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Study of the physical and mechanical characteristics of granite from the Somiag quarry in the urban community of Maneah (prefecture of Coyah)

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Abstract

Development minerals are coveted, particularly granite, for the construction of various buildings. The increase in the number of quarries and industrial granite mining sites in the country, and specifically in the urban commune of Manéah, is leading to major changes that have both environmental and civil engineering impacts. Therefore, we were interested in its quality, which led us to undertake this research, the theme of which is: "Study of the physical and mechanical characteristics of granite from the Somiag quarry in the commune of Manéah (Coyah prefecture)." The objective of this research is to identify the physical and mechanical properties in order to understand the quality of aggregates from the SOMIAG quarry. The methodological approach was based on documentary research, direct observation, and laboratory work. The characteristics of the granite were determined through a series of tests including the degree of impact of balls by Los Angeles, the micro-Deval, the specific gravity of mass water absorption, the volumetric weight, the water content to allow us to assess the quality of the granite. On five fractions of granite on which we carried out the tests, the analysis of the laboratory tests indicates the following values: LA < 30%, MDE ≤ 20, volumetric weight less than 1.60, water content is less than or equal to 1 (TE ≤ 1) and mass absorption less than 1%. These results show that the granite from the SOMIAG quarry is of good quality for civil engineering works. The results of the observation made it possible to identify considerable environmental impacts linked to the production of granite, in particular air pollution by dust in the commune of Manéah.

Keywords: Manéah; Physical Characteristics; Mechanical; Granite; SOMIAG

1. Introduction

Local, national, and regional economies in many countries around the world.

Furthermore, mining, including granite mining, contributes to job creation. Given the diversity of stakeholders involved and the importance of the resulting goods and services, the benefits of mining in Africa contribute significantly to the global economy. From 1995 to 2014, regional gross domestic product (GDP) grew by an average of 4.5% per year, a rate nearly twice that of the previous twenty (20) years (Solie, 2013).

However, mining, although contributing positively to the growth of the global economy, the African continent is lagging significantly behind in terms of development. Several authors agree that large-scale mining operations have a significant impact on the environment and are attempting to implement a strategy to mitigate their impacts (Deshaies, 2009; Maradan, 2011; Randrianandraina, 2015).

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For these authors, pollutants are constantly emitted into the atmosphere at the industrial quarry. This has adverse effects on the population near the site and employees, causing skin and eye irritation and respiratory illnesses such as coughs and colds. The most vulnerable are children, the elderly, and smokers (Xavier, 2000; Marcil, 2018; Kadjo, 2020; Madani, 2015; Darkaoui et al., 2019 and Yahiaoui et al., 2005).

For this other author, quarrying has strong potential for creating direct and indirect local jobs and has closer ties to the local economy because, in addition to its contribution to direct revenue for the state budget, it provides inputs to the industrial, agricultural, road infrastructure, and construction sectors (Sambare, 2018).

Quarrying has a major impact on socioeconomic activities through job creation, school construction, drilling, and road reshaping.

Furthermore, in Quebec, mining has enabled urbanization through the construction of large facilities to enhance the landscape and generate financial resources (Simard et al., 2013).

The Republic of Guinea has some of the most coveted natural resources in the 21st century, including iron, bauxite, uranium, diamonds, gold, granite, etc. This reality has earned it the name "geological scandal," which today gives it a privileged place among the richest subsoil countries in the world.

However, while the existence of potential and mining operations are a necessary condition for the creation of wealth for Guinea, they have not yet succeeded in developing the country and lifting the population out of poverty. This is why Guinea is still among the countries with a very low human development index, which is 0.477 in 2019, which cost Guinea 178th place out of 187 (Solié, 2013). According to the Statistical Yearbook of Mines and Quarries (2023), Guinea had 35 granite quarries in 2022 and 31 in 2023. These extractive industries contributed to GDP in volume terms at chained previous year prices (in billions of CFA francs) in 2014 to 6,731.4%; 6,995.3% in 2015; 7,412.1% in 2016; 7,871.9% in 2017; and 10,130.4% in 2023. The mining and quarrying sector also contributes 14.5% to the Guinean state budget in 2022 and 14.8% in 2023, an increase of 0.3%.

It appears that the country's development does not seem to reflect the revenues received. To this end, we question the rationale for the extractive mining industry in Guinea. This highlights the impacts of extractive industries in the Republic of Guinea.

Mining in Guinea has environmental repercussions, including the pollution of waterways, the deterioration of climatic conditions, the loss of arable land, poverty, which increased from 49.2% in 2002 to 59% in 2010, the proliferation of crime, and the migration of people (Sory, 2013).

It is with this in mind that we chose our research project to focus on the theme "Study of the physical and mechanical characteristics of granite from the SOMIAG quarry in the urban commune of Manéah (Coyah prefecture)." This leads us to ask the following research question: How can we characterize the physical and mechanical properties of granite from the SOMIAG quarry in the urban commune of Manéah?

The overall objective is to assess the quality of the granite from the SOMIAG quarry sampled in Manéah. To achieve this goal, we set two specific objectives:

- Determine the physical properties of granite from SOMIAG;
- Determine the mechanical properties of granite produced in the SOMIAG quarry.

2. Material and methods

2.1. Presentation of the Study Area

The Urban Commune of Manéah falls within the administrative region of Conakry. It is located 1 km from the Prefecture of Coyah, 88 km from the administrative region of Kindia and 49 km from Conakry on the national road 1. It is bordered to the east by the Urban Commune of Coyah, to the west by the urban communes of Matoto and Ratoma, to the south by part of the CU of Wonkifong and the Urban Commune of Matoto and to the north by the Urban Commune of Dubréka. It covers an area of 320 km2 with an average density of 15 inhabitants per km2. The referenced geographical coordinates are West longitude 013°34391 and North latitude 09°77754. The CU of Maneah has a population of 167,705 inhabitants (RGPH3) including 82,987 men and 84,718 women.

The relief is gentle, consisting mainly of plateau, low alluvial and marshy plains favourable for rice cultivation. The climate is shaped by maritime winds, with a rainy season from May to October and a dry season from November to April. The town is crossed by numerous navigable waterways and is surrounded by mangroves, mangrove trees, palm trees and coconut trees.

According to the National Institute of Statistics of Guinea (2016), Kamsar counted over 360,000 inhabitants, drawn from diverse ethnic groups such as the Bagas, Nalous, Landouma, Soussous, Kpelles, Malinke's, Tomas, Peul's, and many foreigners. Economic activities are primarily based on extractive industry, trade — notably at the Sahara market — and fishing, which generates income for fishermen and many women who smoke and market the products. The city features two ports: Port Fory (former) and Port Nene (new). However, most boats are unmotorised and port infrastructure is outdated, limiting incomes and rendering the population vulnerable to environmental changes. In addition, agriculture, crafts and livestock raising are also practised.

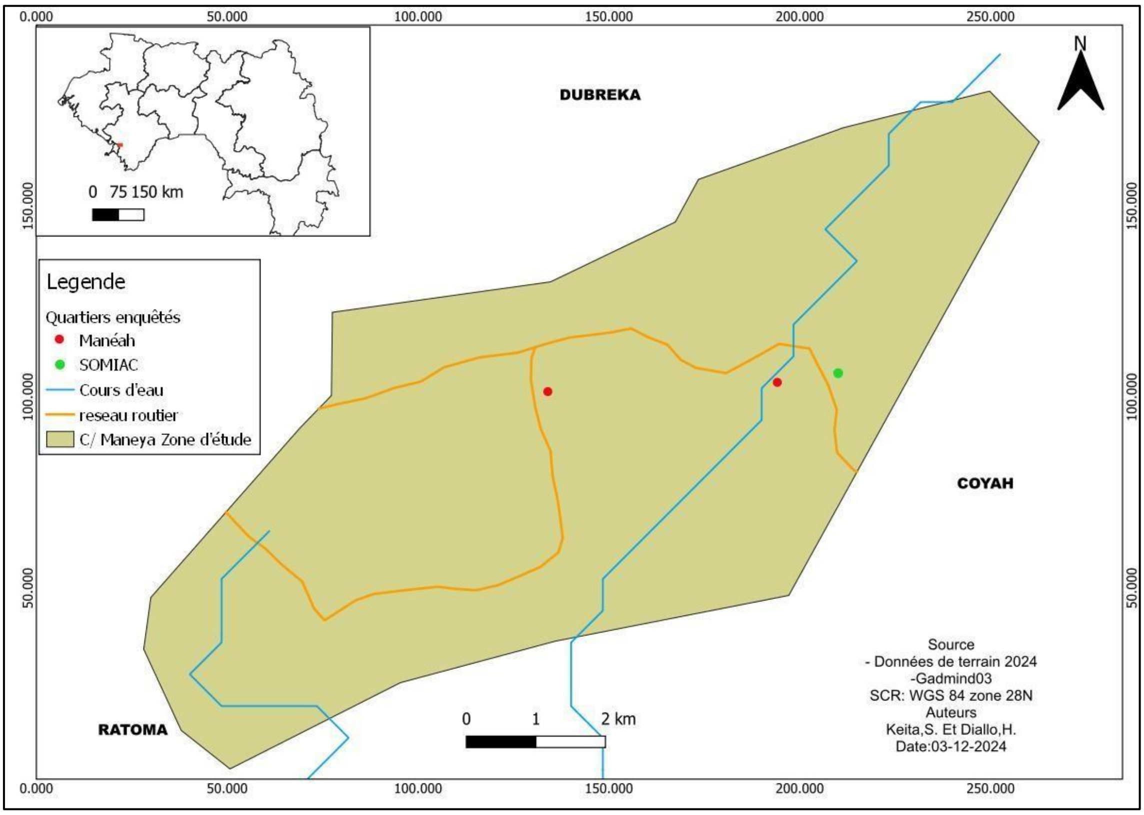

Figure 1 Map of study area

2.2. Experimental procedure and analyses

The methodological approach is divided into two parts based on the two objectives.

In this study, given the nature of the subject and the data we wanted to collect on granite, we used a quantitative approach, which allowed us to analyze the quantitative data by translating the observations into statistical tables. To conduct this assessment, we used laboratory and observational analyses. The survey focused on biophysical data from the environment. These data made it possible to determine the mechanical and physical properties of granite from the SOMIAG quarry. To collect the data, we used an analytical method. Samples were taken for analysis in the Building Materials Laboratory of the Civil Engineering Department at Gamal Abdel Nasser University in Conakry, using AFNOR standards. These tests are listed according to our specific objectives:

2.3. Physical properties:

Water content test: NF EN 1097-5

$$W = \frac{1-M3}{M3} \times 100 \quad (2)$$

1 is the mass of the test portion in grams;

M3 is the constant mass of the dried test portion in grams

2.4. Mass water absorption: NF EN 1097-6

Water absorption reflects the maximum amount of water that a rock can absorb. The water absorption capacity of the stones studied was measured according to the following protocol: the sample is dried in an oven (110°C for 24 hours) and then its mass (M0) is measured. It is then immersed in distilled water for several hours until complete saturation and its mass Ms is measured.

$$W = [100(Ms–M0)/M0] \quad (5)$$

Where Ms is the mass of saturated, surface-dry aggregates in air, in grams; M0 is the mass of the oven-dried test sample in air, in grams.

A- A- Mechanical properties:

2.5. Los Angeles

For Los Angeles, we dry-sieved the samples on each sieve of the selected grain size, starting with the largest sieve.

Wash the sieved material and dry it in an oven at 105°C until the mass is constant, i.e., until two successive weighing of the sample, separated by one hour, do not differ by more than 0.1%. The mass of the test sample will be 5000g ± 5g. We will then carefully introduce the ball load corresponding to the selected grain size, followed by the test sample.

The Los Angeles LA coefficient is by definition the ratio:

$$100\frac{m}{5000} \quad (1)$$

Or: m=5000 –m' is the dry mass of the fraction of the material passing through the 1.6 mm sieve after testing.

The result will be rounded to the nearest unit according to standard P18-573

2.6. Bulk volumetric weight: NF EN 1097-3

The density is calculated for each test piece according to the following equation:

$$\rho = \frac{\mathrm{m2-m1}}{\mathrm{V}} (3)$$

ρ is the bulk density, in megagrams per cubic meter; m1 is the mass of the container and test piece, in kilograms; m2 is the mass of the empty container, in kilograms; V is the capacity of the container in liters.

Record the bulk density ρ as the average of the three test values.

2.7. Micro Delval Humide: NF EN 1097-1

$$M_{DE} = \frac{500-m}{5} \quad (4)$$

Where MDE is the micro-Deval coefficient of the test in the presence of water; m is the oversize mass at 1.6 mm, in grams.

Calculate the average value of the coefficient using the values obtained for the two test specimens.

2.8. Granulometry: P 18- 560

The test is performed on the material at its current moisture content prior to analysis to avoid drying, which has disadvantages: time wasted drying prior to sieving, and the risk of particle agglomeration due to drying. Two test samples are therefore prepared from the laboratory sample. One with a mass of M1h is used to determine the dry mass of the sample subjected to particle size analysis, and the other with a mass of Mh is used to perform the particle size analysis.

weighing of the two samples M1h and Mh;

drying in an oven until constant mass (i.e., until two successive weighing of the sample, separated by one hour, do not differ by more than 0.1%) from the first sample M1h and weighing, i.e., its dry mass M1s. The dry mass (Ms) of the sample submitted to granulometric analysis is calculated as follows:

$$M_S = \frac{M1S}{M1h} \times M_h \quad (6)$$

For this dry test Ms and the cumulative rejection percentages thus obtained, entered on the test sheet.

$$\frac{Ri}{Ms} \times 100 \quad (7)$$

The corresponding sieve percentages are equal to:

$$100 - \left[\frac{Ri}{Ms} \times 100\right] \quad (8)$$

Table 1 Summary of methods for determining physical and mechanical parameters

Methodes	Materials	Settings
Los Angeles	Los Angeles Machine Ball Load A motor providing the machine's drum with a regular rotation speed of between 30 and 33 rpm. A bin A rev counter	Resistance to fragmentation
MicroDeval wet	Balance; set of sieves; ventilated oven, means necessary for washing; equipment necessary for reduction; graduated cylinder.	The Deval micro coefficient
Water content	Container; Heat-resistant stirrer (knife, spatula, etc.), Scales, Ventilated oven, Desiccator filled with desiccant - - Trays.	The percentage of water
Mass water absorption	Oven, ventilated; Scale, water bath; Thermometer; Test sieve; Trays; Absorbent cloths; Washing equipment; Timer	The mass water absorption coefficient
Bulk density	Airtight cylindrical container; scale; shovel; ruler; thermometer; heating oven; glass plate.	the quotient obtained by dividing the mass of dry aggregate filling a specified container without compaction by the capacity of the container.
Granulometry	Tubs, brushes, paintbrushes. Scale - Oven - A washing device.	Grain size curve

3. Results and discussions

This section presents the results of our research displayed in tables and graphs

Table 2 Summary of physical and mechanical parameters

		Mechanical Properties			*Physical Properties*	
Samples	*Rock appearance*	*Los Angeles Class (16/31.5)*	*Bulk density gr/cm 3*	*Micro-Deval Humide Class (10/14)*	*Absorption d'eau massique en %*	*Teneur en eau %*
Ech.01	Gray granite with black feldspar and white mica crystals	22.4	1.35	16	0.78	1
Ech.02		23.2	1.30	16	0.99	0.4
Ech.03		22.6	1.50	17	0.60	1
Ech.04		21.1	1.32	15	0.70	0.3
Ech.05		25.0	1.42	18	0.40	0
Standards		**NF P18-573** LA≤ 30	**NF EN 1097-3**	**NF EN 1097-5**	**NF EN 1097-6**	**NF EN 1097-1** MDE≤ 20

3.1. Granulometric analysis

CELAM
Laboratory Test Report
/BTP
NF EN
P V N°:002 PARTICLE SIZE ANALYSIS BY SIEVING
933-1
Sampling date:
Material source: SOMIAG
09/05/2024
Class of aggregate d/D: 8/16 Test date: 10/05/2024
Masse totaled
3000 g and sum =100% sèche(g)
Career Name
Mesh opening Refusal Sum (%)
(mm) g % Cumulative refusal Passage
40 0 0,0 0,0 100.0

Table 3 Granular class 8-16

31.5	0	0.0	0.0	100.0
25	0	0.0	0.0	100.0
20	70	2.3	2.3	97.7
16	180	6.0	8.3	91.7
8	2490	83.1	91.5	8.5
6.3	105	3.5	95.0	5.0
4	100	3.3	98.3	1.7
2	30	1.0	99.3	0.7
1	5	0.2	99.5	0.5
	0	0.0	99.5	0.5
	0	0.0	99.5	0.5
	0	0.0	99.5	0.5
Fond	15	0.5	100.0	0.0
Somme	2995	100.0		

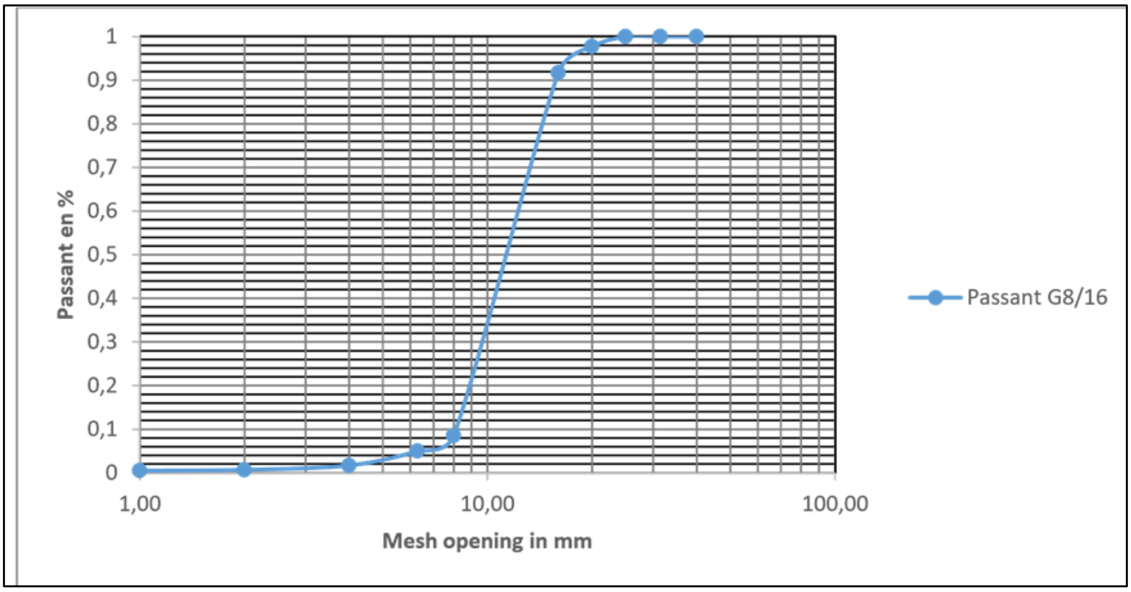

Figure 2 Granulometric curve

Table 4 Granular class 16-25:

	Laboratory Test Report			**CELAM /B TP**
P V N°:001	PARTICLE SIZE ANALYSIS BY SIEVING			NF EN 933-1
Material source: SOMIAG	Sampling date: May 9, 2024			
Class of aggrega te d/D : 16/25	Test date: May 10, 2024			
Total dry mass (g)	3000 g and sum =100%			
Career Name				
Mesh opening (mm)	Refusal		Somm e (%)	
	g	%	Cumulative refusal	Passage

40	0	0.0	0.0	100.0
31,5	0	0.0	0.0	100.0
25	325	10.8	10.8	89.2
20	1695	56.5	67.3	32.7
16	835	27.8	95.2	4.8
8	145	4.8	100.0	0.0
6.3	0	0.0	100.0	0.0
4	0	0.0	100.0	0.0
2	0	0.0	100.0	0.0
1	0	0.0	100.0	0.0
	0	0.0	100.0	0.0
	0	0.0	100.0	0.0
	0	0.0	100.0	0.0
Fond	0	0.0	100.0	0.0
Sum	3000	100.0		

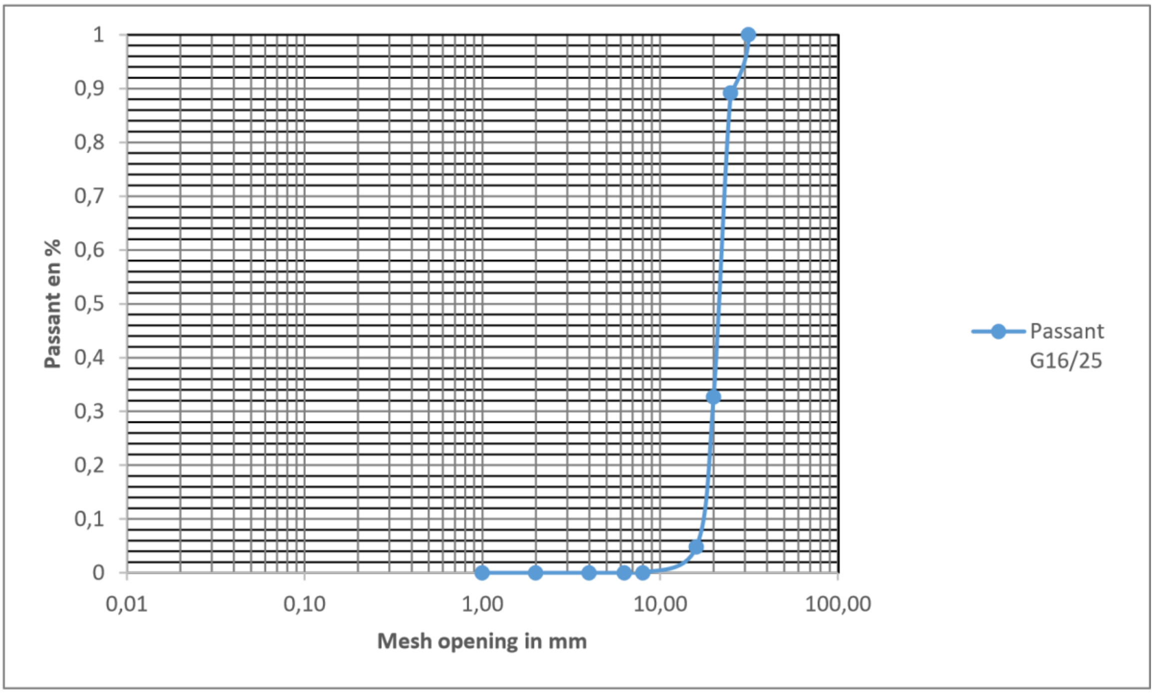

Figure 3 Grain size curve 16/25

The granulometric analysis of the samples made it possible to plot the granulometric curves which reflect the size of the particles in these samples (gravel, pebbles). The analysis of the two curves shows that the samples are all made up of elements of varying sizes. In addition, the calculation of the granulometric parameters for each sample shows the following results:

- For sample S1 (16/25):
  Effective diameters: D10 = 25,000 µm; D60 = 20,000 µm
  Coefficient of uniformity (D60/D10): Cu = 0.8
- For sample S2 (8/16):

Effective diameters: D10 = 6300 µm, D60 = 16000 µm

Uniformity coefficient Cu = (D60/D10) = 0.393

Cu = 0.393

These results show that 10% of the total weight of sample S1 has a diameter less than 25,000 µm and 60% has a diameter less than 20,000 µm. As for sample S2, 10% of the total weight has a diameter less than 6,300 µm and 60% has a diameter less than 16,000 µm. The uniformity coefficients of both samples are between 0 and 2.5, so the grain size of these samples is uniform.

The grain size analyses were carried out on two types of granite, namely: granite 8-16, that of 16-25. The grain size analysis of the 8-16mm sample gave a proportion of 100% passage on the 40mm sieve, 100% on the 31.5 sieve; 100% on the 25 sieves; 97.7% on the 20 sieves; 91.7% on the 16 sieves; 8.5% on the 8 sieves; 5% on the 6.3 sieve; 1.7% on the 4 sieves; 0.7% on the 2 sieve and 0.5% on the 1 sieve. This means that the true granular class is 6.3-16 mm

For sample 16-25, the results of the particle size analysis gave a proportion of 100% passage on the 40mm sieve, 100% on the 31.5mm sieve; 89.2% on the 25mm sieve; 32.7% on the 20mm sieve; 4.8% on the 16mm sieve; 0% on the 8mm sieve; 0% on the 6.3mm sieve; 0% on the 4mm sieve; 0% on the 2mm sieve and 0% on the 1mm sieve; as well as 0% at the bottom. This implies that the true particle size class is 16-25mm.

This data allows us to know the true particle size class and the type of aggregates.

3.2. Impacts sur la qualité de l'air :

According to our on-site surveys, 50% of all respondents stated that the operation pollutes the air, compared to 18% for noise pollution. Then we had to make direct observations which also showed that the air is polluted by the deposit of a whitish layer on the vegetation. Finally, we carried out air quality measurement tests using the RS9680 RS PRO device, which allowed us to obtain PM 2.5 and 10 values of 458 µg/m3 and 206 µg/m3, respectively, compared to the WHO AQG standard of 25 µg/m3 and 50 µg/m3, respectively. This also proves that the air is highly polluted in this location.

Figure 4 Granite crushing emanating dust

4. Discussions

Our The results of our laboratory tests indicate that the granite aggregates from the SOMIAG quarry (Manéah, Coyah prefecture) exhibit mechanical and physical properties that make them suitable for use in civil engineering works. First, all measured values of the NF P 18-573 Los Angeles (LA) test are below 30%. As the standard specifies LA ≤ 30% for acceptable resistance to fragmentation and abrasion, our granite meets this key criterion.

Beyond the LA test, the resistance to degradation under wet conditions (as measured by the Micro-Deval test) is also satisfactory: all our Micro-Deval (MDE) values are ≤ 20, in line with accepted thresholds for durable aggregates. This result suggests good resistance to abrasion and attrition, including when aggregates are exposed to moisture — a critical feature in tropical environments like Guinea, where wet-dry cycles can accelerate degradation.

The physical tests also support the quality of the granite: water absorption is less than 1%, and the bulk (volumetric) density values for most samples fall within ranges recommended for construction use. Low water absorption indicates low porosity, which helps reduce long-term weathering and enhances durability. Mass absorption being under 1% aligns with findings from other studies on high-quality granite aggregates.

Grain size (granulometry) analysis reveals that the samples tested correspond to standard aggregate classes: 6.3–16 mm (medium gravel) and 16–25 mm (coarse gravel), which are commonly used in concrete mixes and road base layers. The uniformity coefficients (Cu) calculated show a reasonably uniform gradation, which is beneficial for the stability and compaction behaviour of granular mixtures in concrete or road construction.

Taken together, the mechanical and physical test results indicate that SOMIAG granite aggregates are of good quality, with adequate toughness, low porosity, and suitable granulometry for use in concrete and road base applications. Their performance in both dry and wet abrasion tests indicates resilience, which is essential to ensure long-term durability of structures and pavement layers, especially under the climatic conditions of Guinea.

However, it is important to note the environmental observations made during this study. Dust produced during crushing and processing was observed to deposit on nearby vegetation; direct air-quality measurements revealed particulate matter ($PM_{2.5}$ and PM_{10}) far above guidelines set by World Health Organization (WHO). These findings highlight the environmental and public-health risks associated with quarrying and highlight the need to implement dust-control and mitigation measures at the extraction site.

Moreover, while our tests show the granite's suitability for structural use, long-term behaviour (weathering, freeze-thaw cycles if relevant, durability under cyclic loading, etc.) was not assessed. Likewise, we did not perform petrographic or mineralogical analyses, which could provide further insight into durability (e.g., presence of microfractures, mineral composition, potential reactivity). Such analyses would complement the mechanical and physical tests and strengthen the assessment of aggregate quality.

Finally, although our sample size and fraction types tested (e.g., 6.3–16 mm, 16–25 mm) correspond to typical ranges used in construction, further tests involving a wider variety of granule sizes — especially fine aggregates (sand, fines) and possibly larger sizes — may be needed to fully validate applicability for all structural and road construction contexts in Guinea.

5. Conclusion

In summary the present study demonstrates that granite from the SOMIAG quarry in Manéah possesses physical and mechanical characteristics compatible with standards for construction aggregates. The low Los Angeles abrasion index (LA < 30%), satisfactory Micro-Deval resistance (MDE ≤ 20), low water absorption (< 1%), appropriate bulk density, and acceptable granulometry (6.3–16 mm and 16–25 mm) indicate that this granite is suitable for use in concrete, road bases, and other civil engineering applications.

Nevertheless, the environmental impacts identified — notably severe air pollution linked to dust emissions — raise serious concerns about the sustainability and health implications of quarry operations. As such, while the material itself is of high quality, quarrying operations need to be accompanied by mitigation measures (dust suppression, environmental management) to protect nearby communities and ecosystems.

For future research, we recommend: (1) expanding the characterization to include petrographic and mineralogical analyses; (2) assessing long-term durability under local environmental conditions (moisture cycles, weathering, mechanical loading); and (3) evaluating fine aggregates and a broader spectrum of particle sizes to ensure comprehensive suitability for all construction needs in Guinea.

In conclusion, the SOMIAG granite represents a promising aggregate resource for construction in Guinea — provided that quarry management integrates environmental safeguards.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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