standard depth of 2 meters, ensuring a representative distribution across the North, Central, and South senatorial

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districts. Following collection, the samples were transported to the Geotechnical Engineering Laboratory at Federal Polytechnic Ado-Ekiti. There, they were analyzed for strength, geochemical, and index properties, ensuring all methodologies aligned with the BS 1377:1990 regulatory framework.

3.0 Results and Discussion

3.1 Natural Moisture Content Test Results

The moisture content of fine-grained soils significantly influences their engineering behaviour, particularly in terms of compaction, strength, and compressibility. In this study, the moisture content of samples from the Southern, Northern, and Central districts ranged from 1.4% to 29.5%, 1.9% to 34%, and 1.1% to 33%, respectively. These relatively high moisture values suggest considerable water retention capacity, which is typical of fine-grained soils. According to established guidelines, soils with moisture content between 5% and 15% are considered ideal, while values above 20% may pose challenges unless stabilized. The soils in the Central district generally exhibited more favourable moisture conditions for construction than those in the Southern and Northern districts.

Table 1: Summary of results for natural moisture content (NMC) for Ekiti South Senatorial District

Index Properties	**Division of the districts and range of values**		
	Southern	**Northern**	**Central**
NMC (%)	1.4-29.47	1.9-34	1.1-33.0
GS	1.87-2.60	1.9-2.58	2.17-2.90
LL (%)	32.5-63	35-68	21-55
PI (%)	8.5-25	11-28	7.5-22
(%) Pass Sieve 200	15-55	2.9-45	2.0-37

3.2 Results of specific gravity (Gs) test

The variation in specific gravity across the three senatorial districts highlights the differing extents of weathering and mineral compositions found within the state. This index property helps explain the shift in suitability from base-course material in the Central District to sub-grade material in the North and South.

The values recorded in this study ranged from 1.87 to 2.60 for the Southern district, 1.90 to 2.58 for the Northern district, and 2.17 to 2.90 for the Central district. The relatively higher specific gravity values in the Central district suggest a higher degree of laterization, which correlates with better engineering properties. Previous research has linked higher specific gravity with enhanced shear strength, stiffness, and load-bearing capacity, making these soils more suitable for engineering applications. Therefore, the soils from the Central district are likely more appropriate for use in sub-grade and foundation applications.

3.3 Grain Size Analysis Tests Results

Grain size distribution is essential in determining soil classification and predicting its engineering behaviour. The results showed that a considerable portion of the soils had more than 35% fines, classifying them as clays or silty soils with high compressibility. High fines content negatively impacts the soil's engineering utility by depressing the maximum dry density and increasing hydro-sensitivity. This makes the soil prone to strength loss and deformation when saturated, explaining the lower suitability of certain samples for base-course applications. The variation in fine content across the districts highlights the heterogeneous nature of the soils, which are influenced by weathering and depositional processes. Soils with a well-graded particle size distribution generally exhibit better compaction and strength because of the efficient packing of particles, while poorly graded soils tend to exhibit weaker mechanical properties. The dominance of fine-grained soils in the Southern and Northern districts indicates potential challenges in construction, suggesting the need for soil improvement techniques.

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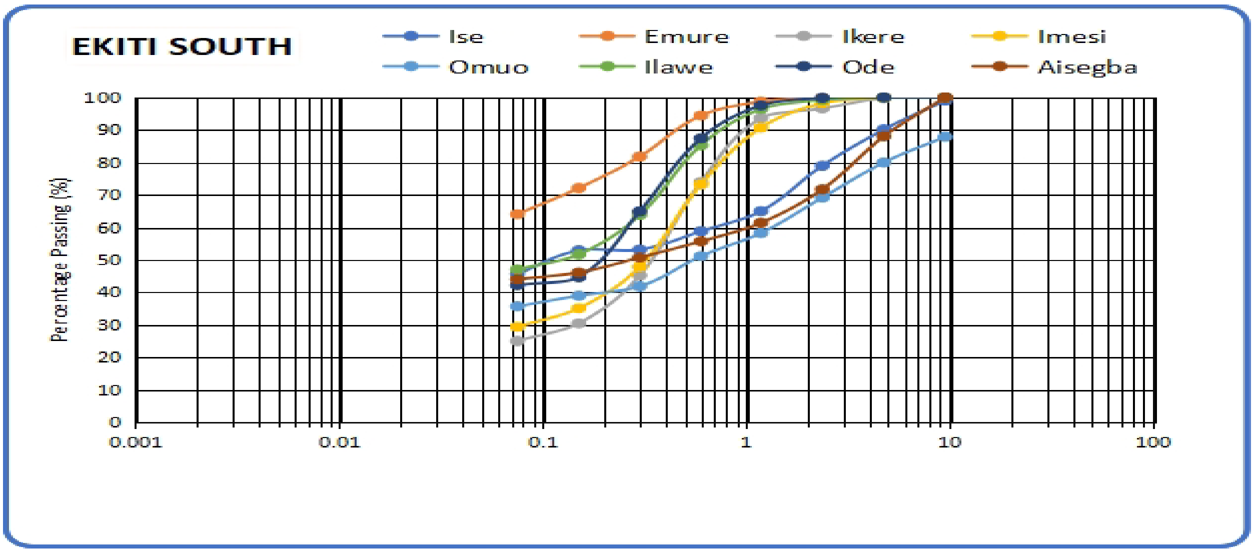

Figure1: Graph of sieve analysis Ekiti Southern Senatorial Districts (ESSD)

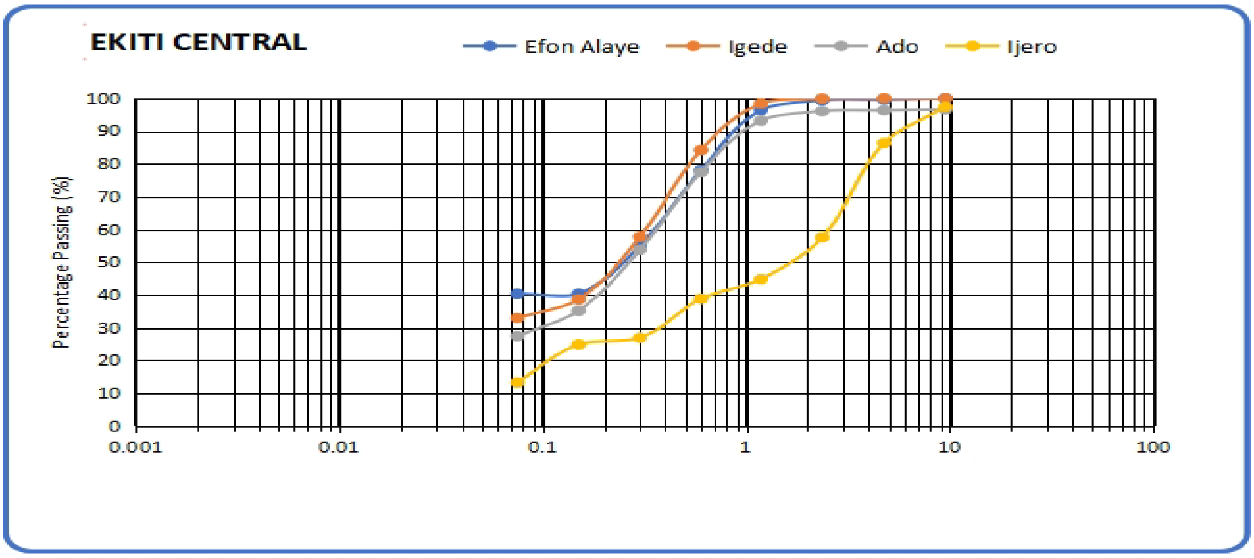

Figure 2: Graph of sieve analysis of Ekiti Central Senatorial Districts (ECSD)

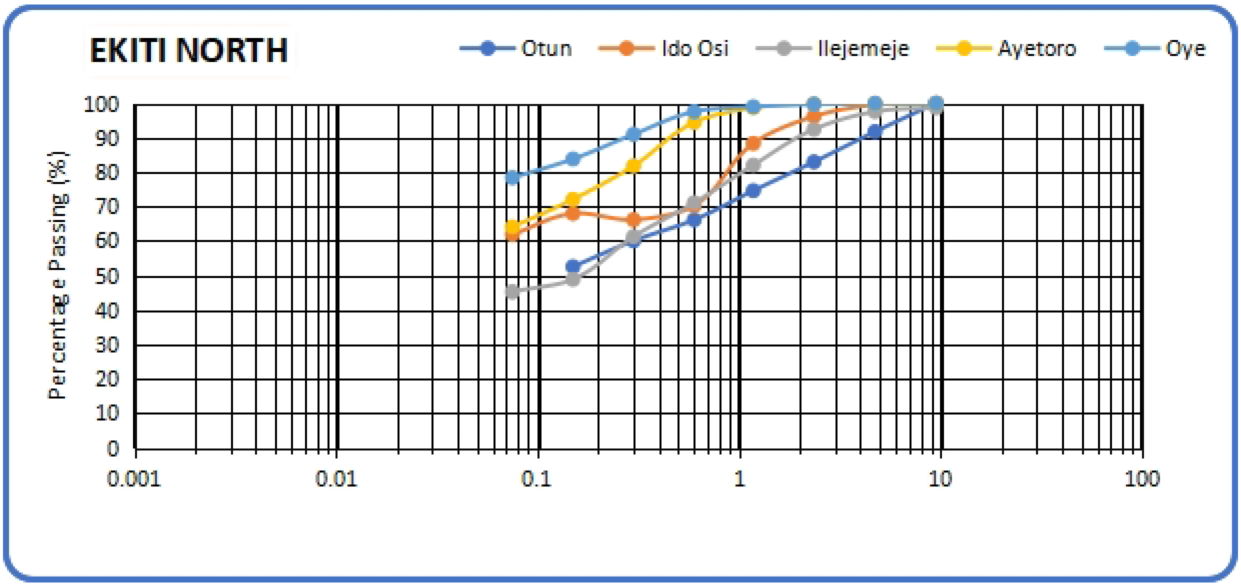

Figure 3: Graph of sieve analysis Ekiti Northern Senatorial Districts (ESND)

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3.4 Results consistency tests

Atterberg limits are commonly employed to assess the plasticity of soils and to predict their potential for swelling and compressibility. "The laboratory analysis revealed a broad spectrum of plasticity characteristics across the study area. Liquid limits (LL) were recorded as low as 16.7% and as high as 71%, while the plasticity index (PI) spanned from 2.4% to 59%. This significant variance highlights the heterogenous nature of Ekiti's soil profile, ranging from non-plastic granular materials to highly plastic clays. Higher plasticity values typically correspond to increased compressibility and swelling potential, which can negatively impact the soil's engineering properties. Standard guidelines specify that sub-base and base materials should have lower plasticity limits to maintain stability. Based on these findings, it is suggested that soils from the Northern and Southern districts may require stabilization due to their elevated plasticity, which could hinder their suitability for construction purposes without modification.

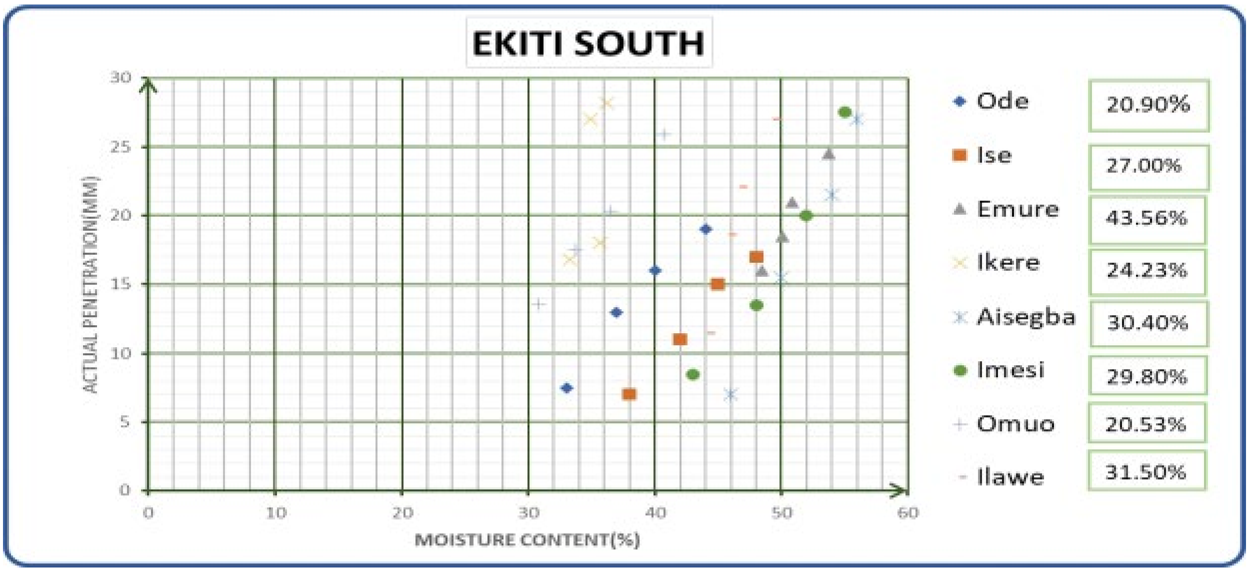

Figure 4: Graph of liquid limit Ekiti Southern Senatorial Districts (ESSD)

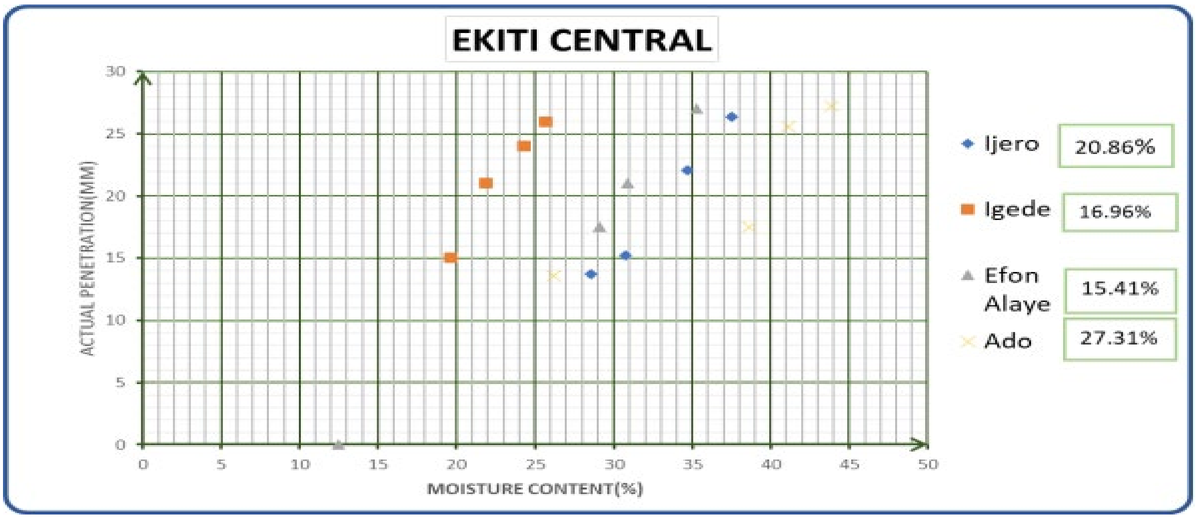

Figure 5: Graph of liquid limit of Ekiti Central Senatorial Districts (ECSD)

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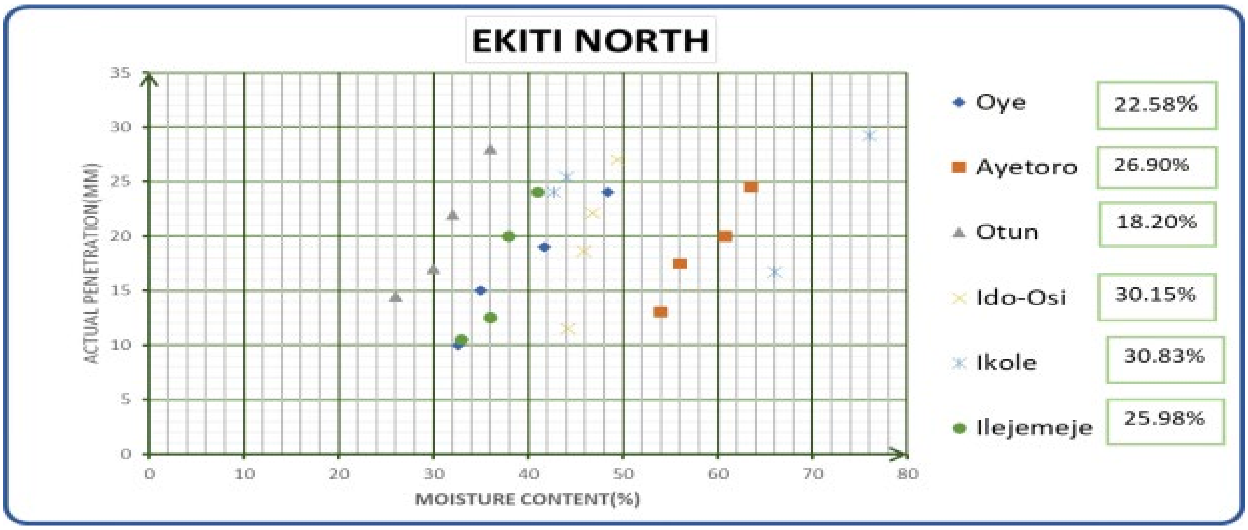

Figure 6: Graph of liquid limits Ekiti Northern Senatorial Districts (ENSD)

3.5 Classification of soils within the senatorial districts

To predict the performance of local materials under traffic loads, this research utilized established grouping methods such as the AASHTO and Unified Soil Classification System (USCS) [2], [25]. The analytical data confirms that materials sourced from the Central District meet the rigorous requirements for base and sub-base construction, while samples from the North and South are better aligned with lower-tier structural applications [7], [16], while soils from the Southern and Northern districts are predominantly suitable for subgrade applications, though they may require improvement. This classification aligns with previous research on lateritic soils, which has highlighted the variability in engineering properties depending on the soil's mineral composition and degree of weathering.

4.0 Conclusion

The evaluation of index properties of soils in Ekiti State indicates that:

i. Soils from the Central Senatorial District have lower Natural Moisture Content and exhibit better engineering characteristics compared to soils from the Southern and Northern districts.
ii. The higher Specific Gravity values in the Central District indicate a greater extent of laterization, which results in improved engineering properties.
iii. Grain size analysis across all districts shows a significant presence of fines, which could influence soil strength and compaction behaviour.
iv. Plasticity Index values suggest that soils in the Northern and Southern districts may pose settlement challenges due to their higher plasticity.
v. Soil classification confirms that soils from the Central District are most appropriate for use in base and sub-base layers, while soils from other districts are better suited for subgrade applications.

5.0 Recommendations

It is recommended that regions in the Northern and parts of the Southern Senatorial Districts, where soils exhibit high moisture sensitivity, incorporate effective drainage systems. This will mitigate strength degradation caused by water ingress. Additionally, soils with high plasticity and fines content should be stabilized using methods such as lime or cement treatment to enhance their engineering performance, particularly for road pavement applications.

References

[1] B. M. Das, *Principles of Geotechnical Engineering*, 8th ed. Boston, MA, USA: Cengage Learning, 2017, pp. 1–750.
[2] K. Terzaghi, R. B. Peck, and G. Mesri, *Soil Mechanics in Engineering Practice*, 3rd ed. New York, NY, USA: John Wiley & Sons, 1996, pp. 1–592.
[3] R. F. Craig, *Craig's Soil Mechanics*, 8th ed. London, U.K.: Spon Press, 2012, pp. 1–636.
[4] A. Adeyeri, "Geotechnical site investigation practices in Nigeria," *Nigerian Journal of Engineering*, vol. 22, no. 1, pp. 45–52, 2015.
[5] N. A. Oyebode, O. A. Afolayan, and S. A. Olatunji, "Effects of inadequate site investigation on pavement performance in West Africa," *International Journal of Pavement Engineering*, vol. 23, no. 6, pp. 2304–2315, 2022. DOI: https://doi.org/10.1080/10298436.2021.1895618

Received: 11/03/2026; Revised: 08/04/2026; Accepted: 09/04/2026; Published: 15/05/2026

[6] A. A. Amadi, "Evaluation of lateritic soils for subgrade stabilization," *Journal of Materials in Civil Engineering*, vol. 31, no. 6, Art. no. 04019120, 2019. DOI: https://doi.org/10.1061/(ASCE)MT.1943-5533.0002731
[7] T. H. Ogunribido, A. O. Akinwumi, and O. O. Oladunjoye, "Assessment of geotechnical properties of subgrade soils for road construction," *Case Studies in Construction Materials*, vol. 16, Art. no. e00865, pp. 1–12, 2022. DOI: https://doi.org/10.1016/j.cscm.2021.e00865
[8] O. Oladele, A. Adeyemo, and J. Adepoju, "Geotechnical characterization of lateritic soils for sustainable pavement design," *Construction and Building Materials*, vol. 300, Art. no. 124124, pp. 1–10, 2021. DOI: https://doi.org/10.1016/j.conbuildmat.2021.124124
[9] M. Sridharan and K. Prakash, *Geotechnical Engineering: Principles and Practices*. New Delhi, India: Tata McGraw-Hill, 2012, pp. 1–500.
[10] H. Rahardjo, A. Satyanaga, and E. C. Leong, "Effects of water content on engineering properties of soils," *Canadian Geotechnical Journal*, vol. 53, no. 6, pp. 891–906, 2016. DOI: https://doi.org/10.1139/cgj-2014-0558
[11] J. R. Underwood, *Soil Mechanics and Foundations*. New York, NY, USA: McGraw-Hill, 1967, pp. 1–400.
[12] J. E. Bowles, *Engineering Properties of Soils and Their Measurement*, 4th ed. New York, NY, USA: McGraw-Hill, 2012, pp. 1–650.
[13] O. O. Oyediran and O. Durojaiye, "Variability in geotechnical properties of lateritic soils," *Electronic Journal of Geotechnical Engineering*, vol. 16, pp. 1–12, 2011.
[14] R. Roy and B. M. Dass, "Effect of specific gravity on shear strength parameters of soil," *International Journal of Engineering Research*, vol. 3, no. 8, pp. 500–503, 2014.
[15] A. O. Alao and O. R. Adegun, "Influence of specific gravity on strength characteristics of residual soils," *Bulletin of Engineering Geology and the Environment*, vol. 81, pp. 411–425, 2022. DOI: https://doi.org/10.1007/s10064-021-02340-7
[16] K. W. S. Abiodun and E. O. Oladiran, "Influence of soil parameters on CBR performance for pavement design," *Transportation Geotechnics*, vol. 34, Art. no. 100812, pp. 1–9, 2022. DOI: https://doi.org/10.1016/j.trgeo.2022.100812
[17] ASTM D2487-17, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. West Conshohocken, PA, USA: ASTM International, 2017. DOI: https://doi.org/10.1520/D2487-17
[18] R. K. Garg, *Soil Mechanics and Foundation Engineering*. New Delhi, India: Khanna Publishers, 2009, pp. 1–600.
[19] M. F. Yussuf and A. S. Ibrahim, "Effects of fines content on soil compaction and strength," *Soils and Foundations*, vol. 61, no. 4, pp. 1142–1154, 2021. DOI: https://doi.org/10.1016/j.sandf.2021.04.004
[20] J. A. Gidigasu, "Laterite soil engineering: Pedogenesis and engineering principles," *Geotechnique*, vol. 21, no. 1, pp. 1–20, 1971. DOI: https://doi.org/10.1680/geot.1971.21.1.1
[21] S. Naresh and E. Nowatzki, "Influence of particle size distribution on soil compaction," *Journal of Geotechnical Engineering*, vol. 132, no. 5, pp. 653–661, 2006. DOI: https://doi.org/10.1061/(ASCE)1090-0241(2006)132:5(653)
[22] B. M. Das and K. Sobhan, *Principles of Geotechnical Engineering*, 8th ed. Boston, MA, USA: Cengage Learning, 2017.
[23] M. Alhassan and M. G. McNally, "Influence of plasticity on compressibility behavior of soils," *Soils and Foundations*, vol. 57, no. 2, pp. 234–245, 2017. DOI: https://doi.org/10.1016/j.sandf.2017.02.002
[24] Federal Ministry of Works (FMW), *General Specifications for Roads and Bridges*. Abuja, Nigeria: FMW, 1997.
[25] AASHTO M145, *Standard Specification for Classification of Soils and Soil-Aggregate Mixtures*. Washington, DC, USA: American Association of State Highway and Transportation Officials, 2017.

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