

Contribution to the Geotechnical Mapping of Lateritic Gravels in Western Senegal for Road Construction in Senegal, West Africa

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Received December 01, 2025; Revised January 01, 2026; Accepted January 08, 2026

Abstract Lateritic gravels (LG) constitute a strategic material for road construction in Senegal. This study aims to map and perform a geotechnical characterization of lateritic borrow pits from the Dakar and Thiès regions, in order to assess their suitability for use in sub-base and base layers of road pavements. Physical and mechanical tests were carried out on laterites from nine sites in their natural state, and after stabilization with 1%, 2%, and 3% cement. The results show that most laterites from the Dakar and Thiès regions except those from the Ngoundiane and Lam-Lam quarries, which exhibit excessive plasticity ($PI > 25\%$) are suitable for use as sub-base materials ($CBR > 30\%$). However, most of them do not meet the CEBTP and AGEROUTE standards for base course applications. After cement stabilization at 1%, 2%, and 3%, the CBR values range between 54% and 374.53%. Laterites from Toglou 1, Sindia, and Tchicky can be used as base course materials (CBR at 95% $> 80\%$, and in some cases $> 160\%$) starting from 2% cement content, while all laterites become suitable from 3% cement, except Lam-Lam, which meets specifications only at 4% cement content. Unconfined compressive strength (UCS) tests on cement treated laterites (1%, 2%, and 3%) yielded results that comply with CEBTP (1984) standards ($1.8 < R_c < 3.0$ MPa). In terms of tensile strength, only the Sindia, Toglou, Yeba, and Tchicky quarries met the CEBTP criterion ($R_t > 0.3$ MPa) after 3% cement treatment.

Keywords: Geotechnical mapping, lateritic gravels, CBR, base course, sub-base, borrow pits, Dakar, Thiès, Senegal

Cite This Article: Papa Sanou Faye, Adama Dione, Issa Ndoeye, Saliou Pene, Fatou Samb, and Ibrahima Khalil Cissé, "Contribution to the Geotechnical Mapping of Lateritic Gravels in Western Senegal for Road Construction in Senegal, West Africa." *American Journal of Civil Engineering and Architecture*, vol. 14, no. 1 (2026): 1-10. doi: 10.12691/ajcea-14-1-1.

1. Introduction

Lateritic gravels are widely used in road construction across tropical regions due to their abundance and relatively low cost. These are residual soils formed under humid tropical climates and composed primarily of a granular fraction. Lateritic gravel results from the weathering of a parent rock that becomes depleted in silica and enriched in iron and alumina [1]. Depending on their physical and mechanical properties, laterites can be used as pavement layers, embankments, or for other civil engineering purposes [2,3,4,5,6,7,8]. The suitability of laterite in road construction mainly depends on its mechanical strength, permeability, and bearing capacity [5,8,9]. However, its geotechnical properties vary considerably depending on geological origin, degree of weathering, and particle-size composition.

In Senegal, lateritic soils are widespread throughout the country, particularly in the western regions. Numerous quarries are found across the territory, especially in the regions of Thiès, Dakar, Louga, and Kaolack. These materials have been the subject of several previous studies [1,2,3,4,5,6,7,8]. Nevertheless, their effective use continues to raise key questions concerning their geotechnical characteristics especially their mechanical behavior, their ability to withstand increasing heavy traffic loads associated with economic growth, and their durability under the specific environmental conditions of the region.

This study aims to contribute to a better understanding of the lateritic gravels (LG) of Senegal. Specifically, it seeks to inventory and map lateritic borrow pits in the Dakar and Thiès regions, characterize their geotechnical properties, and assess their suitability for use as sub-base and base layers in road pavements.

The research approach is based on a detailed

geotechnical characterization of lateritic materials from these two regions, with the ultimate goal of evaluating their potential use in pavement layer construction.

2. Materials and Methods

2.1. Study Area

The study area is located in the western part of Senegal, spanning the administrative regions of Dakar and Thiès [Figure 1](#). It covers a large portion of the Cap-Vert Peninsula, including the natural regions of the Diass Horst and the Thiès escarpment.

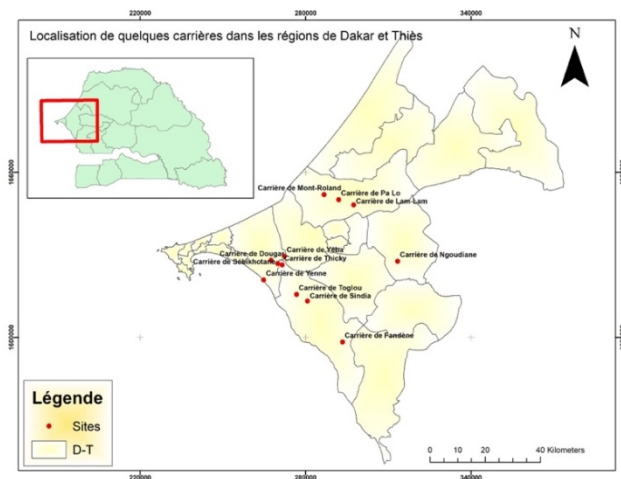


Figure 1. Distribution of lateritic borrow pits in the Dakar and Thiès regions

The Thiès Plateau is bounded to the west by a steep cliff known as the “Thiès cuesta.” Eastward, the plateau gently slopes under a Quaternary sand cover, extending beyond Thiès to Diack, about thirty kilometers southwest of Khombole [\[10\]](#). The Diass Horst corresponds to an anticlinal dome with a Maastrichtian sandstone core, stretching from Pout to Popenguine in a north–south direction. It gradually subsides north of Pout and terminates southwestward along a line of coastal cliffs. To the east and west, the dome is bordered by depressed zones corresponding to drowned regions. The highest point of the horst is at Tchicky (104 m), but the overall landscape consists of tabular hills partially covered by remnants of a ferruginous crust [\[11\]](#). Tessier [\[12\]](#) described the Diass dome as “generally composed of soft sandstones, covered by laterite and irregularly dissected into small hills.” Demoulin & Michel [\[13\]](#) also reported the presence of “a compact ferruginous crust over the upper parts of the massif, and a lower, conglomeratic or gravelly ferruginous crust” [\[1\]](#).

The Dakar region, located at the extreme western tip of Senegal, experiences a tropical climate strongly influenced by the southwest monsoon, while the Thiès region is characterized by a tropical Sahelian climate influenced by maritime trade winds and the harmattan. Due to its coastal position, the study area is also affected by maritime trade winds from November to June, resulting in a local coastal-type climate (Leroux, 1983 in [\[14\]](#)). The

continental trade wind, or harmattan, is weakly felt in Dakar during the dry season and becomes more noticeable farther inland.

Monthly and annual variations in rainfall and temperature were analyzed using meteorological data from the National Civil Aviation and Meteorology Agency (ANACIM) for the Dakar-Yoff and Thiès stations ([Figure 2](#) and [Figure 3](#)). The monthly rainfall data show a wet season extending from June to October, with peak precipitation in August. Average monthly rainfall reaches 162.4 mm in Thiès and 138.7 mm in Dakar, while the remainder of the year is almost rain-free. Annual rainfall displays considerable variability, alternating between deficit and surplus periods.

Temperatures in the study area range between 17°C and 25°C from December to April, and between 27°C and 30°C from May to November. Long-term temperature trends (1970–2020) indicate a general warming trend, particularly since the 1980s. After a relatively cool period during the 1970s, annual temperatures regularly exceeded the long-term mean of 36°C from the 1990s onward, confirming progressive warming. In Thiès, the hottest months are April and May, with maximum temperatures reaching 40°C, whereas December and January are characterized by cooler conditions.

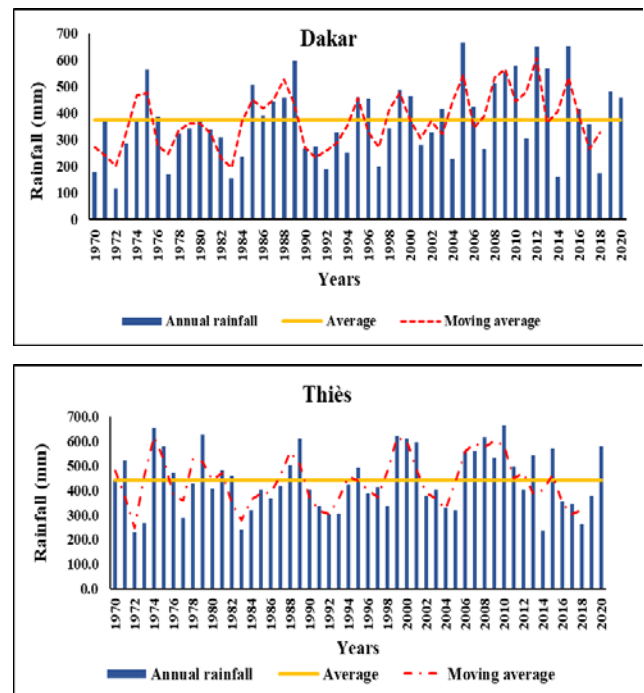
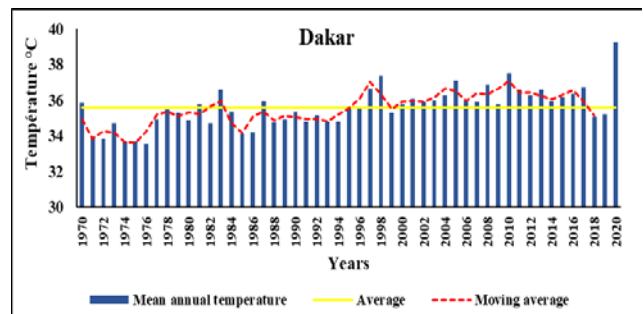


Figure 2. Annual cumulative rainfall in Dakar and Thiès (1970–2020)



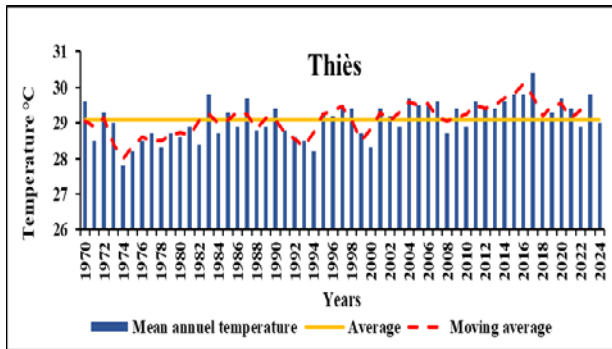


Figure 3. Annual cumulative temperature in Dakar and Thiès (1970–2020)

2.2. Sampling and Testing Program

Field investigations were carried out in nine lateritic quarries located in western Senegal: Sindia, Yéba, Toglou, Tchicky, Sébikotane, Lam-Lam, Ngoundiane, Fandène, and Mont Rolland. Figure 1 shows the geographical

distribution of the study area and the locations of the investigated borrow pits.

In each site, sampling campaigns were conducted, with sampling points selected based on the physical appearance of the material in the field. In the Tchicky, Toglou, Fandène, and Yéba borrow pits, two distinct sampling points were identified and collected.

The raw samples were subjected to standard geotechnical laboratory tests, including grain size analysis, Atterberg limits, Proctor compaction, California Bearing Ratio (CBR), methylene blue value (VBS), Los Angeles (LA), and Micro-Deval (MDE) tests.

The suitability of the lateritic materials for use as sub-base or base course layers was evaluated according to the specifications of CEBTP [15,16] and AGEROUTE [17] (Table 1). To improve their mechanical properties, cement stabilization was performed with dosages ranging from 1% to 4%. The acceptability criteria for stabilized lateritic gravels, as defined by CEBTP [16] and AGEROUTE [17], were then applied (Table 1 and Table 2).

Table 1. Specifications of CEBTP [15] and AGEROUTE [16] for the use of natural lateritic gravels in base and subbase layers

Spécification	Layer type	Grain size analysis			Atterberg limits		Proctor test		CBR (95% OPM)	GTR Classification
		0.08 mm	2 mm	50 ou 40 mm	W _L (%)	PI (%)	W _{opt} (%)	ρ _{dmax} (g/cm ³)		
CEBTP (1984)	Subbase	05-35	28-65	95-100 ⁽⁴⁰⁾	-	≤ 25	-	≥ 1.9	≥ 30	-
	Base	04-20	12-50	100 ⁽⁵⁰⁾	-	≤ 15	-	≥ 2	≥ 80	
AGER-OUTE	Subbase	04-30	16-50	100 ⁽⁴⁰⁾	≤ 40	≤ 20	-	≥ 1.8	≥ 30	B4/B5/B6
	Base	04-20	16-50	100 ⁽⁴⁰⁾	≤ 35	≤ 15	-	≥ 2	≥ 60	

Table 2. Specifications of CEBTP [16] and AGEROUTE [17] for the use of cement-stabilized lateritic gravels in base and subbase layers

Spécification	Unconfined compression test		CBR (95% OPM)
	R _c (Bars)	R _t (Bars)	
CEBTP (1984)	18 < R _c < 30	R _t > 3	> 160
AGEROUTE	15 < R _c < 30	-	> 80

3. Results

3.1. Material Characterization

The collected samples underwent physical and mechanical identification tests to determine their geotechnical characteristics.

3.1.1. Grain Size Analysis

Grain size analyses were conducted in accordance with standards NF P 94-056 and NF P 94-057. The results show that all samples contain a significant proportion of coarse particles, classifying them as gravelly laterites.

Laterites from Toglou and Yéba exhibit higher proportions of coarse particles compared to the other materials. Those from Sindia and Lam-Lam show a well-graded and continuous particle size distribution, similar to Mont Rolland, Fandène, Ngoundiane, Sébikotane, and Tchicky. The Yéba laterite, in particular, displays a continuous and moderately well-graded distribution.

The proportion of particles passing the 80 µm sieve ranges from 12% to 26%, remaining below the 35% limit. Laterites from Fandène, Tchicky, and Mont Rolland contain more fine particles, consistent with previous findings by Samb [1] on Mont Rolland laterites. Only the

Toglou and Yéba samples show less than 12% passing the 80 µm sieve. The percentage passing the 2 mm sieve varies between 12.8% and 48.1%, all remaining below 70%. These results are illustrated in Figure 4, Figure 5, and Figure 6.

3.1.2. Atterberg Limits

Atterberg limit tests show that the Plasticity Index (PI) ranges from 7.4% to 28.75%, and the Liquid Limit (WL) from 21.5% to 48.8%.

Samples from Sébikotane, Yéba, Tchicky, Fandène, Sindia, Mont Rolland, and Lam-Lam have low clay contents, with PI values between 12% and 25%, classifying them as slightly clayey materials. In contrast, Ngoundiane and Toglou display higher clay contents, with PI values between 25% and 40% and liquid limits above 40%, categorizing them as highly plastic and clayey soils.

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However, some borrow pits such as Yéba and Toglou also contain zones with low plasticity ($PI < 12\%$) and low liquid limits.

The methylene blue values (VBS) range between 0.2 and 1.5, indicating that the clay fraction present in the lateritic soils is composed of inactive clays, consistent with the relatively low fine particle content (Table 2).

3.1.4. Compaction Properties

The compaction characteristics (Proctor test) reveal maximum dry densities (ρ_{dmax}) ranging from 1.84 to 2.17 g/cm³, and optimum moisture contents (W_{opt}) between 6% and 11.4%.

The highest dry densities were recorded for laterites from Sébikotane, Tchicky, and Toglou, followed by those

from Fandène, Sindia, and Ngoundiane. In contrast, Mont Rolland and Lam-Lam laterites show the lowest densities.

The materials from Mont Rolland and Fandène require higher moisture contents to reach their maximum dry densities (10.35–11.4%), followed by Ngoundiane and Lam-Lam. Conversely, Sébikotane, Sindia, Tchicky, Toglou, and Yéba require less water, with optimum moisture contents between 6% and 9.8% the lowest values being observed in Tchicky, Toglou, and Yéba.

The detailed results of the Proctor test are presented in Table 3, and the corresponding compaction curves are shown in Figure 8.

Based on the identification tests, the laterites were classified according to the NF P 11-300 (GTR) standard. Most laterites fall into the category of slightly plastic clayey gravels (B6), except Yéba, which is classified as a slightly plastic silty gravel (B5), and Toglou, which corresponds to slightly plastic clayey gravel (B4).

3.1.5. California Bearing Ratio (CBR)

The CBR test results indicate values ranging from 34.98% to 90.22% (Table 3). The Sindia samples exhibit the highest bearing capacity ($CBR = 90.22\%$), followed by Tchicky. In contrast, Yéba, Toglou, and Tchicky show localized zones with lower CBR indices.

The CBR values for Toglou range between 35.88% and 62.57%, those for Tchicky between 34.98% and 76.78%, and Yéba between 35% and 47.79%. The Fandène samples display relatively stable CBR values, averaging around 53% and 55%.

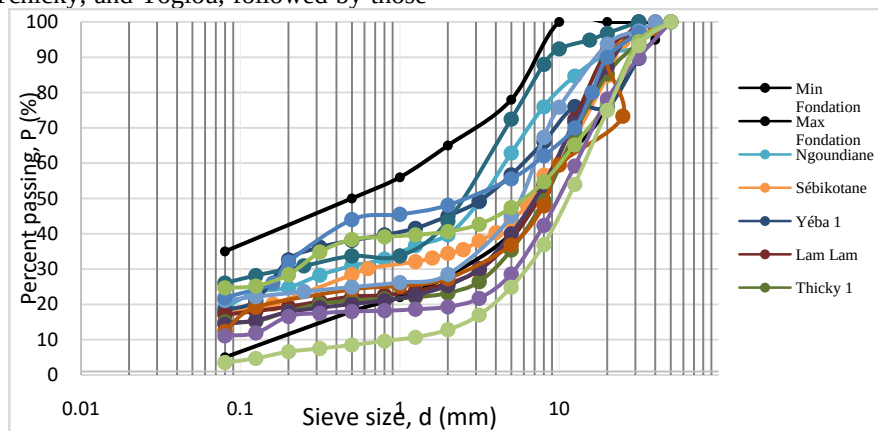


Figure 4. Grain size curves of lateritic gravels from the Thiès and Dakar regions for sub-base use (according to CEBTP [16])

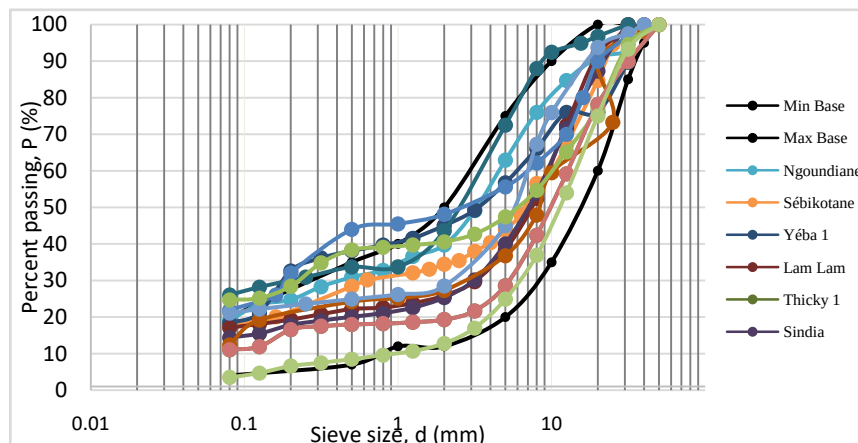


Figure 5. Grain size curves of lateritic gravels from the Thiès and Dakar regions for base course use (according to CEBTP [16])

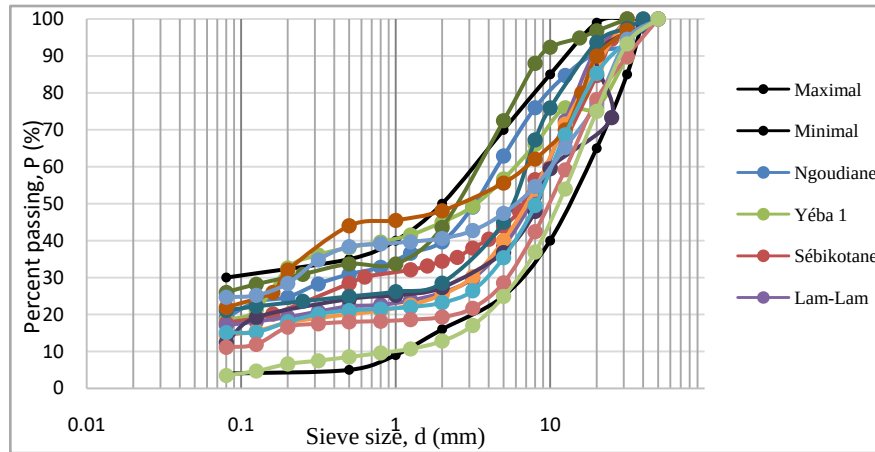


Figure 6. Grain size curves of lateritic gravels from the Thiès and Dakar regions (according to AGEROUTE [17])

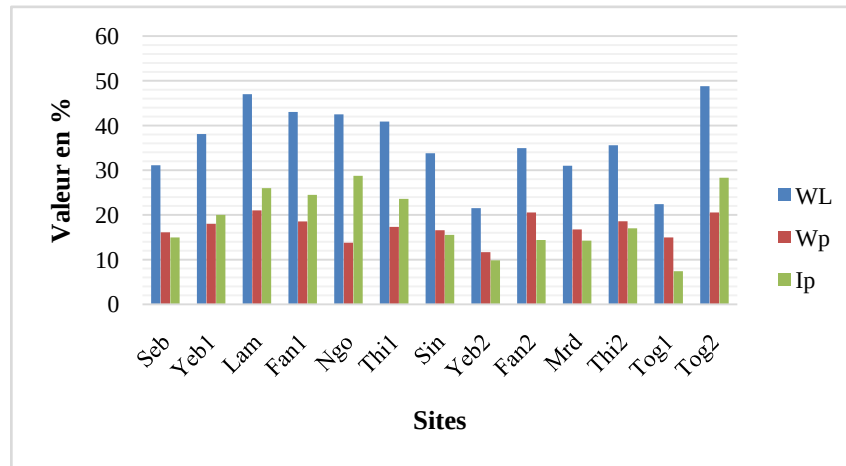


Figure 7. Results of Atterberg limits for lateritic quarries from the Thiès and Dakar regions

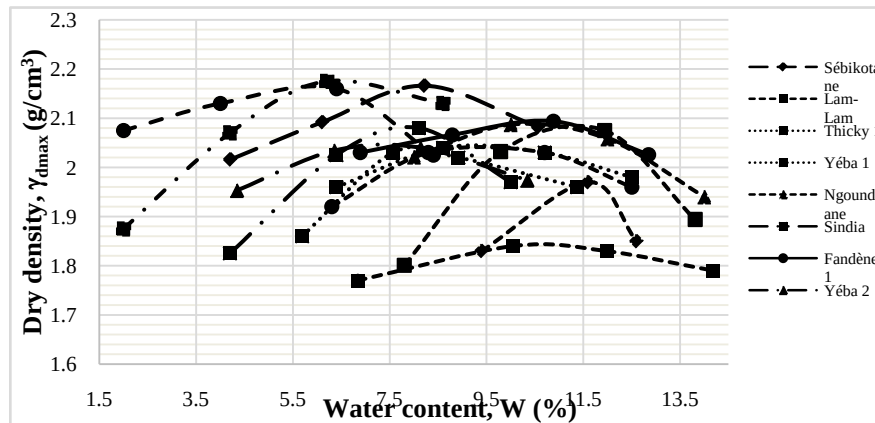


Figure 8. Proctor compaction curves of lateritic gravels from the Thiès and Dakar regions

Table 3. Suitability of lateritic gravels for road construction according to CEBTP and AGEROUTE standards

Quarry	Grain size analysis		Atterberg limits			Proctor test		CBR (95% OPM)	GTR	Suitability	
	$\Phi < 0.080$ mm	$\Phi < 0.002$ mm	W_p (%)	W_L (%)	I_p (%)	W_{opt} (%)	γ_{dmax} (g/cm ³)			Subbase	Base
Sindia	14.37	25.35	19.6	33.8	14.20	7.2	2.08	90.22	B6	Suitable	Suitable
Toglou 1	11.1	19.3	19.95	22.4	7.4	6.6	2.17	62.57	B4	Suitable	Suitable
Sébikotane	17.72	34.44	16.12	31.1	14.98	8.2	2.17	56.37	B6	Suitable	Not suitable
Fandène 1	26	28.2	18.53	43.03	24.5	10.2	2.09	53	B6	Suitable	Not suitable
Yéba 1	18.37	45.01	20.07	38.37	18.31	8.00	2.04	47.79	B6	Suitable	Not suitable
Fandène 2	21.1	26.3	20.54	34.93	14.39	11.4	2.09	55	B6	Suitable	Not

Quarry	Grain size analysis		Atterberg limits			Proctor test		CBR (95% OPM)	GTR	Suitability	
	$\Phi < 0.080$ mm	$\Phi < 0.002$ mm	W_p (%)	W_L (%)	I_p (%)	W_{opt} (%)	γ_{dmax} (g/cm ³)			Subbase	Base
											suitable
Yéba 2	12.40	27.30	11.67	21.50	9.83	7.10	2.04	35	B5	Suitable	Not suitable
Thicky 2	24.7	40.6	18.59	35.6	17.01	6.00	2.17	34.98	B6	Suitable	Not suitable
Mont Rolland	21.9	48.1	16.76	31	14.24	11.4	1.97	54	B6	Suitable	Not suitable
Ngoundiane	19.2	39.7	13.8	42.5	28.75	10.4	2.08	47	B6	Not suitable	Not suitable
Lam-Lam	17.1	25.90	26	47	21	10.35	1.84	42	B6	Not suitable	Not suitable
Thicky 1	15.1	23.2	17.33	40.9	23.6	9.20	2.04	76.78	B6	Not suitable	Not suitable
Toglou 2	3.5	12.8	20.54	48.8	28.3	9.80	2.03	35.88	B4	Not suitable	Not suitable

3.2. Assessment of the Suitability of Natural Laterites

The evaluation of the suitability of lateritic gravels from the western part of Senegal for road construction was based on the criteria defined by CEBTP (1984) and the AGEROUTE Road Design Guide (2018). Following the geotechnical characterization of the materials, the results were compared against the specifications provided in these two main reference standards used in Senegalese road engineering practice.

The particle size distribution curves of the lateritic borrow pits according to CEBTP specifications are presented in Figure 4 for sub-base applications and in Figure 5 for base course applications.

Figure 4 shows that the lateritic gravels from Ngoundiane, Sébikotane, Mont Rolland, the first pockets of Yéba and Fandène, and the second pockets of Tchicky and Fandène fall within the required gradation envelope for use in sub-base layers. However, the 2–5 mm granular fraction of Lam-Lam and Sindia slightly exceeds the minimum recommended limits for this size range. It is noteworthy that the curves of Tchicky 1, Toglou 1, Toglou 2, and Yéba 2 lie outside the required gradation limits.

Figure 5 illustrates that most lateritic samples exhibit gradation curves within the specified range for base course applications. Nevertheless, the 0.2–1.25 mm fraction of Yéba 1, the 0.08–0.25 mm fraction of Fandène 1, the 0.2–0.8 mm fraction of Tchicky 1, and the 0.2–2 mm fraction of Mont Rolland slightly exceed the upper limits for these ranges findings consistent with those of Ndiaye et al. [6].

According to AGEROUTE specifications, the gradation curves presented in Figure 6 indicate that the studied laterites generally fall within the acceptable range for both base and sub-base layers. However, the 0.2–1.25 mm fraction of Yéba 1, the 0.2–2 mm fraction of Mont Rolland, and the 0.315–0.8 mm fraction of Tchicky 2 slightly exceed the recommended maximum limits, while the 1.25–5 mm fraction of Toglou 2 exceeds the lower limit.

According to CEBTP (1984), the plasticity indices exclude Ngoundiane and Toglou 2 from use as sub-base materials. In contrast, the other laterites exhibit PI values below 25, in compliance with sub-base requirements. Only the lateritic gravels from Yéba 2, Fandène 2, Toglou

1, Mont Rolland, Sindia, and Sébikotane have PI < 15, satisfying the requirements for base course use.

As per AGEROUTE criteria, the laterites from Toglou 1, Tchicky 2, Sébikotane, Mont Rolland, Fandène, Sindia, and Yéba 2 meet the requirements for sub-base layers (PI < 20 and WL < 40%). Furthermore, Fandène 2, Yéba 2, Toglou 1, Sébikotane, Sindia, and Mont Rolland also fulfill the base layer conditions (PI < 15 and WL < 35%).

According to CEBTP (1984), all laterites except Lam-Lam exhibit maximum dry densities greater than 1.9 g/cm³, making them suitable for sub-base construction. Under AGEROUTE specifications, all tested laterites meet the requirements for sub-base layers. With the exception of Lam-Lam and Mont Rolland, all materials also show optimum dry densities above 2.0 g/cm³, fulfilling the base course criteria of both CEBTP and AGEROUTE.

All laterites present CBR values above 30, making them suitable for sub-base use according to CEBTP (1984). Among them, Sindia alone exhibits a CBR > 80, meeting the requirements for base course application.

According to AGEROUTE, all lateritic samples have CBR > 30, confirming their suitability for sub-base layers. The bearing capacities of Sindia, Toglou 1, and Tchicky 1 exceed 60, satisfying the criteria for base layers.

In summary, the lateritic gravels from Sébikotane, Fandène, Sindia, Yéba, Mont Rolland, Tchicky 2, and Toglou 1 are considered suitable for use as sub-base materials according to both CEBTP (1984) and AGEROUTE (2018). However, only Sindia (under both standards) and Toglou 1 (under AGEROUTE) meet the requirements for base course use. These findings highlight the need for hydraulic binder stabilization to enhance the bearing capacity of Senegalese lateritic gravels [3,8,18,19,20].

3.3. Evaluation of Cement-Stabilized Lateritic Gravels

To improve the mechanical performance of the materials, a cement stabilization treatment using CEM II / 32.5 R was applied. Cement contents varied between 1% and 3% for Sindia, Tchicky, Yéba, and Toglou, and between 2% and 4% for Lam-Lam.

Modified Proctor, CBR, and unconfined compressive strength tests were carried out on the samples stabilized

with 1%, 2%, 3%, and 4% cement (Table 4).

The results show that the optimum moisture content (W_{opt}) increases with the cement dosage, while the maximum dry density (ρ_{dmax}) varies depending on the cement percentage. The Modified Proctor curves for the different stabilized lateritic gravels (GLA) are shown in Figure 9-Figure 14.

Among the tested materials, Toglou 1 exhibits the highest dry densities and the lowest optimum moisture contents. For Toglou 2, the maximum dry density is very high in the natural state but decreases with increasing cement content. A similar trend is observed for Tchicky 2, although its optimum moisture content increases after cement addition. The laterites from Yéba and Tchicky 1 show higher densities at 1% cement content compared to other dosages.

The CBR values for Sindia, Toglou 1, and Tchicky 2 exceed 160 after stabilization with 2% cement, while Yéba, Toglou 2, and Tchicky 1 reach this threshold after 3%. Lam-Lam achieves a CBR > 160 after 4% cement, thus meeting CEBTP (1984) criteria. Consequently, the optimum cement contents retained for improved laterites are 3% for Sindia, Toglou, Yéba, and Tchicky 1, and 4% for Lam-Lam.

Unconfined compressive strength (R_c) values obtained at 1–2% cement are generally low, except for Toglou 1,

which exceeds 18 bars at 2% cement. At 3% cement, R_c values for all samples range from 18.21 to 23.62 bars, falling within the CEBTP (1984) range ($18 < R_c < 30$). Tchicky 2 shows a tensile strength (R_t) below 3 bars even at 3% cement, whereas other samples exceed 3 bars at or above this dosage. Lam-Lam reaches $R_t > 3$ bars only at 4% cement.

Therefore, according to CEBTP (1984), Tchicky 2 does not meet the tensile strength criterion, but according to AGEROUTE (2018), it becomes acceptable from 2% cement onwards. Under AGEROUTE standards, the compressive strengths for Tchicky and Toglou 1 exceed 15 bars at 2% cement. For Yéba 1, Sindia, Lam-Lam, and Toglou 2, strengths exceed 15 bars at 3% cement. The CBR values for Yéba 1, Sindia, and Toglou 1 surpass 80 at 1% cement, whereas those of Tchicky, Lam-Lam, and Toglou 2 reach this threshold at 2% cement. Accordingly, the recommended cement dosages are 2% for Toglou 1 and Tchicky, and 3% for Sindia, Yéba, Lam-Lam, and Toglou 2.

In summary, Tchicky 2 fails to meet CEBTP (1984) tensile strength requirements ($R_t < 3$ bars) even at 3% cement, but satisfies AGEROUTE (2018) specifications from 2%. Overall, all the studied lateritic gravels can be used in base layers when stabilized with 3% cement, except Lam-Lam, which requires 4%.

Table 4. Suitability of Cement-Stabilized Lateritic Gravels for Base Course Applications

Emprunts	Proctor test		Unconfined compression test		CBR (95% OPM)	Suitability for base layer	
	ρ_{dmax} (g/cm ³)	W _{opt} (%)	R _c (Bars)	R _t (Bars)		AGEROUTE	CEBTP
1 % de ciment							
Thicky 2	2.10	8.2	9.17	1.29	68.99	Not suitable	Not suitable
Sindia	2.10	8.3	6.07	0.19	81.1	Not suitable	Not suitable
Toglou 1	2.12	6.14	9.99	1.13	115.1	Not suitable	Not suitable
Toglou 2	1.10	9.8	8.98	0.3	54	Not suitable	Not suitable
Yéba 1	2.09	10.2	5.65	0.26	94.31	Not suitable	Not suitable
Thicky 1	2.00	10.2	8.87	0.8	69.74	Not suitable	Not suitable
2 % de ciment							
Thicky 1	2.11	12.6	16.34	1.15	93.63	Suitable	Not suitable
Thicky 2	2.09	8.1	15.67	1.85	168.2	Suitable	Not suitable
Lam-Lam	1,88	10	< 15	< 1.8	84	Not suitable	Not suitable
Sindia	2.05	9.4	12.14	0.64	171.3	Not suitable	Not suitable
Toglou 1	2.13	7.2	18.27	2.01	263.7	Suitable	Not suitable
Toglou 2	1.93	10.1	14.36	1.31	130.3	Not suitable	Not suitable
Yéba 1	1.95	10.8	9.10	1.12	150.8	Not suitable	Not suitable
3 % de ciment							
Thicky 1	1.97	11.7	19.41	3.09	217.71	Suitable	Suitable
Thicky 2	2.11	8.4	19.01	2.21	192.4	Suitable	Non conforme!
Lam-Lam	1,87	8,1	18.21	1.8	104	Suitable	Non conforme!
Sindia	2.03	10.0	19.89	3.24	281.8	Suitable	Suitable
Toglou 1	2.11	8	23.62	3.38	>374.5	Suitable	Suitable
Toglou 2	1.95	9.7	18.65	3.07	233.9	Suitable	Suitable
Yéba	1.95	10.15	18.27	3.00	196.7	Suitable	Suitable
4 % de ciment							
Lam-Lam	1,8	7,8	22.7	3.61	164	Suitable	Suitable

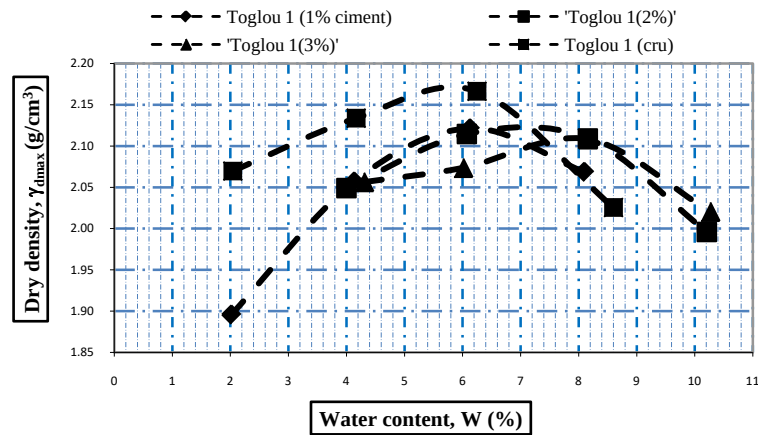


Figure 9. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Toglou 1 at 1%, 2%, and 3% cement contents

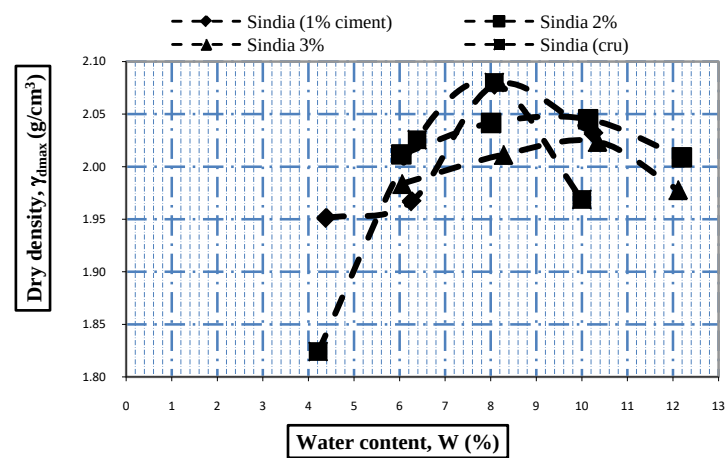


Figure 10. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Sindia at 1%, 2%, and 3% cement contents

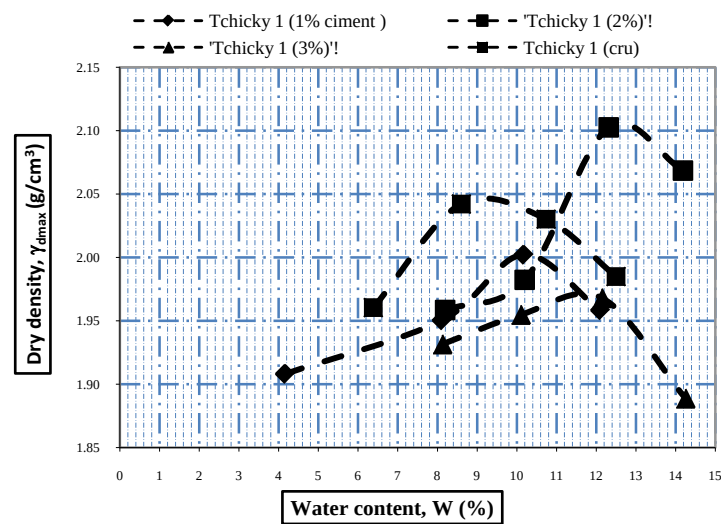


Figure 11. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Tchicky 1 at 1%, 2%, and 3% cement contents

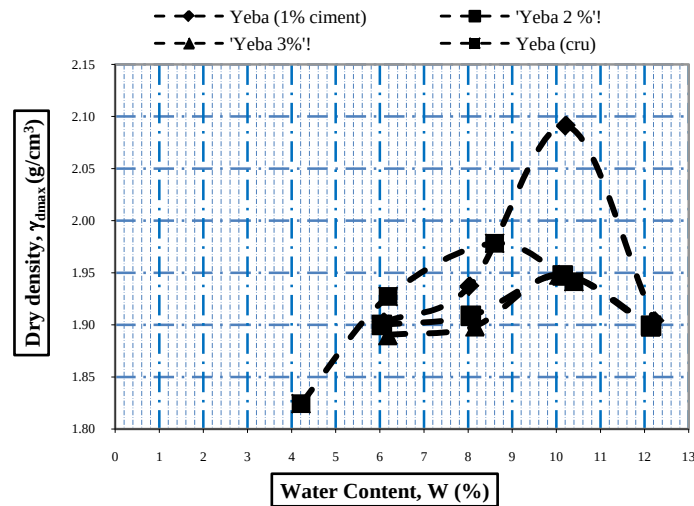


Figure 12. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Yéba at 1%, 2%, and 3% cement contents

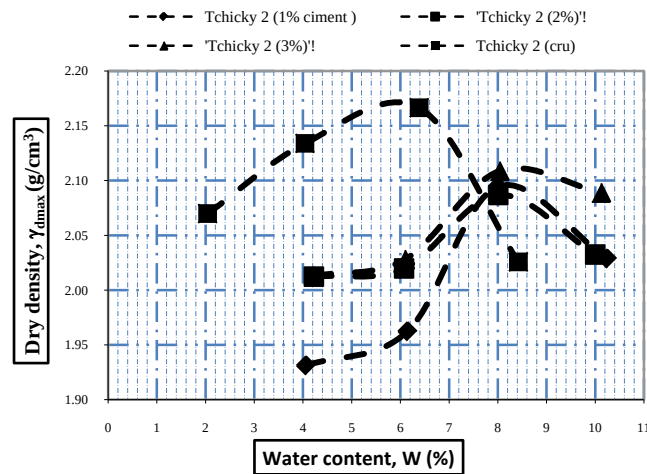


Figure 13. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Tchicky 2 at 1%, 2%, and 3% cement contents

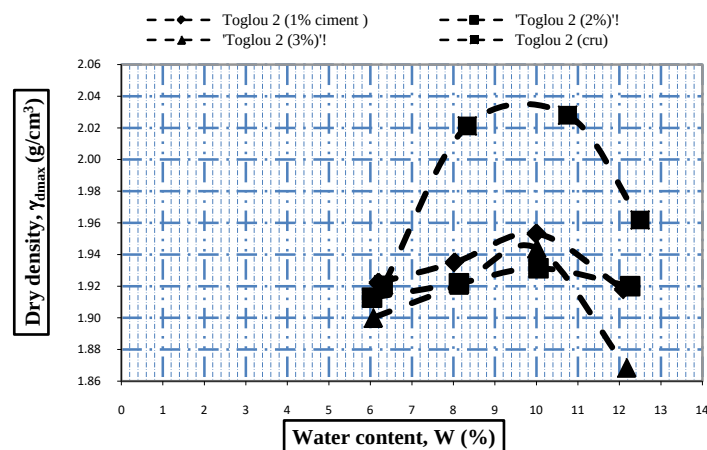


Figure 14. Modified Proctor curves of cement-stabilized lateritic gravel (GLA) from Toglou 2 at 1%, 2%, and 3% cement contents

4. Conclusion

The main objective of this study was to enhance understanding of the lateritic gravels (LG) of Senegal by compiling an inventory and mapping of lateritic borrow

pits. A detailed geotechnical characterization of laterites from the Dakar and Thiès regions was carried out to assess their suitability for road pavement construction.

The results show that the borrow pits of Sindia, Yéba, Toglou, Tchicky, Sébikotane, Lam-Lam, Ngoundiane, Fandène, and Mont Rolland contain fines ranging from

3.5% to 24.7%, with plasticity indices (PI) between 7.4% and 28.3%, dry densities above 1.9 g/cm³, and CBR values ranging from 34.98% to 90.22%. The study indicates that most laterites in Dakar and Thiès are suitable for sub-base layers (CBR > 30%), except Ngoundiane and Lam-Lam, which show excessive plasticity (PI > 25%). Their use in base layers is more limited due to lower bearing capacities (CBR < 80%).

Cement stabilization (1–3%) significantly improved the geotechnical properties of these materials. After treatment, CBR values ranged from 54% (Toglou 2 at 1% cement) to 374.53% (Toglou 1 at 3%). Laterites from Toglou 1, Sindia, and Tchicky become suitable for base course use at 2% cement, while all laterites achieve base layer suitability at 3%, except Lam-Lam, which requires 4%.

Unconfined compressive strength tests confirmed that the stabilized materials meet the CEBTP (1984) criteria ($18 < R_c < 30$ bars), while tensile strength tests showed that only Sindia, Toglou, Yéba, and Tchicky achieve $R_t > 3$ bars at 3% cement.

These results demonstrate the potential of Senegalese lateritic gravels for road construction when appropriately stabilized, and highlight the importance of cement treatment in enhancing their mechanical behavior and durability under traffic and environmental loads.

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