

Comparative Geotechnical Analysis of the Properties of Sands from the Major Sandpits in the West Region of Cameroon

Penka Jules Bertrand^{1*}, Wetka Tchoupe Ulrich Parfait Lelong¹, Nkibeu Jean Bertin²

¹Research Unit of Civil Engineering and Architecture, National Higher Polytechnic Institute of Bamenda, University of Bamenda, Bambili, Cameroon

²Laboratory of Civil Engineering and Mechanics, National Advanced School of Engineering, The University of Yaoundé 1, Yaounde, Cameroon

Email: *penkajules@gmail.com

How to cite this paper: Bertrand, P.J., Lelong, W.T.U.P. and Bertin, N.J. (2025) Comparative Geotechnical Analysis of the Properties of Sands from the Major Sandpits in the West Region of Cameroon. *Open Journal of Civil Engineering*, 15, 771-785.

<https://doi.org/10.4236/ojce.2025.154042>

Received: September 26, 2025

Accepted: November 23, 2025

Published: November 26, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Sandpits produce sands of different properties, based on the nature of the weathered mother rocks and sand quality directly affects the performance, durability and functionality of products and processes in construction. A comparative analysis was done on the sandpits in the Noun, Mifi, Hauts Plateaux and Koung-Khi Divisions of the West region to assess the geotechnical characteristics and potential uses of the various sands in construction for sustainable infrastructural development. This comparative analysis consisted of identifying and locating the major sandpits in the West region of Cameroon, determining the geotechnical properties of the various sands, and classifying the various sands to determine their potential uses in construction. The geotechnical testing of the sands was carried out in accordance with AFNOR, EN, and ISO standards, whereas the classification of the sands was performed according to EN, ISO, and ASTM standards. The Noun, Mifi, Baleng, Batié and Bandjoun sand had natural moisture content of 12.90%, 12.10%, 9.50%, 11.42% and 6.98% respectively. From the grain size analysis, the coefficient of uniformity (Cu) and curvature (Cc) of the sands were 2.43 and 0.93, 2.71 and 0.83, 12.86 and 0.84, 8.28 and 1.74, 12.50 and 1.45 respectively. The fineness moduli (FM) obtained were 2.43, 2.40, 3.27, 3.78 and 2.96 respectively. The sands had sand equivalent (SE) of 93.15%, 86.65%, 53.80%, 78.60% and 94.90% respectively. The specific gravities obtained were 2.586, 2.394, 2.471, 2.474 and 2.557 g/cm³ respectively. The apparent densities were 1.516, 1.456, 1.713, 1.577 and 1.631 g/cm³ respectively. The compressive strengths of the formulated B25 concrete (That is a concrete designed to achieve a characteristic compressive strength of 25 MPa at 28 days) obtained at 28 days for the various sands were 23.19, 22.32, 20.14, 25.23 and 33.62 MPa respectively. The classification of the

various sands according to the USCS showed that the Batié and Bandjoun sand are well graded (SW) while the Noun, Mifi, and Baleng sand are poorly graded (SP). The Batié and Bandjoun sand gave the desired resistance at 28 days, therefore, these sands are good for concrete production. The Noun, Mifi and Baleng sand did not give the desired resistance at 28 days due to their poor gradation and can only be used for light structural applications (15 to 20 MPa).

Keywords

Sands, Analysis, Properties, Classification, Applications

1. Introduction

Sandpits are of great importance in construction and infrastructure development because they provide sand which is a crucial natural resource (material) in the construction industry and plays a vital role in infrastructure development. Sand is a key component of concrete, which is the most widely used construction material worldwide. It provides bulk, strength, and workability to the concrete mix. Silt-free and well-graded sand is essential for producing high-quality concrete with the desired strength and durability [1]. Sand is used in various aspects of building construction, such as masonry work, plastering, and rendering. It provides a suitable bedding material for laying bricks, blocks, and stones, ensuring stability and structural integrity [2]. Sand is also used in asphalt production for road construction. It contributes to the stability, strength, and durability of asphalt mixtures. Properly graded sand helps to improve the performance and longevity of asphalt pavements [3].

Sand quality directly affects the properties and performance of construction materials like concrete and asphalt. By studying sand quality, engineers can determine the suitability of local sand for construction purposes. The quality of sand used in construction also influences the structural integrity of buildings, roads, bridges, and other infrastructure. Poor-quality sand can lead to reduced strength, increased porosity, and higher vulnerability to cracking, settlement, or structural failures [1]. This information helps in selecting appropriate construction materials, ensuring the safety, durability, and longevity of infrastructure projects in the region.

Understanding the sand quality in the region helps in assessing the availability and sustainability of this important construction material. By studying factors such as grain size distribution, silt and clay content, and density, engineers can estimate the available quantity of suitable sand and plan resource management strategies accordingly. Sand is a critical resource in the construction industry, and constraints on its availability or quality can increase costs and affect project feasibility [4] [5]. Local sourcing of sand reduces transportation costs and promotes regional development. By studying sand quality, policymakers and contractors

can make informed decisions on sourcing sand locally or from other regions, taking into account cost-effectiveness and the overall economic impact on the West region.

2. Materials and Methods

2.1. Identification and Location of the Major Sandpits

The identification and location of the major sandpits in the region was done mainly through inquiries from contractors, builders and quarry workers in the areas. The sandpits (sources) identified were the Noun sandpit, Mifi sandpit, Baleng quarry, Batié quarry and the Bandjoun quarry. A mobile GPS was used to record the geographical coordinates and the ArcMap software was used to bring out the map of the location of the sandpits.

2.2. Sampling

At each sandpit, samples were collected from just removed sand placed in hips beside the pit and the samples were collected at different spots from the hips to ensure the samples were representative of the overall sand deposit. Twenty (20) litres of sand were collected from each pit and placed in labeled bags. A small portion of each sample was then placed in an airtight plastic container to prevent moisture loss for the determination of moisture content. The samples were then transported from the pits to the geotechnical laboratory for testing and analysis.

2.3. Geotechnical Properties of the Sand Samples

Laboratory tests and analysis were conducted on the sand samples collected from the various sandpits to determine their geotechnical properties. The standard geotechnical testing methods that were employed to determine these properties included the natural moisture content, grain size analysis, specific gravity, apparent density, and sand equivalent test. The requirements, procedure and analysis for the various tests followed established French Norm (AFNOR), European Standards (EN), and equivalent International Standards (ISO) to ensure the reliability and reproducibility of the results. The geotechnical analysis was carried out at the Société BUNS laboratory at Santa, Mezam Division, working on the rehabilitation of the Babadjou-Bamenda road.

Quartering was done at the start of every test conducted to ensure accuracy. Quartering is a technique in which a representative sample is reduced to a convenient size for laboratory tests. It ensures that the sample is reduced to a convenient quantity having all the representatives of the material. The NF EN 932-1 standard outlines the methods for sampling including the quartering method.

The natural moisture content was determined according to NF P94-050, the grain size distribution and finesse modulus (FM) according to NF P94-056, the specific gravity according to NF P 94-054, the apparent density according to NF EN ISO 17892-2, and the sand equivalent (SE) according to NF EN 933-81.

2.4. Concrete Formulation

Since the fineness modulus is an important parameter in concrete mix design, concrete was formulated using the various sands to directly evaluate their performance in practical applications. This approach allowed the assessment of how the fineness modulus reflects the actual quality and suitability of each sand for concrete production. Concrete with characteristic resistance of 25 MPa at 28 days (C25 class of concrete) was formulated using the Dreux-Gorisse method and the NF P18-305 which provides the guidelines for the production and conformity of concrete. Dreux-Gorisse method permits to determine the optimal quantities of materials (water, E; cement, C; sand, S; fine gravel, g; coarse gravel, G) necessary for the confection of one metre cube of concrete in accordance with the specifications. The concrete dosage with the different sands was 350 Kg/m³ with sand to gravel ratio of 1:2 in general. The testing of the concrete was done according to NF EN 12390 which provides guidelines for the curing and preparation of concrete specimens for compressive strength testing.

2.5. Classification of the Sands

The classification of the various sands was done following the limits specified by the EN, ISO, and ASTM. The key parameters considered for the classification include grain size distribution, fineness modulus, specific gravity and sand equivalent.

2.5.1. Classification According to Gradation

From the grain size analysis, depending on the gradation, sands can be classified as poorly or uniformly graded (short range of sizes) and well graded (good range of sizes). The coefficient of uniformity C_u and curvature C_c provide quantitative information about the gradation and particle size distribution of the sands according to [6]. Sand with $C_u > 4$ is well graded and $C_u < 4$ is poorly or uniformly graded, while sand with $1 \leq C_c \leq 3$ is well graded and $C_c < 1$ and $C_c > 3$ is poorly graded.

2.5.2. Classification According to Fineness Modulus

The fineness modulus (FM) is a numerical value that provides a measure of the coarseness or fineness of a sand or aggregate material. It is calculated by adding the cumulative percentages retained on a series of standard sieves and dividing the sum by 100. The specific sieves for calculating fineness modulus of sand as defined in the AFNOR standards are 0.16 mm, 0.315 mm, 0.63 mm, 1.25 mm, 2.5 mm, and 5 mm concrete. The classification of sands based on fineness modulus according [7] is as follows:

- **Coarse sand:** FM greater than 2.3. Used in concrete for structural applications such as load bearing elements where higher strength are required.
- **Medium sand:** FM 1.8 and 2.3. Used in concrete suitable for a wide range of applications including masonry work and some structural elements.

- **Fine sand:** FM less than 1.8. Used for finishing applications such as floor screeds, plasters, and renders. It may also be used for specialized applications like self-compacting concrete.

2.5.3. Classification According to Sand Equivalent

The sand equivalent (SE) classification is an important consideration in the selection and quality control of sand used in concrete, mortar and other construction materials as it helps ensure the desired performance and consistency of the final product. The sand equivalent is a measure of the relative proportion of fine dust or clay-like materials in the sand. According to the EN ISO 14688-2 [7] standard, the classification of sand based on sand equivalent (SE) is as follows:

- Very low sand equivalent: SE value less than 30 → very dirty sand
- Low sand equivalent: SE value between 30 and 60 → dirty sand
- Medium sand equivalent: SE value between 60 and 70 → normal sand
- High sand equivalent: SE value between 70 and 90 → clean sand
- Very high sand equivalent: SE value greater than 90 → very clean sand

The sand equivalent classification provides information about the cleanliness and quality of the sand, which can impact the performance of concrete and other construction materials. Very low and low SE sands have a higher content of fine, clay-like materials, which can negatively affect concrete workability, strength, and durability. Medium SE sands have a balanced amount of fine materials, making them suitable for general construction purposes. High and very high SE sands have a low content of fine materials, resulting in cleaner and higher-quality sand that is preferred for more demanding applications.

2.5.4. Classification According to Specific Gravity

The specific gravity is an important parameter in the classification of sand, as it provides information about the density and composition of the sand particles, which can affect the properties and performance of the material in various applications. This classification system helps engineers and construction professionals to select the appropriate sand for their specific requirements, such as concrete production, soil stabilization, or fill material, based on the desired density and particle characteristics. According to the [7] standard, the classification of sand based on specific gravity is as follows:

- Low specific gravity sand: Concrete made with sand having a low specific gravity of 1.8 to 2.6 g/cm³ has a relatively low density and moderate strength, suitable for general-purpose, non-structural uses.
- Medium specific gravity sand: Concrete made with sand having a medium specific gravity of 2.6 to 2.8 g/cm³ is a standard-grade concrete suitable for a wide range of structural and non-structural applications.
- High specific gravity sand: Concrete made with sand having a high specific gravity of 2.8 to 3.0 g/cm³ has a higher density and increased strength, making it suitable for more demanding structural applications, such as heavily loaded elements.

2.5.5. Classification According to the USCS

The Unified Soil Classification System (USCS) uses a two-letter classification system to identify materials. The first letter represents the broad category (G for gravel, S for sand, M for silt and C for clay), and the second letter represents the gradation (W for well-graded, P for poorly-graded, M for silty and C for clayey). The classification of sands in the USCS is primarily based on the gradation and the amount of fines. In general, a material is considered as sand when 50% or more of coarse fraction is smaller than Number 4 (4.75 mm) sieve size. The USCS classifies sands into the following main categories:

- **Clean Sands (Group Symbols: SW and SP):** with less than 5% passing the number 200 (0.075 mm) sieve.
 - **Well Graded sands (SW):** Sands with a well-distributed grain size, typically containing a mix of different grain sizes. These sands have a coefficient of uniformity (C_u) greater than 4 and a coefficient of curvature (C_c) between 1 and 3.
 - **Poorly Graded Sands (SP):** Sands with a uniform grain size, lacking a well-distributed range of grain sizes. These sands have a coefficient of uniformity (C_u) less than 4.
- **Sands with Fines (Group Symbols: SM and SC):** with more 5% passing the number 200 (0.075 mm) sieve.
 - **Silty Sands (SM):** Sands containing a significant amount of silt, that is 5% to 12% fines passing the 0.075 mm sieve.
 - **Clayey Sands (SC):** Sands containing a significant amount of clay, that is more than 12% fines passing the No. 200 sieve.

3. Results and Discussions

3.1. Identification and Location of the Major Sandpits

The Noun sand is sourced from the Noun River basin in Manki II, known locally as the Mvi River, in the Malantouen Subdivision of the Noun Division. The sand source, called *Kougbamé* in the local language, is located about 3 km from the National Road N6. This sand, derived from alluvial deposits, is fine and rounded due to prolonged water transport, which explains its relatively poor grading and lower strength performance in concrete.

The Mifi sand, also referred to as *black sand* because of its dark coloration, is obtained from the alluvial deposits along the Mifi River near Boya and Ndjinga in the Bafoussam II Subdivision. The river expands during the rainy season, making access difficult. Like Noun sand, its alluvial origin results in smooth, rounded particles that reduce inter-particle friction and thus the mechanical strength of concrete.

The Baleng sand originates from the highlands of Sansang in Baleng, the chief town of Bafoussam II Subdivision, approximately 17 km from Baleng town. The highlands consist primarily of andesite rock masses that are manually excavated and sieved. The resulting sand has more angular particles and a better grain dis-

tribution, enhancing interlocking and mechanical resistance compared to river sands.

The Batié sand is extracted from mountainous areas in Bachepan, Batié Subdivision, Hauts Plateaux Division, about 10 km from Batié town and 1 km off the National Road N5. The parent material is mainly granite with silica and feldspar components. This geological origin produces coarse, angular, and well-graded sand, which contributes to its excellent performance in structural concrete.

The Bandjoun sand comes from the Bandjoun quarry, a basaltic rock deposit in the Koung-Khi Division. The basaltic rocks are blasted and crushed mechanically to produce the sand. Owing to its crushed, angular nature and dense mineral composition, the Bandjoun sand exhibits superior strength characteristics and grading, making it particularly suitable for high-quality concrete production.

A map showing the locations of the various sandpits is presented in **Figure 1**.

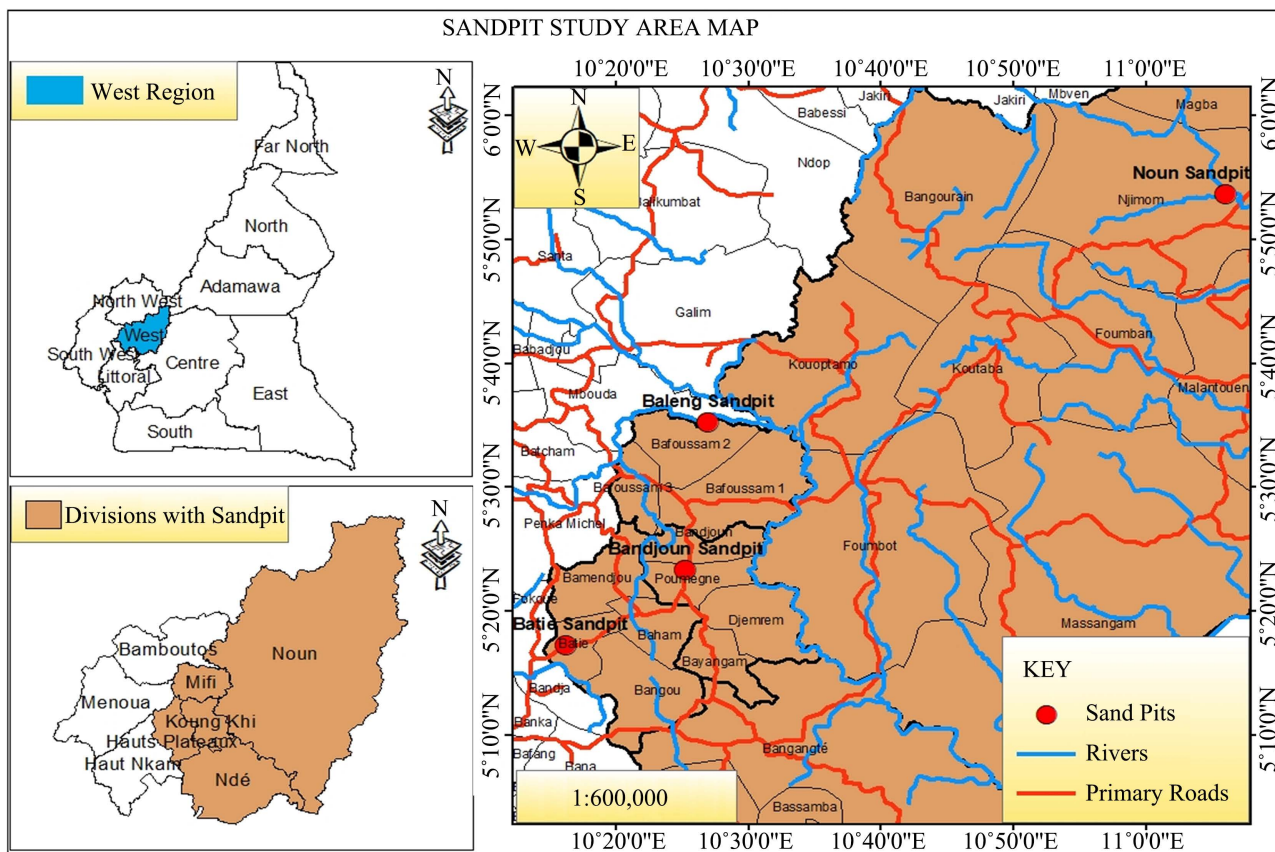


Figure 1. Map showing the location of the various sandpits.

3.2. Geotechnical Properties and Classification of the Sands

3.2.1. Natural Moisture Content

The natural moisture content of the sands (**Figure 2**) ranged from 6.98% to 12.90%, with Bandjoun sand having the lowest and Noun sand having the highest. The range is slightly different from that of the North West sands (8.07% to 15.17%) as investigated by [8].

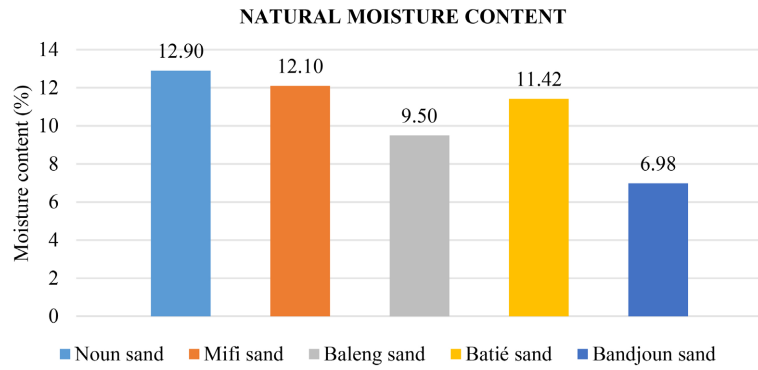


Figure 2. Natural moisture content of the various sands.

3.2.2. Grain Size Distribution Curve

The coefficient of uniformity (C_u) and curvature (C_c) of the sands (Figure 3) obtained from: grain size distribution curves of the various sands (Figure 4) ranged

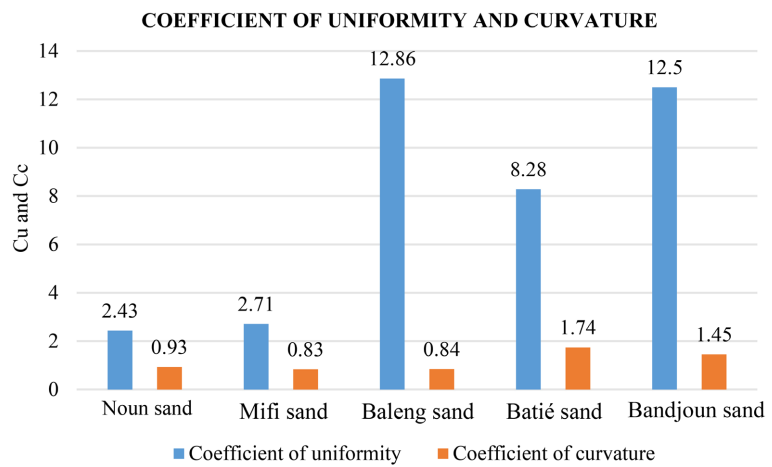


Figure 3. Coefficients of uniformity (C_u) and curvature (C_c) for the sand samples.

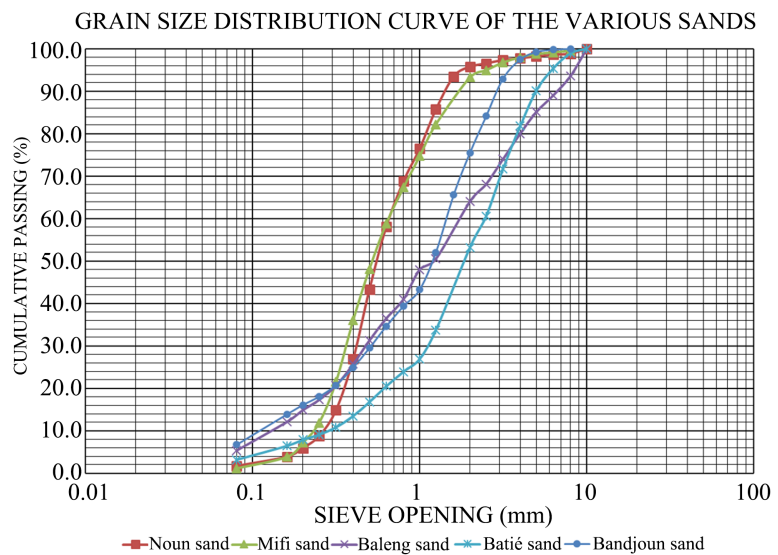


Figure 4. Grain size distribution curves of the various sands.

from 2.43 to 12.86 and 0.83 to 1.74 respectively. Noun sand had the lowest coefficient of uniformity and Baleng sand had the highest, while Mifi sand had the lowest coefficient of curvature and Batié sand had the highest. According to the USCS, Batié and Bandjoun sand were classified as well graded (SW) with Bandjoun sand having a relative amount of fines (silt) similar to studies carried out by [9] and [10]. Noun, Mifi and Baleng sands were classified as poorly graded (SP) with Baleng sand having a relative amount of fines (silt) similar to studies carried out by [11] [12].

3.2.3. Fineness Modulus (FM)

The fineness modulus of the sands (Figure 5) ranged from 2.40 to 3.78, with Mifi sand having the lowest and Batié sand having the highest. This range is wider than that of the North West sands (2.63 to 2.93) as investigated [8], due to the mixture of river and quarry sands in the West region. Studies carried out by [12] reported a fineness modulus of 2.35 for Mifi sand which is slightly different from 2.40 obtained. [9] had a fineness modulus ranging from 2.30 to 2.45 for Batié sand which is different from 3.78 obtained. This difference could be as a result of the improvement in the gradation of the quarry sand over time. From the [7] classification (Table 1), all the sands are coarse grained sands which are suitable for structural applications, where higher strength and durability are required.

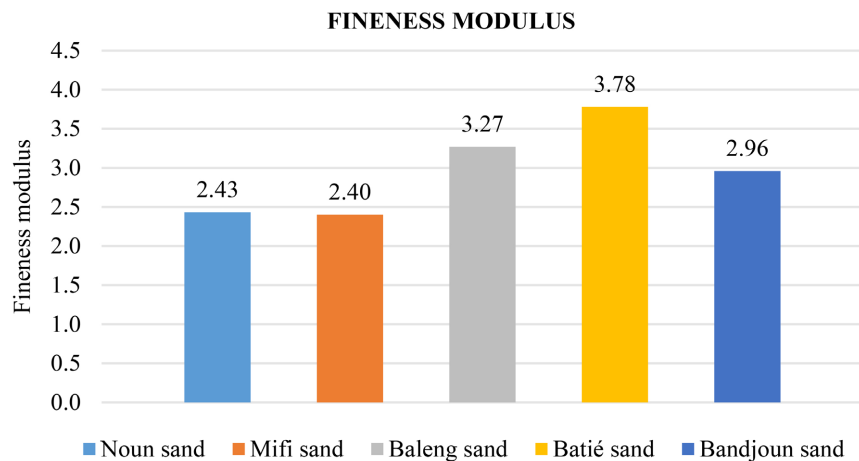


Figure 5. Fineness modulus of the various sands.

Table 1. Classification of the various sands according to fineness modulus.

Sand	PCR 0.16 mm	PCR 0.315 mm	PCR 0.63 mm	PCR 1.25 mm	PCR 2.5 mm	PCR 5 mm	Fineness Modulus (FM)	Classification
Noun	96.1	85.2	42.0	14.3	3.4	1.8	2.43	Coarse sand
Mifi	96.2	78.5	41.2	17.8	5.0	1.2	2.40	Coarse sand
Baleng	87.9	79.4	63.6	49.5	31.9	14.9	3.27	Coarse sand
Batié	93.6	89.2	79.5	66.3	39.4	9.8	3.78	Coarse sand
Bandjoun	86.2	79.3	65.4	48.0	15.9	0.8	2.96	Coarse sand

3.2.4. Specific Gravity

The specific gravity of the sands (**Figure 6**) ranged from 2.394 to 2.586 g/cm³ with Mifi having the lowest and Noun sand having the highest. This range is similar to that of the North West sands (2.486 to 2.548 g/cm³) as determined by [8]. [12] [13] had 2.64 for Mifi and 2.65 g/cm³ for Noun sand respectively. Based on the [7] standard, all the sands had low specific gravity (**Table 2**) and would produce concrete of relatively low density and moderate strength, suitable for general-purpose.

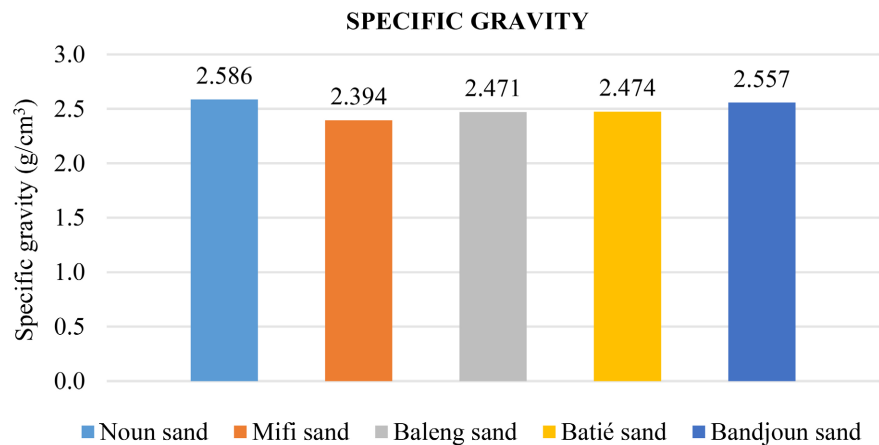


Figure 6. Specific gravity of the various sands.

Table 2. Classification of the various sands according to specific gravity.

Sand	Specific Gravity (g/cm ³)	Classification
Noun	2.586	Low specific gravity
Mifi	2.394	Low specific gravity
Baleng	2.471	Low specific gravity
Batié	2.474	Low specific gravity
Bandjoun	2.557	Low specific gravity

3.2.5. Apparent Density

The apparent densities of the sands (**Figure 7**) ranged from 1.456 to 1.713 g/cm³, with Mifi sand showing the lowest value and Baleng sand the highest. These variations can be attributed to differences in particle size distribution, mineral composition, and particle shape among the samples. Sands composed of heavier minerals or more compact, angular grains tend to exhibit higher apparent densities compared to those with lighter minerals or more rounded particles. Apparent density is a key geotechnical parameter that directly influences both material handling and concrete performance. It is particularly useful in estimating the bulk weight of aggregates during batching and storage. In concrete production, sands with higher apparent density generally contribute to denser mixes, resulting in improved compressive strength and reduced voids. Conversely, sands with lower apparent density yield lighter concretes, which can be advantageous in non-load-

bearing or lightweight applications where reduced self-weight is desired. The apparent density values obtained in this study fall within the typical range of **1.4 - 1.8 g/cm³** for natural sands used in construction, indicating that all the sands investigated are suitable for practical use, with variations reflecting their geological origin and degree of compaction.

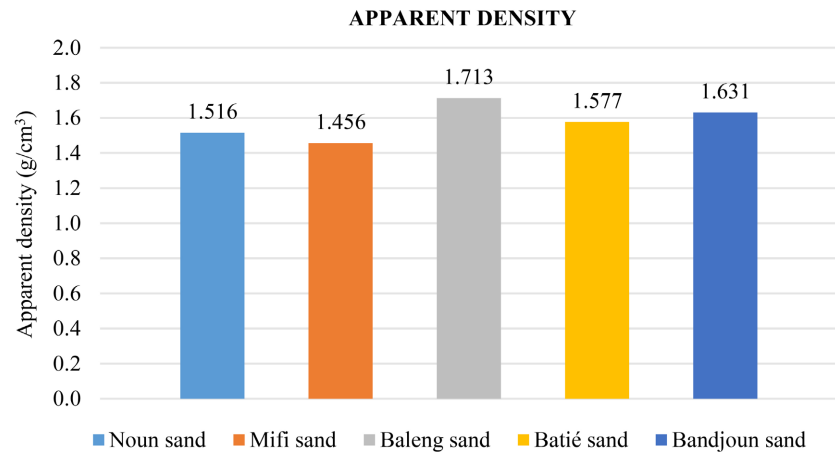


Figure 7. Apparent density of various sands.

3.2.6. Sand Equivalent (SE)

The sand equivalent of the sands (**Figure 8**) ranged from 53.80% to 94.90% with Baleng having the lowest and Bandjoun sand having the highest. [8] reported a range of 65.20% to 91.46% for the North West sands and [10] had 85% for Bandjoun sand. The cleanliness of the sands ranged from dirty to very clean according to the [7] standard (**Table 3**). Very low and Low SE sands have a higher content of fine, clay-like materials, which can negatively affect concrete workability, strength, and durability. Medium SE sands have a balanced amount of fine materials, making them suitable for general construction purposes. High and very high SE sands have a low content of fine materials, resulting in cleaner and higher-quality sand that is preferred for more demanding applications.

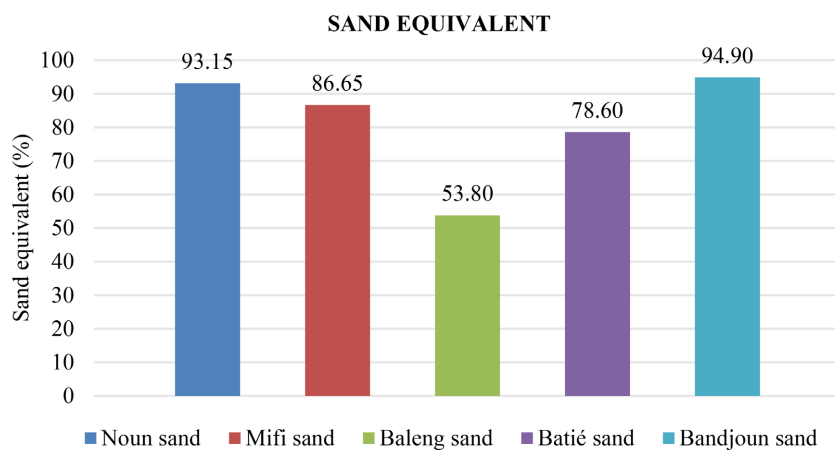


Figure 8. Sand equivalent of the various sands.

Table 3. Classification of the various sands according to sand equivalent.

Sand	Sand Equivalent (%)	Classification
Noun	93.15	Very clean
Mifi	86.65	Clean
Baleng	53.80	Dirty
Batié	78.60	Clean
Bandjoun	94.90	Very clean

3.2.7. Classification According to the USCS

As seen in **Table 4**, according to the USCS, Batié and Bandjoun sand were classified as well graded (SW: $C_u > 4$ and $1 \leq C_c \leq 3$) with Bandjoun sand having a relative amount of fine silt (SM). This is similar to studies carried out by [9] and [10]. Noun, Mifi and Baleng sands were classified as poorly graded (SP: $C_u < 4$ and $1 \geq C_c \geq 3$) with Baleng sand having a relative amount of fine silt (SM) which is similar to studies carried out by [11] [12].

Table 4. Classification of the various sands according to the USCS.

Sand	Cu	Cc	Percentage Passing the 0.08 mm Sieve	Classification
Noun	2.43	0.93	1.7	SP
Mifi	2.71	0.83	1.1	SP
Baleng	12.86	0.84	5.3	SP and SM
Batié	8.28	1.74	3.2	SW
Bandjoun	12.50	1.45	6.7	SW and SM

3.2.8. Concrete Formulation

The compressive strength of concrete with the various sands (**Figure 9**) and summarized in **Table 5** ranged from 9.78 to 14.85 MPa at 3 days with Baleng sand producing the lowest and Noun sand producing the highest. The compressive strength at 7 days ranged from 14.87 to 22.56 MPa with Baleng sand having the lowest and Bandjoun sand having the highest. The compressive strength obtained at 28 days ranged from 20.14 to 33.62 MPa with Baleng sand having the lowest and Bandjoun sand having the highest. The Batié and Bandjoun sand gave resistances equal to and greater than 25 MPa respectively while the Noun, Mifi and Baleng sand gave resistances less than the desired 25 MPa at 28 days due to their poor gradation and low specific gravity. The Bandjoun sand gave the best resistance because of the improved interlocking and bonding characteristics of angular quarry sand particles [14]. The Baleng sand gave the least resistance due to its high fine content.

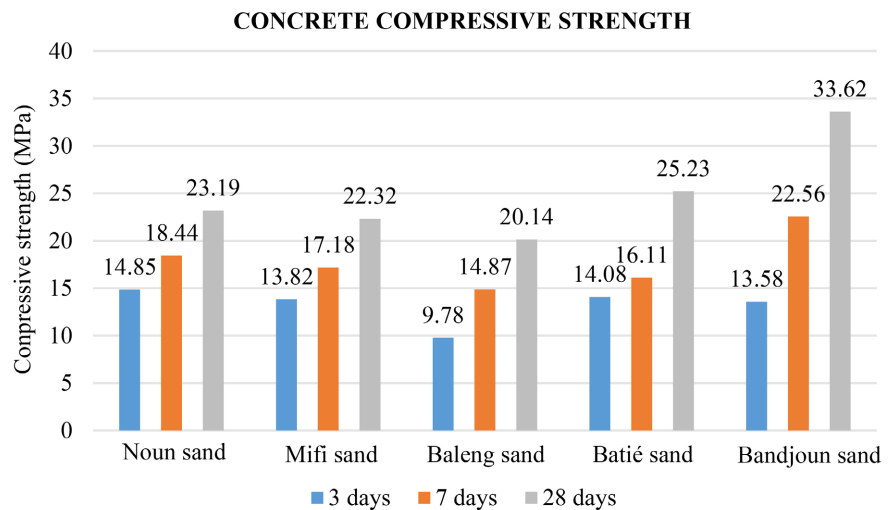


Figure 9. Compressive strength of concrete with various sands.

Table 5. Constituent of concrete with the various sands.

Sand Source	Sand (L/m ³)	Gravel 5/15 (L/m ³)	Gravel 15/25 (L/m ³)	Cement (Kg/m ³)	Water (L/m ³)	Theoretical Density (Kg/m ³)
Noun	254.56	77.78	374.76	350	189.19	2.461
Mifi	261.63	70.71	70.71	350	189.19	2.408
Baleng	318.20	84.85	304.05	350	189.19	2.413
Batié	325.27	106.07	106.07	350	189.19	2.414
Bandjoun	296.98	106.07	304.05	350	189.19	2.347

4. Conclusions

The overall objective of this research was to carry out a comparative geotechnical analysis on sands from the major sandpits in the West region of Cameroon to determine their geotechnical properties and classification for their proper and potential uses in construction.

From the identification and sampling of the sands from the major sandpits, the geotechnical properties of the sands that were analysed in this study are the natural moisture content, grain size distribution, specific gravity, apparent density and sand equivalent. These geotechnical properties were used to classify the sands according to standard norms and concrete was formulated with the different sands to assess their quality for concrete production.

The classification of the various sands according to the USCS showed that only the Batié and Bandjoun sand are well graded (SW) while the others (Noun, Mifi, and Baleng sand) are poorly graded (SP). The [7] classification according to fineness modulus (FM) proved that all the sands are coarse sand (FM > 2.3) and are suitable for structural applications, where higher strength and durability are required. The [7] classification according to sand equivalent (SE) showed that Noun and Bandjoun sand are very clean sands while Mifi and Batié sand are clean sands.

Clean and very clean ($SE \geq 70$) sands have a low content of fine materials, resulting in cleaner and higher-quality sand that is preferred for more demanding applications. Baleng sand is classified as a dirty sand ($SE \leq 60\%$) and has a high fine-particle content, clay-like materials, which can negatively affect concrete workability, strength, and durability. The [7] classification according to specific gravity showed that all the sands have a low specific gravity and concrete made with sand having a low specific gravity (1.8 to 2.6 g/cm^3) would have a relatively low density and moderate strength, suitable for general-purpose, low structural uses.

The Batié and Bandjoun sand gave the desired resistance at 28 days, regardless of their low specific gravities. These sands have high fineness modulus and sand equivalent that contributed to their good resistance; therefore, the sands are good for concrete production. The Noun, Mifi and Baleng sand did not give the desired resistance at 28 days due to their poor gradation and can only be used for light structural applications (non-load-bearing elements including partition walls, plastering, blinding concrete, and mortar works). The Noun and Mifi sand can be used in mortar production as their fineness modulus falls within the acceptable range as prescribed in the ASTM (2.2 to 2.8). It is important to note that the geotechnical properties of sands may vary with factors such as extraction depth, seasonal changes, and quarrying methods. Therefore, continuous quality control and periodic testing at the sandpits are recommended to ensure consistency and reliability of sand used in construction.

Acknowledgements

We thank CER BTP SARL for their collaboration during this research.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Mehta, P.K. and Monteiro, P.J. (2013) *Concrete: Microstructure, Properties, and Materials*. McGraw-Hill Education.
- [2] Chudley, R. and Greeno, R. (2013) *Building Construction Handbook*. Routledge.
- [3] Fang, M., Park, D., Singuranayo, J.L., Chen, H. and Li, Y. (2018) Aggregate Gradation Theory, Design and Its Impact on Asphalt Pavement Performance: A Review. *International Journal of Pavement Engineering*, **20**, 1408-1424.
<https://doi.org/10.1080/10298436.2018.1430365>
- [4] United Nations Environment Programme (2014) *Sand, Rarer Than One Thinks*. UNEP/GRID-Geneva.
<https://unepgrid.ch/storage/app/media/activities/Sand/Sand-as-a-Resource-Paper-FINAL.pdf>
- [5] World Economic Forum (2023) *Global Sand Mining: Demand Impacting Environment and Solutions*.
<https://www.weforum.org/stories/2023/09/global-sand-mining-demand-impacting-environment>

- [6] European Committee for Standardisation (2018) EN ISO 14688-1—Geotechnical Investigation and Testing—Identification and Classification of Soil. Part 1: Identification and Description.
- [7] European Committee for Standardisation (2018) EN ISO 14688-2: 2018—Geotechnical Investigation and Testing—Identification and Classification of Soil. Part 2: Principles for a Classification.
- [8] Mbuh Moses, K., Nsahlai, L.N., Penka, J.B., Mofor, N.A. and Ncham, M.K. (2024) Physical-Mechanical Properties of Sand from Various Sandpits in the North West Region and Their Recommended Domains of Application. Research Square.
- [9] Ngounou, S.M., Nkendon, C.S. and Fokwa, D. (2017) Geotechnical Characteristics of Sand Deposits from Batié, West Region of Cameroon. *International Journal of Geotechnical Engineering*, **11**, 460-467.
- [10] Tenkeng, A.F., Nkendon, C.S. and Fokwa, D. (2018) Evaluation of the Geotechnical Properties of Sand from Bandjoun, West Region of Cameroon.
- [11] Kouam, G.R., Kamdoun, B., Fokam, A. and Ngnikam, E. (2016) Characterization of Sand from the Noun River Basin in Cameroon for Geotechnical Applications. *Journal of Materials and Engineering Structures*, **3**, 65-72.
- [12] Nkendon, C.S., Fokwa, D. and Tenkeng, A.F. (2018) Geotechnical Characterization of Sand from the Mifi River, West Region of Cameroon. *International Journal of Geotechnical Engineering*, **12**, 369-377.
- [13] Nkendon, C.S., Fokwa, D. and Ngounou, S.M. (2020) Geotechnical Characterization of Sand from the Noun River, West Region of Cameroon. *International Journal of Geotechnical Engineering*, **14**, 412-420.
- [14] Sivalingam, K. and Mathavan, G. (2016) Comparative Study on the Properties of River Sand and Quarry Sand Concrete. *International Journal of ChemTech Research*, **9**, 588-594.