



# Science Forum (Journal of Pure and Applied Sciences)



Journal Homepage: <https://atbuscienceforum.com.ng/index.php/jpas>

## Assessment of the Engineering Properties and Aggregate Suitability of Fusa Riebeckite Granite, Jos, North-Central Nigeria

**Abalaka I.E., Momoh, A.**

Department of Geology, Faculty of Natural Sciences, University of Jos, Nigeria

### Abstract

The suitability of Riebeckite Granite from Fusa, Plateau State, North-Central Nigeria, as a potential construction aggregate was evaluated through detailed laboratory investigations of its physical properties. The study was undertaken to determine whether the granite meets standard engineering requirements for use as aggregate material in civil construction projects within Jos and its environs. A total of ten (10) representative rock samples were systematically collected from different locations within the study area to ensure adequate spatial coverage and reliability of results. Laboratory analyses focused primarily on the determination of specific gravity using the pycnometer method, a standard procedure for assessing the density characteristics of rock aggregates. The measured specific gravity values ranged from 2.597 to 2.654, with an average value falling within the accepted standard range (2.50-2.70) for most crystalline igneous rocks used in construction. These values indicate that the Fusa Riebeckite Granite possesses sufficient density and strength characteristics required for durable aggregate materials. The relatively low percentage passing values obtained during aggregate assessment suggest that higher comminution energy is required to dislodge or fragment the rock particles. This implies strong interlocking mineral grains and resistance to mechanical disintegration, which are desirable properties for construction aggregates subjected to load-bearing and abrasive conditions. The comminution energy requirement further reflects the competence and mechanical stability of the granite compared to weaker rock or soil-derived aggregates. Petrographic evidence from existing literature indicates that Riebeckite Granite is predominantly composed of quartz, orthoclase feldspar, hornblende, and biotite. The presence of these hard, crystalline mineral phases contributes to its relatively high specific gravity (greater than 2.50) and enhances its durability and structural integrity. Based on the laboratory results and comparison with established engineering standards, the Fusa Riebeckite Granite satisfies the fundamental physical requirements for use as construction aggregate. Therefore, it is considered suitable for application in concrete production, road construction, and other civil engineering works within Jos and surrounding areas.

### Keywords

Pycnometre;  
Specific Gravity;  
Aggregates;  
Construction;  
Comminution Energy,  
Riebeckite Granite.

ISSN 1119-4618



1119 4618

JPAS



— Faculty of Science, ATBU Bauchi —

## INTRODUCTION

The suitability of Riebeckite Granite in the Fusa community, Plateau State, as a potential aggregate source depends on a combination of geological and engineering factors that determine its performance as a construction material in building, civil, and related engineering applications. Proper evaluation of these factors is essential before siting and developing a quarry for aggregate production. Broadly, these controlling parameters can be classified into three categories: physical, mechanical, and chemical properties of the rock.

The physical properties of granite include density, specific gravity, porosity, electrical characteristics, magnetic properties, and natural radioactivity. These parameters influence durability and long-term performance in structural applications. Mechanical properties, on the other hand, relate to the rock's behavior under applied loads and include compressive strength, tensile strength, elastic modulus, stress-strain relationships, and resistance to deformation (Hook, 1994). These properties are typically determined through standardized laboratory tests using specialized equipment. Chemical characteristics involve the mineralogical composition of the granite and the nature of mineral intergrowth during magma crystallization, commonly referred to as intercrystallinity. The textural relationship among mineral grains significantly affects strength, durability, and resistance to weathering.

Structural features within the rock mass also play a critical role in aggregate suitability. Discontinuities such as joints, faults, folds, fractures, veins, foliations, striations, and lineations influence both quarrying operations and the mechanical stability of the rock. These structures affect slope stability, bench design, tunnel excavation, and overall mine safety.

Riebeckite Granite is generally described as a coarse-grained, light-colored plutonic igneous rock composed predominantly of quartz and alkali feldspar, with minor amounts of mica and amphibole minerals. Petrographically, quartz constitutes approximately 15-55% of the felsic components, while alkali feldspar accounts for 70-95% of total feldspar content (Amethyst, 2014). Its mineralogical composition contributes to its high density, durability, and aesthetic appeal. The rock forms from the slow cooling of magma at depth under conditions of elevated pressure and temperature (Wills, 2006).

Although Riebeckite Granite is typically dense and mechanically competent, its strength can decrease with increasing water content due to reduced internal friction and increased deformability within the rock mass (Ojo and Olaleye, 2004). Nevertheless, its granular texture, hardness, and mineral composition make it suitable for high-grade concrete aggregates and decorative applications.

The objectives of this study are to: (1) collect ten representative rock samples from Fusa, Jos, North-Central Nigeria; (2) determine their specific gravity using the pycnometer method; (3) compare the results with standard values for granite; and (4) evaluate the suitability of Fusa Riebeckite Granite as a potential construction aggregate material.

## LOCATION, ACCESSIBILITY AND GENERAL GEOLOGY

The study area (Fusa), lies approximately between latitudes N 9° 00' 00" and N 9° 00' 00" and between longitudes E 9° 51' 00" and E 9° 45' 00", covering a total area of 282 km<sup>2</sup>. The area is easily accessible all year round because of the good road network of tared and graded roads within the area.

In terms of geology, the Riebeckite granitic rocks which are been investigated are located in Fusa village, Jos, Plateau State. The

Nigerian basement complex extends Westwards and continues within the Dahomey - Togo - Ghana region. Falconer (1911, 1921). In terms of geology, the Riebeckite Granite rocks dominate the study area. They are plutonic rocks which comprise of alkali feldspars, quartz, mica and small portion of mafic minerals. Wright (1971). The rocks found in the study area are classified based on the proportion of the mafic minerals in them. They include: Bukuru Biotite Granite, N'gell Biotite Granite, Jos Bukuru Biotite Granite, Rayfield

Gona Biotite Granite and the Shell Biotite Granite. Macleod et al (1971).

The Geologic map of the study area is seen in Figure 1 which exposes the various rock types that are delineated. The basement Complex rocks of Nigeria is composed predominantly of magmatic and granite gneiss, quartzites, slightly migmatized to unmigmatized to metasedimentary schist and metaigneous rocks, charnockites, gabbroic and dioritic rocks. Figure 1 and 2 show the geologic map as well as the sample location map of the study area.

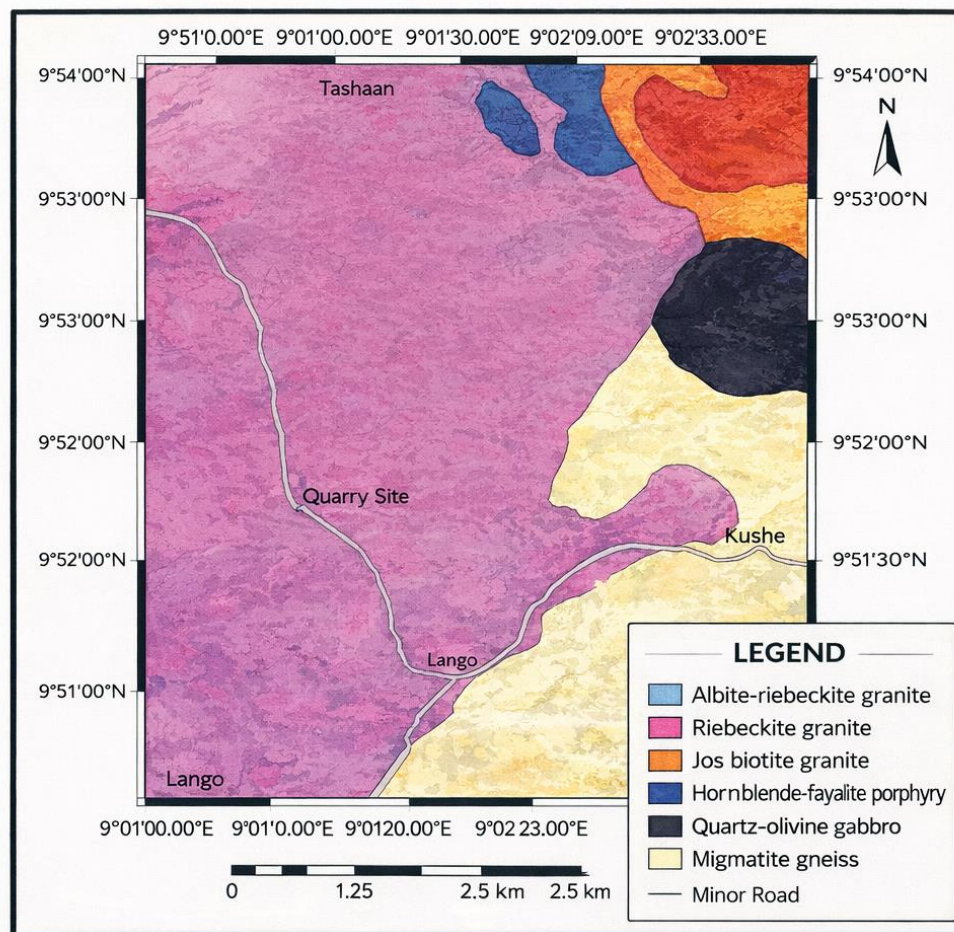


Figure 1: Geological Map of Fusa and Environs

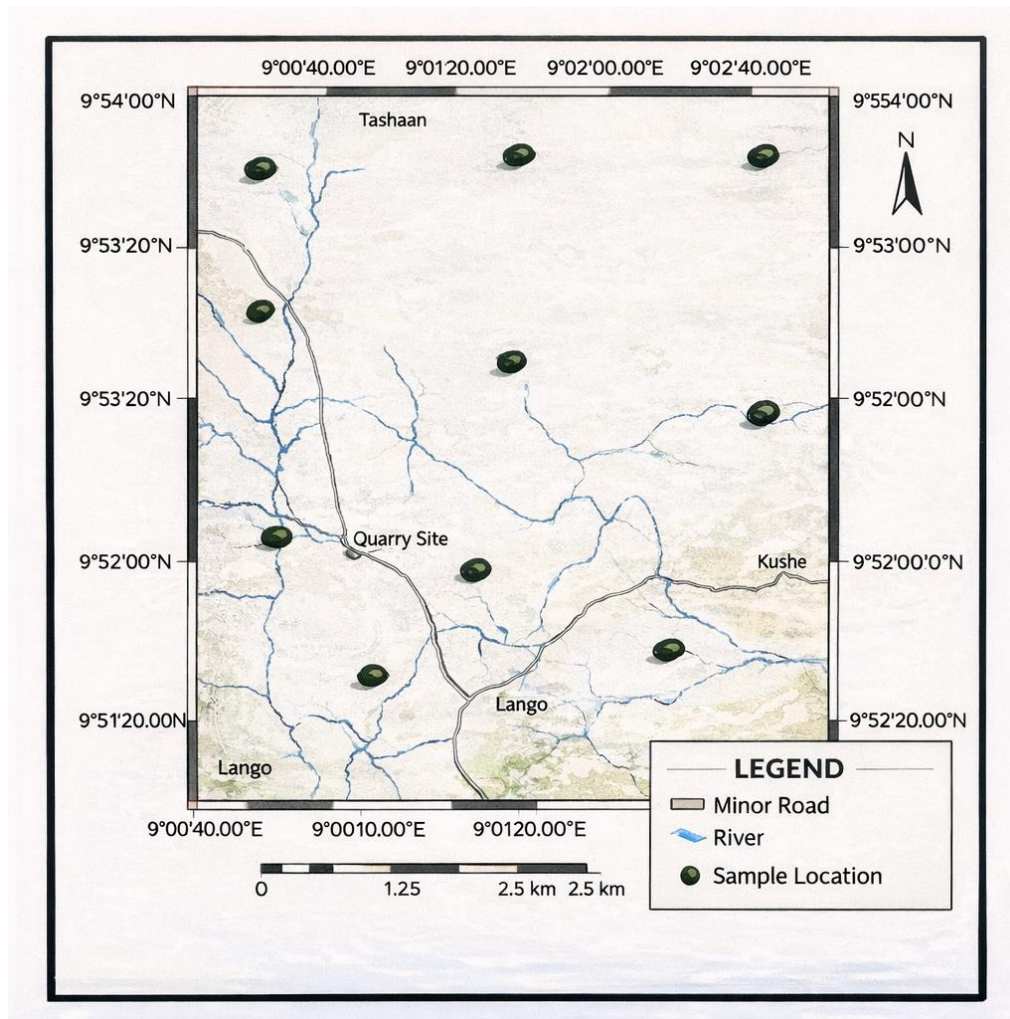


Figure 2: Map Showing the Sample Location Points of the Study Area

## MATERIALS AND METHODS

The materials and equipment used for this investigation included: a sledge hammer for sample extraction, pycnometer for specific gravity determination, Global Positioning System (GPS) for coordinate acquisition, geological compass for orientation measurements, topographic and geological maps of the study area, sample bags, masking tape, permanent markers for labeling, and a field vehicle for mobility during sampling operations.

### Methodology

Both primary and secondary data sources were utilized in this study. Secondary data were

obtained from textbooks, peer-reviewed journals, previous research reports, and relevant online databases. Primary data were acquired through systematic field sampling and laboratory analysis.

### Field Sampling Procedure

Rock samples were collected from six representative stations (A-F) within the Fusa area using a random sampling approach to ensure spatial representativeness. At each station, approximately 10 kg of rock material was obtained using a sledge hammer to produce varying fragment sizes. Two samples were collected per station, resulting in a total of ten (10) samples for laboratory analysis.

### Laboratory Analysis: Specific Gravity Determination

The strength and density characteristics of the aggregates were evaluated using the pycnometer method for specific gravity determination. Specific gravity ( $G$ ) is defined as the ratio of the density of the rock material to the density of water at a specified temperature. It is expressed as:

$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)} \quad G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

Where:

- $W_1$  = Weight of empty pycnometer
- $W_2$  = Weight of pycnometer + dry fine aggregate
- $W_3$  = Weight of pycnometer + aggregate + water
- $W_4$  = Weight of pycnometer filled with water

The average specific gravity for each station was computed as:

$$G_{avg} = \frac{G_1 + G_2}{2} \quad G_{avg} = \frac{G_1 + G_2}{2}$$

Specific gravity is a critical parameter in geotechnical and construction engineering as it influences bulk density, void ratio, moisture content relationships, and foundation design considerations. Typically, granite aggregates have specific gravity values ranging between 2.60 and 2.70.

## RESULTS AND DISCUSSION

The specific gravity values obtained from Stations A-F are summarized below:

Station	Trial 1 ( $G$ )	Trial 2 ( $G$ )	Average ( $G$ )
A	2.615	2.615	2.615
B	2.601	2.629	2.615
C	2.597	2.613	2.605
D	2.605	2.603	2.604
E	2.634	2.654	2.644

Station	Trial 1 ( $G$ )	Trial 2 ( $G$ )	Average ( $G$ )
F	2.620	2.649	2.635

The results show that specific gravity values range from 2.597 to 2.654, with an overall average approximately 2.62-2.64. These values fall within the standard range for hard crystalline rocks used as construction aggregates (2.50-2.80), as documented by Bieniawski (1973, 1976, 1978, 1984).

Comparison with typical specific gravity values of geomaterials shows:

Material Type	Specific Gravity Range
Rock/Sand	2.50 - 2.80
Silt	2.20 - 2.35
Inorganic Clay	2.00 - 2.30
Organic Soil	1.00 - 2.00

The Fusa Riebeckite Granite clearly falls within the competent rock category. The relatively low percentage passing observed during crushing indicates high resistance to fragmentation. This suggests that greater comminution energy is required to disintegrate the rock, reflecting strong mineral interlocking and high mechanical competence. Such resistance to crushing is desirable for aggregates intended for high-strength concrete and pavement construction.

Petrographically, Riebeckite Granite is composed predominantly of quartz, orthoclase feldspar, hornblende, and biotite. The abundance of quartz and feldspar—minerals with high hardness values—contributes significantly to the elevated specific gravity and mechanical durability observed.

Overall, the results demonstrate uniformity across sampling stations, indicating consistent lithological characteristics within the study area.

## CONCLUSION

In conclusion, a total of ten (10) representative rock samples were collected from different locations within the Fusa community and subjected to laboratory analysis. The specific gravity of each sample was determined using the pycnometer method, which is a reliable indicator of the density and mechanical competence of aggregate materials. The results obtained show that the specific gravity values of the samples fall within the established standard range for granite rocks in the study area.

The relatively high specific gravity values indicate that the rocks possess high density, strength, and resistance to crushing. Consequently, a considerable amount of energy is required to break down these materials, reflecting their durability and structural integrity. Based on these findings, the granite aggregates from the Fusa community can be considered competent and suitable for use in construction works, particularly in applications such as concrete production, road construction, and other civil engineering projects where strong and durable aggregates are required.

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