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Geotechnical Characterization of Subgrade Soils along the Baneah-Donkeah Road Section for Pavement Design

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Abstract

Road infrastructure is essential to economic development, yet many road sections in Guinea deteriorate prematurely because of insufficient geotechnical characterisation of subgrade soils, particularly in tropical lateritic contexts. This study assesses the geotechnical suitability of the subgrade soils of the Baneah-Donkeah road section, which provides access to the Banéah and Donkéah hydroelectric plants in Kindia Prefecture, Republic of Guinea. Five hand-dug test pits and dynamic cone penetrometer soundings were carried out along the 10 km section. Soil samples were tested for natural water content, specific gravity, particle-size distribution, Atterberg limits, modified Proctor compaction and soaked California Bearing Ratio (CBR). Soils were classified predominantly as GTR classes B4 and B6, with plasticity indices between 12% and 25%. Modified Proctor maximum dry density ranged from 2.10 to 2.146 t/m³. CBR values exceeded 60% for most samples (subgrade class PF4), except sample PM3-E2 (CBR 38%, class PF3). The subgrade soils of the Baneah-Donkeah section are, overall, geotechnically suitable for road construction, although their high fines content requires strict moisture control, adequate compaction, and, for the most plastic sample, lime treatment.

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Keywords

Subgrade soil, Lateritic soil, Geotechnical characterisation, CBR, Road pavement design, Guinea

Introduction

Road infrastructure represents an essential driver of the socio-economic development of nations: it ensures the mobility of populations, facilitates trade, and provides access to basic services and areas of production (Ilori & Anusa, 2020). In sub-Saharan Africa, where alternative modes of transport such as rail or inland waterways remain poorly developed, roads are often the principal, if not the only, means of opening up territories and integrating them economically (Foko Tamba *et al.,* 2023). The performance and durability of a pavement depend to a large extent on the geotechnical quality of the subgrade soils, which support the entire road structure (Zeng *et al.,* 2013; Bensafia, 2019). This requirement is even more critical in tropical areas, where residual and lateritic soils display strong mineralogical variability, marked sensitivity to moisture, and heterogeneous mechanical behaviour (Kamtchueng *et al.,* 2015; Sorsa *et al.,* 2020; Nait-Rabah *et al.,* 2023). Several recent studies conducted in Central and West Africa confirm that insufficient geotechnical characterisation of subgrade soils prior to pavement design remains one of the main causes of early pavement distress, such as rutting, cracking and localised settlement (Foko Tamba *et al.,* 2023; Kenou *et al.,* 2025). Seasonal wetting-drying cycles typical of tropical climates further weaken foundation layers, particularly where soils contain a high proportion of plastic fines (Yue *et al.,* 2025).

Aware of this issue, the Guinean State has for several years been making substantial investments in the construction and modernisation of its road network, particularly in the country's interior regions, in order to improve traffic flow, road-user safety and support local economic activity. However, despite these efforts, many road sections experience premature deterioration, often attributable to inadequate assessment of the geotechnical properties of the supporting soils, as highlighted by studies conducted in Lower Guinea (Kindia) and Forest Guinea (Diallo *et al.,* 2021). This situation underscores the need for thorough geotechnical characterisation of subgrade soils, an essential prerequisite for reliable and durable infrastructure design (IDRRIM, 2024). The present study focuses on the Baneah-Donkeah road section, in Kindia Prefecture, where the combination of tropical climatic conditions and geological diversity may influence soil bearing capacity and strength, as well as pavement longevity.

The Baneah-Donkeah section provides access to the Banéah and Donkéah hydroelectric power plants, which are currently being rehabilitated to strengthen their production capacity and improve the reliability of the national electricity grid. The success of these operations depends on the availability of a stable road access capable of withstanding the regular passage of heavy equipment, construction materials and technical personnel. A thorough understanding of the geotechnical characteristics of the soils is therefore essential to design and build a durable pavement, ensuring safe and continuous access to the hydroelectric facilities and contributing to the consolidation of the national energy system.

The central question guiding this study is as follows: *do the soils of the Baneah-Donkeah section possess the geotechnical characteristics required to form a subgrade that meets the requirements of reliable and durable pavement design?*

Based on this problem statement, two working hypotheses are proposed: on the one hand, the soils of the Baneah-Donkeah section display characteristics compatible with road standards, allowing their use as a foundation for appropriate pavement design; on the other hand, some soils do not meet the required standards and need treatment or substitution to ensure pavement durability.

The main objective of this study is to assess the subgrade soils of the Baneah-Donkeah section in order to determine their suitability for road construction and to contribute to an appropriate pavement design adapted to the local context (CERTU, 2000). Specifically, the aims are to: 1) identify and classify the soils; 2) determine the compaction characteristics and assess soil bearing capacity; 3) evaluate the in-situ strength of the soils.

Materials and Methods

Description of the Study Area

Kindia Prefecture, located in the western part of the Republic of Guinea, lies between 10°03' North latitude and 12°52' West longitude. It is bordered to the west by Coyah Prefecture, to the north-west by Dubréka Prefecture, to the north by Fria Prefecture, to the north-east by Télimélé Prefecture, to the east by Mamou Prefecture, to the south by Sierra Leone, and to the south-west by Forécariah Prefecture.

The Baneah-Donkeah section, the subject of this study, is located within Kindia Prefecture and extends over 10 km, crossing two sub-prefectures, as shown in Fig.1.

Climate Context

Kindia Prefecture has a humid tropical climate characterised by a dry season extending from November to April and a rainy season extending from May to October. Rainfall is highly variable, with a maximum of 473.5 mm in August and a minimum of 1.2 mm in January, for an annual average of 162.758 mm (OMM, 2026).

During January, February, March, April, November and December, the temperature curve lies above the precipitation curve. This corresponds to the dry season according to the Gaussen criterion, with a maximum temperature of 27.9 °C. Conversely, during May, June, July, August, September and October, the temperature curve lies below the precipitation curve, reflecting the rainy season, characterised by a maximum rainfall of 473.5 mm.

Geological Setting

Kindia Prefecture, in which the study section is located, belongs geologically to the Bové Syneclise, which represents the southern extension of the Taoudeni Basin. The geological formations specific to the sub-prefectures crossed by the study section mainly comprise Ordovician, Silurian, Quaternary and Mesozoic units.

Ordovician: The Ordovician formations, known as the Pita Sandstones, were first distinguished under the name "Pita Series" by Y. Bouféev *et al.,* and A. Belaev *et al.,* (1969) (Mamedov *et al.,* 2010). These Ordovician formations, dated to approximately 505-438 million years (Ma), lie unconformably on Archaean and early Proterozoic crystalline basement rocks, on the upper Riphean-Cambrian central zones of the Bassari-Rokel trough, on the western parts of the Riphean-Vendian Tougué depression, and on the Cambrian sediments of the Falémé Series (Mamedov *et al.,* 2010). They are characterised by quartzose sandstones containing, at various stratigraphic levels, lenses and horizons of quartz gravelite and small-pebble conglomerates, as well as feldspathic-quartz sandstone intercalations (Mamedov *et al.,* 2010). The Ordovician formations, which are predominant in this study area, have a thickness ranging from 950 to 1000 m (Mamedov *et al.,* 2010).

Silurian (Télimélé Series): The Silurian formations of the Télimélé Series, dated to approximately 438-408 Ma, lie conformably on the sandstone formations of the Pita Series (Mamedov *et al.,* 2010). In this region, they are represented by alternating thick beds of siltstone and mudstone, greenish-grey, pinkish-grey, purplish, yellowish and white in colour (Mamedov *et al.,* 2010). They mainly display parallel stratification, with thicknesses ranging from 50 to 70 m (Mamedov *et al.,* 2010).

Quaternary: The Quaternary formations in Guinea consist essentially of superficial deposits of continental, fluvial and coastal origin, resulting from the weathering and sedimentation of rocks under a tropical climate. In this region, they comprise undifferentiated deposits of clayey sands and sandy silts with alluvial gravel, pebbles and gravel; clayey sands and sandy silts with arenaceous material and angular deluvio-proluvial pebbles; as well as marine silts, clays, clayey sands and sands.

Mesozoic: The Mesozoic intrusions are formations linked to the major tectono-magmatic movements that led to the break-up of the Gondwana continent and the opening of the Atlantic Ocean (Mamedov *et al.,* 2010). In this region, these intrusions occur as sills and dykes, represented mainly by dolerites, gabbro-dolerites and konga-diabases, and more rarely by granophyres and diorites.

Sampling

The site investigation campaign for this study, carried out by Geotec-Afrique, comprised field observation and the excavation of five (5) hand-dug pits, 1 m deep, using a shovel and a pick, at points marked in yellow on the site map. Soil samples were collected in simple bags and in sealed plastic bags to preserve the soils' natural water content. To better illustrate the stratigraphy encountered along the section, the five (5) figures below show the hand-dug test pits.

In addition, near these hand-dug pits, heavy dynamic cone penetrometer tests (type B) were carried out at points marked in red, in order to assess the bearing capacity and compactness of the in-situ soil. Fig.5 shows the layout of the test points.

Laboratory Testing

Identification tests were carried out in accordance with relevant geotechnical standards, including natural water content (NF EN ISO 17892-1), particle-size analysis (NF EN ISO 17892-4), Atterberg limits (NF EN ISO 17892-12), and specific gravity (NF EN ISO 17892-3). For mechanical properties, standard and modified Proctor tests were carried out in accordance with standard NF P 94-093. Bearing capacity was determined using the soaked CBR test, carried out in accordance with standard NF P 94-078. In addition to laboratory tests, in-situ tests were carried out, notably the dynamic cone penetrometer test, in accordance with standard ISO 22476-2.

Results and Discussion

Dynamic Cone Penetrometer Soundings

Dynamic cone penetrometer testing provides a qualitative assessment of the strength of the soils traversed. The full results of the dynamic penetrometer soundings are presented below, sounding by sounding, where: qd is the dynamic point resistance; qu is the failure stress; and qad is the allowable bearing stress.

The results show that the soil is heterogeneous and that bearing capacity increases with depth. The surface horizons show low to medium strength, whereas the deeper, more compact layers offer excellent bearing capacity, with the exception of PD2, which shows good bearing capacity at shallow depth. These results (PD1 to PD5) indicate that the surface layers require very good compaction or, where traffic loading is high, possible improvement. In addition to properly executed compaction, pavement design must take into account the low bearing capacity of the surface layers.

Physical Properties

The natural water content of a soil is an essential parameter for assessing its hydric state. Table.6 presents the natural water content values obtained for each sample.

Analysis of the table shows that natural water content values range from 11.7% to 33.4%, reflecting the variability of the soils studied. The reddish-brown gravelly lateritic soils observed in samples PM2-E2, PM4-E1 and PM5-E1 show relatively similar water contents, between 11.7% and 16.9%, reflecting similar hydric behaviour linked to their coarse nature and good drainage capacity.

Intermediate water contents are observed in the slightly clayey sandy soils, while the highest value is recorded in sample PM4-E2, owing to the presence of water in the hand-dug pit. This sample corresponds to a fines-rich blackish sandy silt, characterised by a high water-retention capacity.

The specific gravity of solid particles, measured using a pycnometer for all samples, is presented in Table.7.

The density values obtained for lateritic soils PM2-E2, PM4-E1 and PM5-E1 are relatively low compared with those reported by (Konaté *et al.,* 2025), namely 2.60 and 2.67 g/cm³ respectively.

This difference could be attributable to local geological conditions, degree of weathering, or mineralogical composition.

Particle Size Analysis

Particle-size analysis determines the distribution of soil particles by diameter using a series of standard sieves. Fig.6 presents the particle-size distribution curves for six samples: PM1-E1, PM2-E2, PM3-E2, PM4-E1, PM5-E1 and PM4-E2.

All curves are continuous and increasing, indicating a normal particle-size distribution without marked discontinuity. At 0.08 mm, the percentage passing lies between 20% and 40%, except for the PM2-E2 curve, which lies between 10% and 20%. This indicates the presence of fine particles, meaning the soils are not purely sandy or gravelly.

The slope of the curves generally lies within the sandy fraction (0.08-2 mm) for samples PM4-E2, PM3-E2 and PM1-E1. Sample PM5-E1 shows an almost balanced proportion between the sandy and gravelly fractions, indicating intermediate behaviour. Samples PM2-E2 and PM4-E1, whose curves lie further to the right, show coarser fractions, indicating a predominance of gravel. The soils are predominantly sandy with fines, with a variable but not dominant gravel content across samples. The soils are well graded, which is favourable for good bearing capacity and moderate permeability.

Classification according to the GTR system (SETRA, 2000) shows that the samples analysed belong predominantly to family B, mainly classes B4 and B6, corresponding to sandy to sandy-gravelly soils with a non-negligible fines content. The curves show a good particle-size range, indicating generally well-graded soils favourable to compactness and bearing capacity when properly implemented. However, the presence of fine particles gives the soils a sensitivity to water that may reduce bearing capacity under wet conditions.

Atterberg Limits

Atterberg limits comprise the liquid limit and the plastic limit. Table.8 presents the Atterberg limits for all soil samples studied.

Analysis of the table shows that all samples studied have a plasticity index between 12% and 25%, indicating moderately clayey soils. According to standard NF P11-300 (AFNOR, 1992), soils with a percentage passing the 0.08 mm sieve between 12% and 35% and a plasticity index above 12% are classified as class B6, corresponding to sands and gravels that are clayey to highly clayey. Most soils show low to medium plasticity, compatible with road use, while samples PM2-E2 and PM5-E1 show high plasticity requiring special precautions or treatment. Sample PM5-E1 requires a slight improvement of 4-8% lime to enhance its mechanical performance, a treatment approach whose effectiveness has been demonstrated on similar soils (Kenou *et al.,* 2020; Israël Mamah *et al.,* 2025).

Casagrande plasticity charts for all samples are provided in the appendix to this document.

Proctor Compaction

The Proctor test determines the maximum dry density and the optimum water content, key parameters for the CBR test. The curves below present the Proctor test results for all samples.

In road applications, water contents between 7% and 10%, combined with a maximum dry unit weight above 2 t/m³, indicate an excellent material.

Analysis of the Proctor curve for sample PM2-E2 shows a maximum dry density of 2.106 t/m³ at an optimum water content of 9.2%.

This result indicates good compaction ability, as the material is dense and high-performing.

Analysis of the Proctor curve for sample PM3-E2 shows a maximum dry density of 2.10 t/m³ at an optimum water content of 9.8%. This result indicates very good mechanical behaviour.

Analysis of the Proctor curve for sample PM4-E1 shows a maximum dry density of 2.146 t/m³ at an optimum water content of 7.4%. This result indicates an excellent road-construction material.

Analysis of the Proctor curve for sample PM5-E1 shows a maximum dry density of 2.146 t/m³ at an optimum water content of 7.4%. This result indicates an excellent road-construction material.

Overall, the Proctor curves show that samples PM5-E1, PM2-E2 and PM4-E1, of lateritic nature, display the best compaction characteristics, with high maximum dry densities and low optimum water contents.

CBR Index

The CBR test is essential for assessing soil bearing capacity. The results of all CBR tests carried out in this study are presented in the graphs below.

Analysis of the CBR curve for sample PM2-E2 indicates a CBR value, measured at 95% of the modified Proctor optimum, of 61%, for a corresponding dry density of 2.001 t/m³. These results indicate a very good bearing material.

Analysis of the CBR curve for sample PM3-E2 indicates a CBR value, measured at 95% of the modified Proctor optimum, of 38%, for a corresponding dry density of 1.97 t/m³. These results indicate medium bearing capacity, usable under certain conditions.

Analysis of the CBR curve for sample PM4-E1 indicates a CBR value, measured at 95% of the modified Proctor optimum, of 65%, for a corresponding dry density of 1.847 t/m³. These results indicate a very good bearing material.

Analysis of the CBR curve for sample PM5-E1 indicates a CBR value, measured at 95% of the modified Proctor optimum, of 69%, for a corresponding dry density of 2.039 t/m³. These results indicate a very good bearing material, reflecting excellent road-performance behaviour.

The CBR values obtained confirm that bearing capacity is generally high for the soils studied, with values above 60 for several samples, making these materials suitable for road foundation layers. Only PM3-E2 shows medium bearing capacity, requiring a more conservative design approach. These soils fall within subgrade class PF4, except for sample PM3-E2, which falls within class PF3 (very low deformability).

Summary of Results

Table.9 presents the cross-tabulated summary of the results obtained in this study.

The combined analysis of particle-size results, plasticity indices, modified Proctor compaction parameters and CBR indices highlights an overall consistency in the geotechnical behaviour of the soils studied.

The particle-size curves show that most samples display a continuous distribution with a significant proportion of coarse fractions (sands and gravels), favourable to good bearing capacity. Plasticity indices remain generally low to moderate, indicating plasticity compatible with road construction. Samples with lower PI values (PM1-E1, PM3-E2, PM4-E2) are generally associated with better mechanical performance.

Modified Proctor results show high maximum dry density values, ranging from 2.10 to 2.146 t/m³, reflecting excellent compaction ability. These values are consistent with the lateritic and gravelly nature of the soils. Samples PM2-E2, PM4-E1 and PM5-E1 show

CBR indices above 60%, reflecting very good bearing capacity, placing them in subgrade class PF4.

In contrast, PM3-E2, despite good compactness, shows a lower CBR (38%), requiring a more cautious design approach, although it remains a very low-deformability material (PF3). Thus, the cross-tabulated summary shows that a soil combining good particle-size distribution, low plasticity and high maximum dry density results in high bearing capacity.

Particle-Size Distribution and GTR Classification: The particle-size distribution results obtained in this study, with a fines content generally between 20% and 40% passing the 0.08 mm sieve, are consistent with those reported by CEBTP (1984, 1992) for lateritic gravels and clayey sands recommended for use in road foundation layers. A comparable grading pattern has also been reported in other West and Central African contexts: working on lateritic soils derived from sedimentary rock along the Lagos-Ibadan expressway in Nigeria, (Ajayi *et al.,* 2024) classified their materials as clayey sands to silty clays with similar grading characteristics, and likewise found that the coarser, better-graded samples were the most suitable for subgrade use, mirroring the distinction observed here between the coarser samples PM2-E2 and PM4-E1 and the finer sample PM4-E2. By comparison, (Kouassi *et al.,* 2025) obtained a percentage passing the 0.08 mm sieve of 18%, slightly lower than the values observed in this study, suggesting a somewhat higher fines content in our samples; this is broadly consistent with the range reported by (Yabi *et al.,* 2026) for fine lateritic soils in southern Benin, where the percentage passing the 80 µm sieve was likewise found to strongly control subsequent GTR classification and treatment requirements.

Atterberg Limits, Plasticity and Water Sensitivity: Regarding plasticity, the indices obtained in this study (12-25%) are comparable to those reported by (Konaté *et al.,* 2025; Kouassi *et al.,* 2025) (16-22%), confirming the medium plasticity typical of lateritic soils in the sub-region. They also fall within the range reported by (Yabi *et al.,* 2026), who found average plasticity indices of 22-27% for fine lateritic soils suitable for lithostabilised base-course use in Benin, and are broadly consistent with the moderate-to-high plasticity values reported for lateritic subgrade and sub-base materials in south-western Nigeria by (Ajayi *et al.,* 2024). This convergence across several independent West and Central African studies supports the conclusion that fines-rich lateritic soils in this plasticity range are a recurring, rather than site-specific, characteristic of tropical road corridors, and that their water sensitivity should be treated as a standing design consideration rather than an anomaly. The correlation observed here between higher plasticity (samples PM2-E2 and PM5-E1) and reduced or more variable bearing performance echoes the findings of (Mezie *et al.,* 2025), who showed that the durability of lateritic soils under wetting-drying cycles is strongly governed by their fines content and plasticity, with the most plastic soils losing more strength unless stabilised. This reinforces the appropriateness of the lime treatment recommended in this study for sample PM5-E1, an approach whose effectiveness on similarly plastic soils has been demonstrated both in Cameroon (Kenou *et al.,* 2020; Israël Mamah *et al.,* 2025) and, more broadly, through calcium-based stabilisation of West African lateritic soils (Mbengue *et al.,* 2023).

Compaction Characteristics: The Proctor test values obtained in this study are consistent with the recommendations of CEBTP (CEBTP, 1984) for use in foundation layers, a requirement also highlighted by (Mengue *et al.,* 2015) in the design of pavement base layers using treated lateritic soils. They are also comparable to results reported by (Kouassi *et al.,* 2025), confirming the geotechnical suitability of the materials studied for road use. Furthermore, (Konaté *et al.,* 2025) obtained higher optimum water contents and relatively lower maximum dry densities than those measured here, a difference that may reflect the somewhat coarser, less plastic nature of the Baneah-Donkeah samples compared with the soils they studied. Similar maximum dry densities, in the range of 2.0-2.15 t/m³, have also been reported for comparable lateritic sub-base materials in Nigeria (Ajayi *et al.,* 2024) and Burkina Faso (Mbengue *et al.,* 2023), supporting the view that, once properly compacted, these soils generally achieve densities adequate for road applications across the sub-region.

Bearing Capacity (CBR) and Pavement Implications: The CBR results obtained here are relatively lower than those obtained by (Kouassi *et al.,* 2025) in their study of a lateritic soil in central Côte d'Ivoire, where CBR values reached 88%. This difference is explained by the higher fines content in our samples, consistent with the inverse relationship between fines content and CBR gain reported by (Yabi *et al.,* 2026) for lithostabilised fine lateritic soils in Benin, where a lower plasticity index and lower fines percentage were both associated with greater CBR improvement after treatment.

Table.1 Sounding PD1

Depth (m)	qd avg (MPa)	qu avg (MPa)	qadm avg (MPa)	qadm avg (bar)	Qadm avg (kPa)
0 – 1	2.60	0.37	0.12	1.24	123.75
1 – 2	1.63	0.23	0.08	0.78	77.69
2 - 2.50	14.13	2.02	0.67	6.73	672.96

Refusal at 2.50 m

Table.2 Sounding PD2

Depth (m)	qd avg (MPa)	qu avg (MPa)	qadm avg (MPa)	qadm avg (bar)	Qadm avg (kPa)
0 - 1	5.20	0.74	0.25	2.48	247.51
1 - 1.30	15.64	2.23	0.74	7.45	744.56

Refusal at 1.30 m

Table.3 Sounding PD3

Depth (m)	qd avg (MPa)	qu avg (MPa)	qadm avg (MPa)	qadm avg (bar)	Qadm avg (kPa)
0 - 1	2.02	0.29	0.10	0.96	96.25
1 - 2	1.77	0.25	0.08	0.84	84.17
2 - 2.90	9.71	1.39	0.46	4.62	462.23

Refusal at 2.90 m

Table.4 Sounding PD4

Depth (m)	qd avg (MPa)	qu avg (MPa)	qadm avg (MPa)	qadm avg (bar)	Qadm avg (kPa)
0 - 1	9.24	1.32	0.44	4.40	440.01
1 - 2	4.49	0.64	0.21	2.14	213.66
2 - 3	2.06	0.29	0.10	0.98	97.88
3 - 4	8.28	1.18	0.39	3.94	394.29
4 - 5	7.52	1.07	0.36	3.58	358.20
5 - 6	6.50	0.93	0.31	3.10	309.76

Stopped at 6.00 m

Table.5 Sounding PD5

Depth (m)	qd avg (MPa)	qu avg (MPa)	qadm avg (MPa)	qadm avg (bar)	Qadm avg (kPa)
0 - 1	5.63	0.80	0.27	2.68	268.13
1 - 2	1.36	0.19	0.06	0.65	64.74
2 - 3	1.93	0.28	0.09	0.92	91.77
3 - 3.30	22.73	3.25	1.08	10.82	1082.37

Refusal at 3.30 m

Table.6 Natural water content results

Sample	PM1-E1	PM2-E2	PM3-E2	PM4-E1	PM4-E2	PM5-E1
Water content (%)	13.8	16.9	21.1	11.7	33.4	15

Table.7 Specific gravity results

Sample	PM1-E1	PM2-E2	PM3-E2	PM4-E1	PM4-E2	PM5-E1
Density (g/cm³)	2.452	2.434	2.322	2.285	2.275	2.326
Unit weight (kN/m³)	24.03	23.85	22.76	22.39	22.30	22.79

Table.8 Atterberg limits results

Sample	PM1-E1	PM2-E2	PM3-E2	PM4-E1	PM4-E2	PM5-E1
LL (%)	24.8	41.6	28.32	41.5	24	37.31
PL (%)	11.56	18.12	14.78	21.75	11.87	15.57
PI (%)	13.23	23.48	13.53	19.74	12.12	21.73

Table.9 Cross-tabulated summary (PI - Proctor - CBR)

Sample	PI (%)	γdmax (t/m³)	CBR (%)	Assessment
PM1-E1	13.23	-	-	Good
PM2-E2	23.48	2.106	61	Good but water-sensitive
PM3-E2	13.53	2.10	38	Medium
PM4-E1	19.74	2.146	65	Good
PM4-E2	12.12	-	-	Good
PM5-E1	-	2.146	69	Excellent

Fig.1 Location of the Baneah-Donkeah study section, Kindia Prefecture

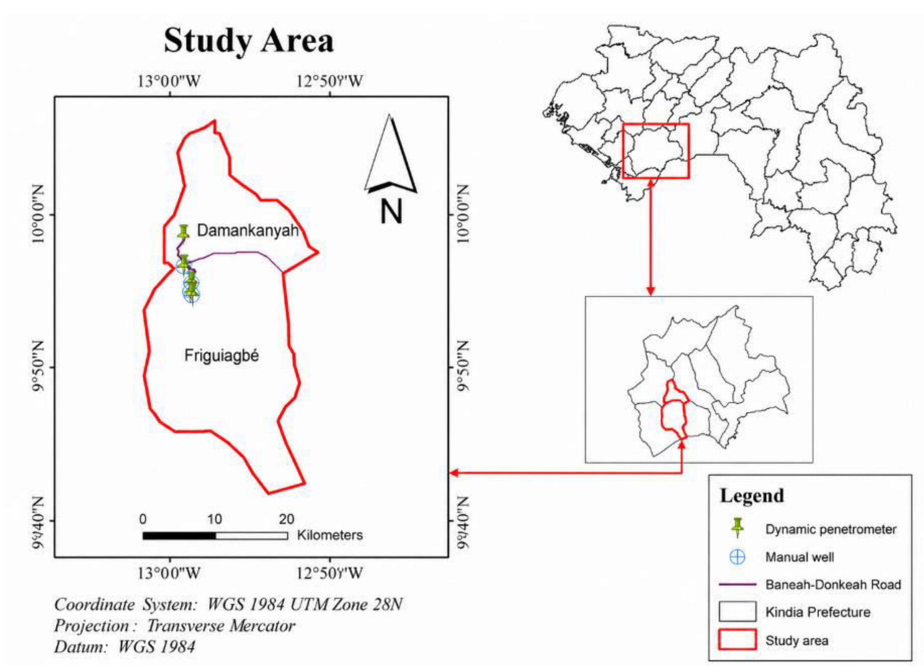


Fig.2 Climatic evolution in Kindia Prefecture

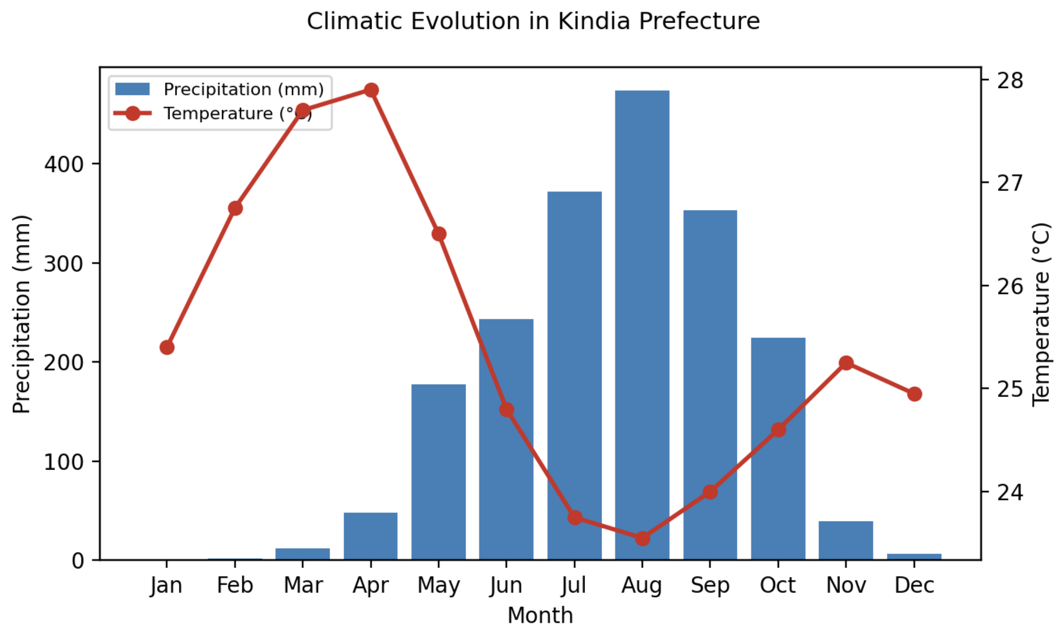


Fig.3 Geological map of the study area

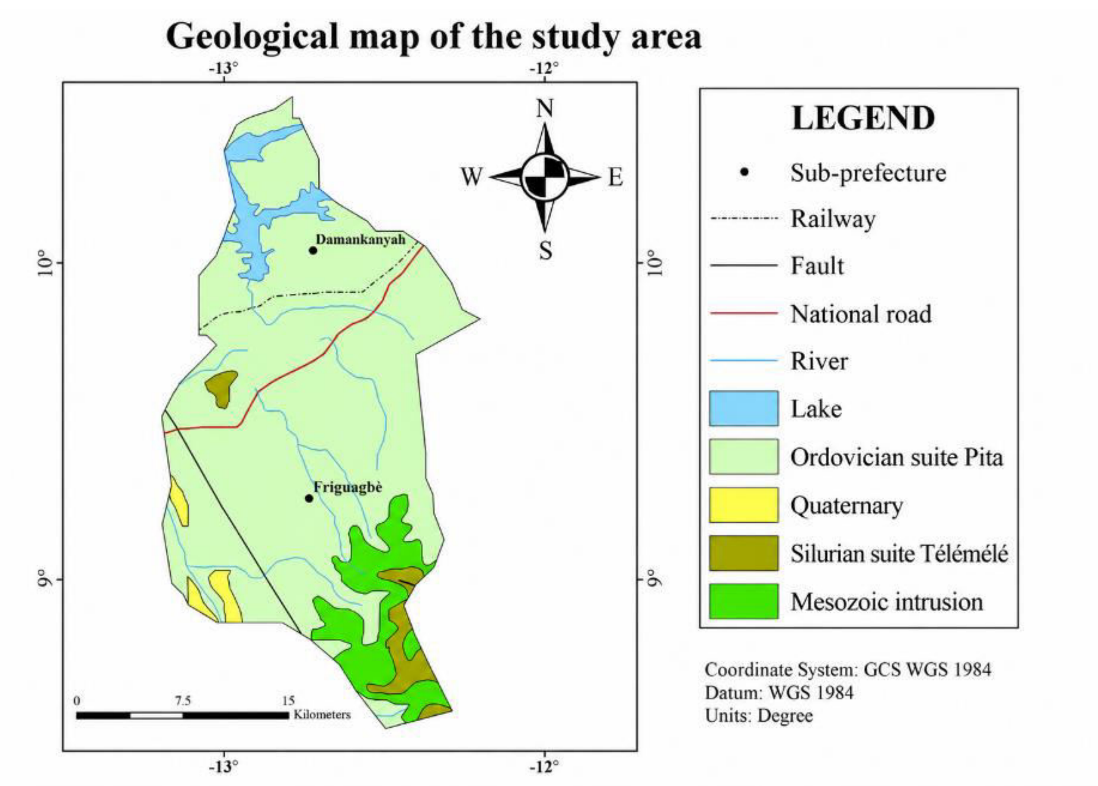


Fig.4 Hand-dug test: (a) pit PM1, (b) pit PM2, (c) pit PM3, (d) pit PM4 and (e) pit PM5

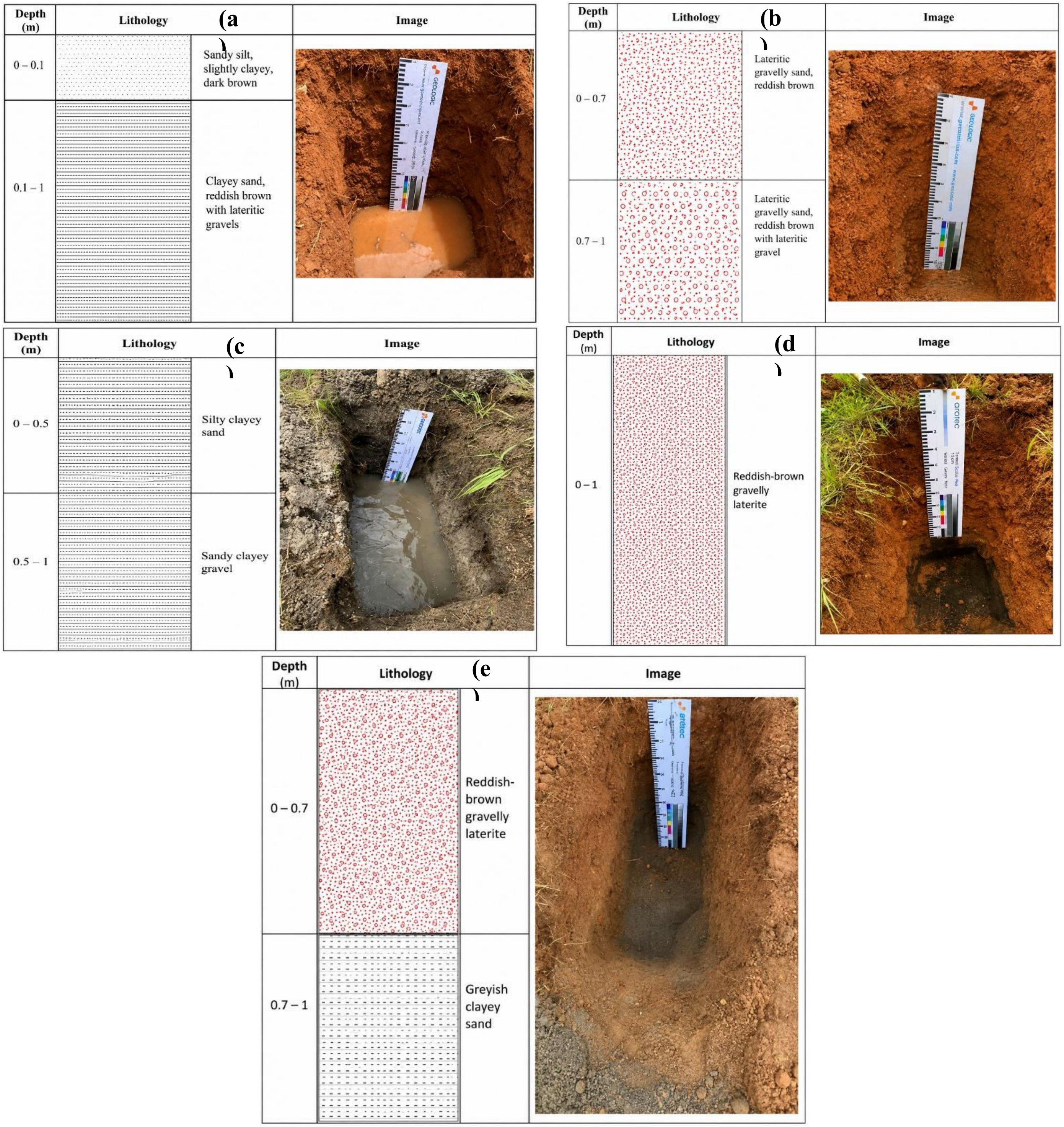


Fig.5 Layout plan of the test points

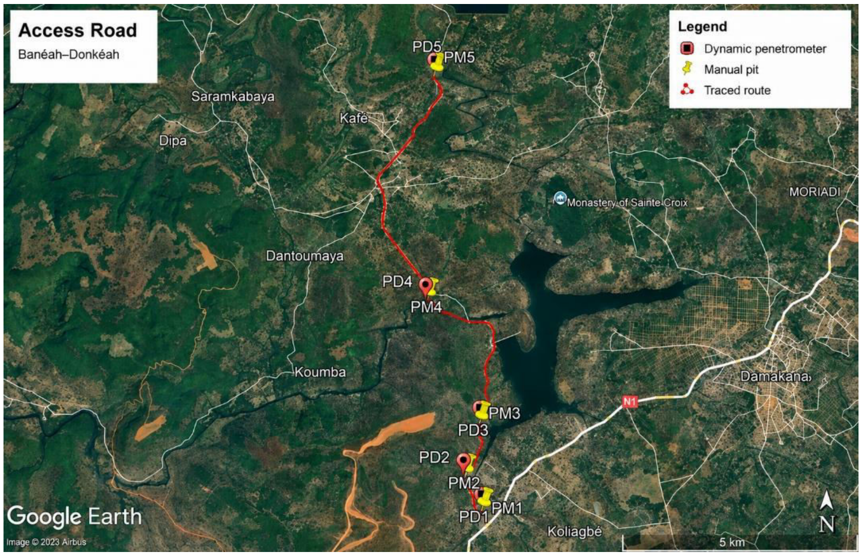


Fig.6 Particle-size distribution curves

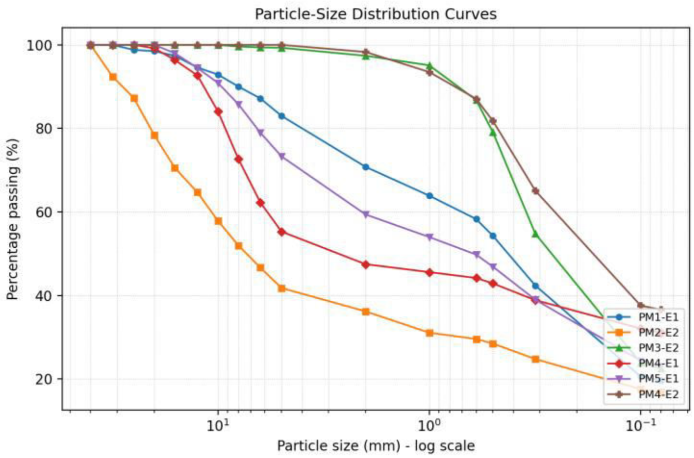


Fig.7 Proctor compaction curve - sample PM2-E2

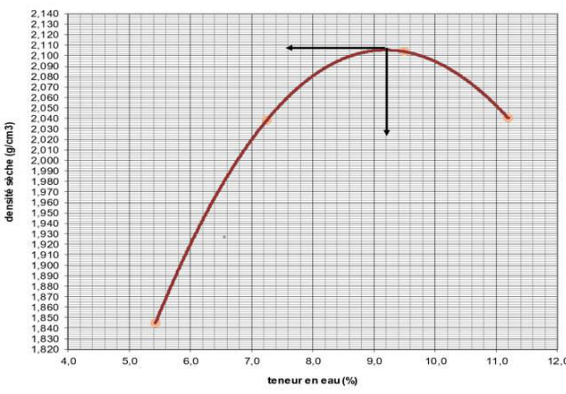


Fig.8 Proctor compaction curve - sample PM3-E2

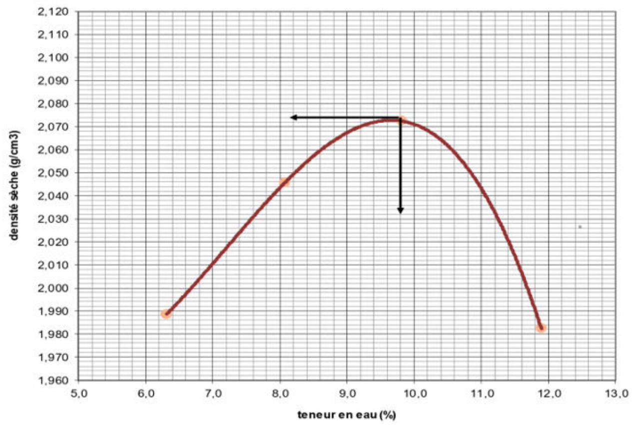


Fig.9 Proctor compaction curve - sample PM4-E1

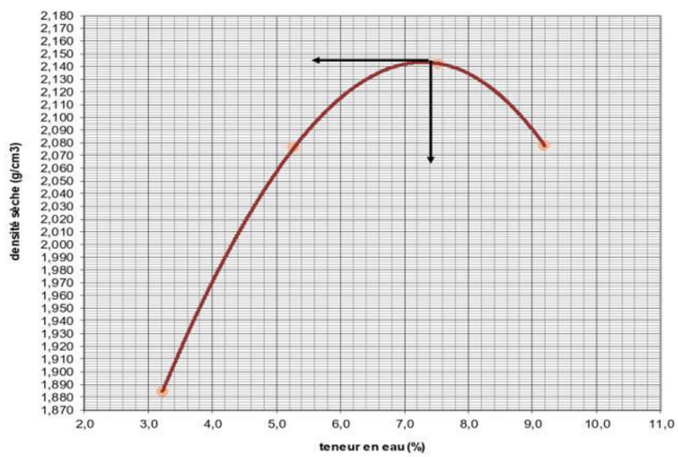


Fig.10 Proctor compaction curve - sample PM5-E1

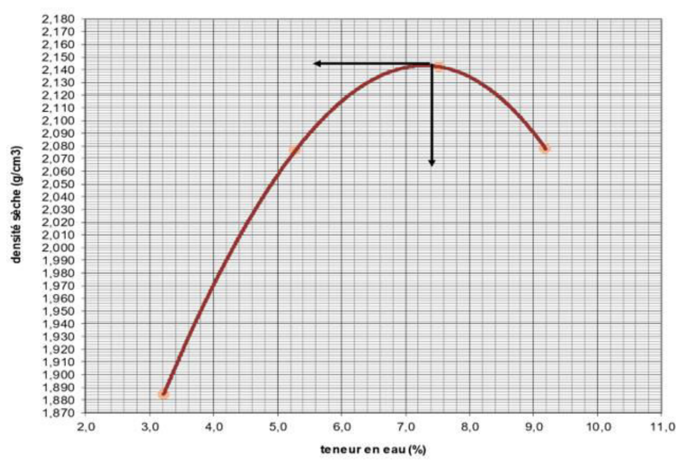


Fig.11 CBR curve - sample PM2-E2

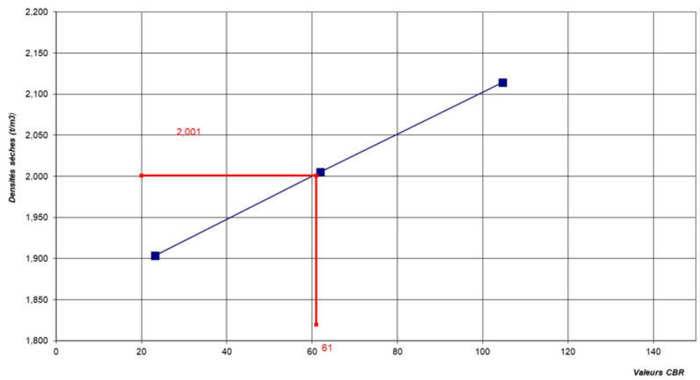


Fig.12 CBR curve - sample PM3-E2

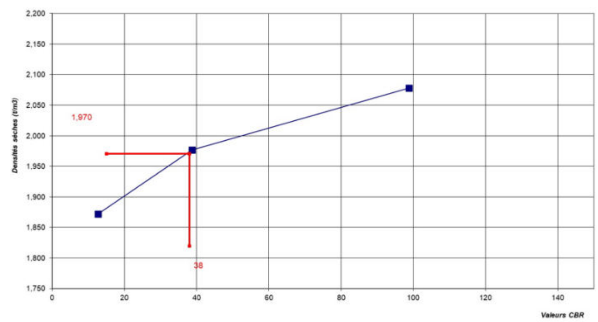


Fig.13 CBR curve - sample PM4-E1

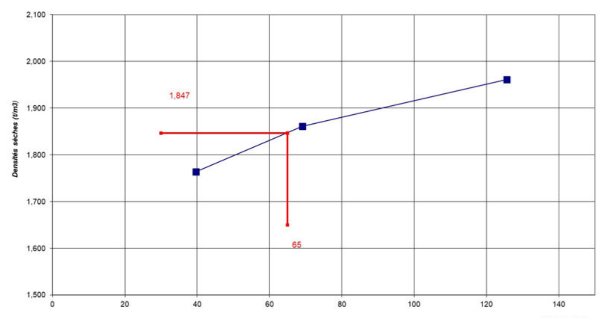
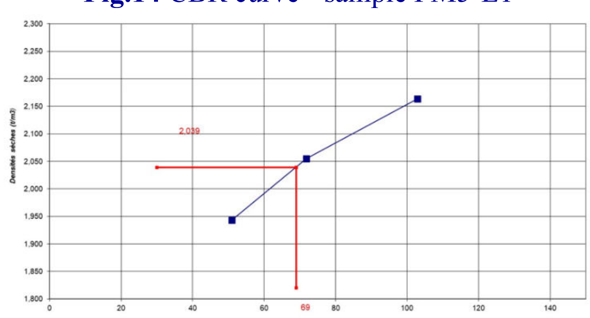


Fig.14 CBR curve - sample PM5-E1



Similarly, (Mbengue *et al.,* 2023) observed that the initial physical and mineralogical properties of lateritic soils, and not only the treatment subsequently applied, strongly control the magnitude of CBR gain achievable through cement or lime addition; this is consistent with the more limited bearing capacity of the finer, more plastic samples (PM2-E2, PM3-E2) relative to the coarser samples (PM4-E1, PM5-E1) observed in the present study. The subgrade classes obtained (PF4 for most samples, PF3 for PM3-E2) are consistent with the

CBR ranges reported for other tropical lateritic subgrade soils assessed for direct road use without treatment, such as those studied by (Ajayi *et al.,* 2024) in Nigeria and (Sorsa *et al.,* 2020) in Ethiopia, where samples with higher fines content and plasticity likewise returned the lowest, though still generally acceptable, bearing values. This consistency across several independent regional studies strengthens confidence that the classification obtained for the Baneah-Donkeah section reflects a genuine geotechnical characteristic of the corridor rather than a testing artefact.

Implications for Design and Durability: Taken together, these results confirm that, while the Baneah-Donkeah subgrade soils are broadly suitable for road construction, their water sensitivity, linked to fines content and plasticity, remains the main geotechnical risk factor, consistent with durability concerns raised for comparable lateritic soils elsewhere in the sub-region (Yue *et al.,* 2025; Mengue *et al.,* 2015; Mbengue *et al.,* 2023; Mezie *et al.,* 2025). As demonstrated by (Konaté *et al.,* 2025) for Guinean lateritic subgrade soils subjected to cyclic wetting-drying, bearing capacity can decline markedly after the first wetting-drying cycle before stabilising; this supports the recommendation, made in the Conclusion, that the Baneah-Donkeah soils be subjected to similar cyclic durability testing before final pavement design, particularly for the finer, more plastic samples identified in this study.

Conclusion and Recommendations

Road infrastructure is an important lever for economic exchange and the social development of a region. However, several road sections experience premature deterioration due to a lack of, or insufficient, geotechnical studies.

The Baneah-Donkeah section is subject to increasing traffic and substantial rainfall, hence the need to characterise the in-situ soils in order to better design the pavement layers.

The results of the particle-size analysis and Atterberg limits show that all samples are classified, according to the GTR system (SETRA, 2000), in classes B4 and B6, corresponding respectively to clayey gravels and to sands and gravels that are clayey to highly clayey. These soils are characterised by a significant proportion of fine elements, reflecting high water sensitivity.

CBR bearing tests allowed most soils to be classified in subgrade category PF4, indicating an overall satisfactory suitability to support the pavement. However, sample PM3-E2 was classified as PF3, reflecting a medium bearing capacity lower than that of the other soils studied, highlighting a degree of geotechnical heterogeneity along the section.

The study therefore answered the research question, showing that the subgrade soils of the Baneah-Donkeah section overall display geotechnical characteristics compatible with use in road infrastructure (soils generally acceptable as subgrade). Nevertheless, the high fines content and potential water sensitivity require appropriate technical measures, such as strict moisture control during construction and compaction in accordance with Proctor specifications.

Depending on traffic loading, this study will help define the thickness of the various pavement layers and their implementation conditions, in order to ensure the reliability and durability of the structure.

Finally, it is recommended that this study be supplemented by further investigations, particularly durability tests such as wetting-drying cycles, following the approach adopted by (Konaté *et al.,* 2025) on Guinean lateritic soils, in order to assess the evolution of soil bearing capacity in relation to climatic variations, as well as an analysis of future traffic to optimise pavement design and ensure the long-term durability of the infrastructure.

Author's Contributions

The author conceived the study, carried out the field sampling and laboratory testing, analysed the data, and drafted and approved the final version of the manuscript.

Conflict of Interest

The author declares that there is no conflict of interest.

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