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Physico-Mechanical Properties of Rukuba Granitic Rock as a Source of Construction Aggregate: Laboratory Assessment and Engineering Evaluation

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Abstract

This study investigated the physico-mechanical properties of Rukuba granitic rock from Jos Plateau, North-Central Nigeria, to assess its viability as construction aggregate. Despite ongoing commercial quarrying in the area, comprehensive, standardised engineering characterisation data for Rukuba granite remains limited, creating a knowledge gap for regional infrastructure development. Five rock samples were systematically collected from spatially distributed locations within an active quarry and subjected to comprehensive laboratory testing following American Association of State Highway and Transportation Officials (AASHTO T85, T19, T2), British Standards (BS 812), and American Society for Testing and Materials (ASTM C127, C131, D7012) protocols. Physical characterisation revealed mean specific gravity of 2.65 ± 0.02, water absorption of 0.55 ± 0.11%, and bulk density between 1485 and 1615 kg/m³. Mechanical testing demonstrated a uniaxial compressive strength (UCS) of 162 ± 9 MPa, aggregate crushing value (ACV) ranging from 18.7% to 21.7% (mean: 20.2 ± 1.2%), aggregate impact value (AIV) from 17.0% to 19.7% (mean: 18.4 ± 1.2%), and Los Angeles abrasion value (LAAV) from 22.3% to 26.0% (mean: 24.0 ± 1.6%). All measured parameters satisfied the requirements specified in AASHTO, BS, and ASTM standards for high-quality construction aggregates. The findings indicate that Rukuba granite is highly suitable for structural concrete applications, high-strength concrete production, flexible pavement construction, and other engineering purposes requiring durable aggregate materials.

Keywords: *Granite aggregate, rock mechanics, uniaxial compressive strength, aggregate crushing value, Nigerian Younger Granite.*

1.0 Introduction

Rock-derived aggregates represent critical raw materials for modern construction, comprising the predominant volumetric component of concrete and pavement structures. With annual global extraction surpassing 50 billion tonnes (UNEP, 2019), aggregates constitute the most extensively mined solid material worldwide. The performance characteristics of aggregates directly influence the strength, durability, and long-term sustainability of construction projects. International specification frameworks including ASTM C33, BS 882, and EN 12620 define rigorous performance thresholds to ensure material suitability for demanding structural applications (Neville & Brooks, 2010).

1.1 Critical review of physical and mechanical properties of aggregates

Specific gravity, a dimensionless ratio of aggregate density to the density of water, is determined using AASHTO T85 (AASHTO, 2022) or its equivalent, ASTM C127, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate. Neither standard prescribes a pass/fail acceptance range, since specific gravity is primarily a mix-design input rather than a durability criterion; however, normal-weight aggregates used in structural concrete and pavement work are generally expected to fall between 2.4 and 2.9 (BSI, 1995; Omopariola & Jimoh, 2018). Values below this range are typically associated with porous, weathered, or low-density rock that absorbs excess mixing water and is prone to early breakdown in base-course applications, while unusually high values often indicate a heavy-mineral-rich rock that can accelerate wear on crushing and handling equipment (ASTM International, 2015; Petrounias et al., 2018).

Water absorption, determined alongside specific gravity under the same AASHTO T85/ASTM C127 procedure, reflects the volume of permeable pore space in the aggregate. BS 812: Part 2 (BSI, 1995) and most concrete specifications regard values below 1.0% as indicative of a dense, durable, low-porosity aggregate suitable for high-quality concrete, while values above roughly 2.0% are generally associated with weathered or vesicular basement rocks of reduced durability (Kolawole et al., 2019; Neville & Brooks, 2010).

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Bulk density (unit weight) is determined following ASTM C29/C29M or its AASHTO equivalent, T19 (AASHTO, 2020), Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate. A minimum loose bulk density of approximately 1400 kg/m^3 is generally specified for aggregates intended for structural applications (BSI, 1995); lower values point to a lightweight, porous, or poorly graded material that may compromise the load-bearing capacity of concrete and pavement layers.

Uniaxial compressive strength (UCS) is determined following ASTM D7012 or the ISRM suggested method (Xie et al., 2025). Under the ISRM strength classification, rocks with UCS between 100 and 250 MPa are described as very strong; aggregate sources yielding UCS below about 50 MPa are generally regarded as unsuitable for high-strength or heavy-duty structural applications (Amuda et al., 2014).

The aggregate crushing value (ACV), determined per BS 812: Part 110 (BSI, 1990a), estimates resistance to gradual crushing under a slowly applied compressive load. BS 882 sets a maximum ACV of 25% for aggregate used in concrete wearing surfaces and 30% for aggregate used elsewhere in concrete, with lower values indicating a mechanically stronger and more durable material. The aggregate impact value (AIV), determined per BS 812: Part 112 (BSI, 1990b), estimates resistance to sudden shock loading; a maximum AIV of 25% is generally specified for aggregate used in heavy-duty concrete floors and road-surfacing applications, and 30% for general concrete use (Afolagboye et al., 2016; Alabi et al., 2017).

The Los Angeles abrasion value (LAAV), determined per ASTM C131 (its AASHTO equivalent is T96), estimates resistance to abrasion, impact, and grinding during production, placement, and service. Most highway agencies specify a maximum LAAV of 40% for base and sub-base aggregate, while BS 812 applies a stricter indicative limit of around 30% for aggregate used in wearing courses subject to heavy trafficking (ASTM International, 2006; Teymen, 2019). Below the lower end of the acceptable range, an aggregate that is unusually dense or resistant can still be uneconomical to crush and process, while above the upper limit, an aggregate degrades rapidly under traffic and equipment loading, generating excess fines that compromise pavement skid resistance and structural performance (Kolawole et al., 2019; ASTM International, 2024).

Validation of rock aggregate suitability for engineering construction necessitates systematic evaluation through these standardised testing protocols. According to Neville and Brooks (2010) and Petrounias et al. (2018), superior aggregate quality is essential for optimal performance in construction applications, and the physico-mechanical characteristics of aggregates fundamentally govern their behaviour and effectiveness across diverse construction scenarios.

Nigeria's accelerating urbanisation and infrastructure expansion have intensified demand for high-quality construction aggregates. However, the nation confronts persistent challenges including variable aggregate quality, dependence on weathered or substandard materials, and insufficient characterisation of domestic rock resources (Teymen, 2019); such shortcomings in material characterisation have been directly implicated in premature pavement failures elsewhere in the country (Babadiya & Igwe, 2021). The Jos Plateau in North-Central Nigeria, underlain by the Nigerian Younger Granites, a Jurassic anorogenic intrusive suite (Kamaunji et al., 2023) recognised for mechanical durability and extensive surface exposure (Alabi et al., 2017; Abalaka & Odumu, 2025), presents a substantial reservoir of potentially high-grade aggregate material.

Previous investigations have confirmed the aggregate potential of several Jos Plateau granites and comparable Nigerian basement rocks. Research by Dung et al. (2021) documented ACV of 19.6% and AIV of 17.8% for Mista Ali Granite, with compressive strengths exceeding 140 MPa in selected samples from the plateau. Kolawole et al. (2019) reported ACV of 17.46–21.00% and specific gravity of 2.44–2.67 for Minna granitic formation aggregates, while Amuda et al. (2014) recorded specific gravity of 2.61–2.70 and UCS of 95.76–169.70 MPa for basement granites at Kajuru, Kaduna State. Falowo (2019) similarly documented favourable physico-mechanical properties across a range of Nigerian basement rock types used as pavement aggregate, reinforcing the broader suitability of basement-complex lithologies for engineering construction. Omopariola and Jimoh (2018) found that granites from four quarry sites in Ogun State varied in specific gravity (2.61–2.86) and water absorption (0.16–2.13%) depending on aggregate size and source location, underscoring the importance of site-specific testing even within the same geological province. Similarly, Mallo and Sani (2012) reported reduced mechanical performance in sericitized granite from the Miango area, North Central Nigeria, underscoring the importance of fresh, unweathered samples for quality aggregate production. Recent regional studies reinforce this pattern: Aghamelu (2023) demonstrated that natural moisture content can reliably predict weathering-related degradation of water absorption, crushing resistance and soundness in Nigerian volcaniclastic aggregates, while Emioge et al. (2023) documented strength anisotropy in granite and granodiorite from the Southwestern Basement Complex, and Abalaka and Odumu (2025) confirmed the suitability of Fobur biotite-granite, another Jos Plateau outcrop, for road construction.

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Beyond granite specifically, engineering characterisation of other Nigerian rock types intended for mining and geotechnical applications reinforces the value of laboratory-based physico-mechanical assessment prior to use. Ismail and Abdulwahid (2021), for example, characterised limestone and marlstone aggregates in the Koya area of Iraq using the same suite of physical and mechanical tests applied here, demonstrating that this laboratory-based approach transfers readily across rock types and regions. Adegboye (2026), in a pilot investigation of Ashaka limestone, demonstrated that elevated temperature exposure measurably alters strength and durability indices relevant to mining and geotechnical design, underscoring that the physico-mechanical behaviour of any candidate rock, whether limestone or granite, cannot be assumed from geological classification alone and must be established through direct testing.

The Rukuba locality within the Jos-Bukuru Ring Complex hosts extensive exposures of medium- to coarse-grained granite exhibiting minimal surface weathering (Alao & Blaize, 2016). Despite its proximity to major urban centres and ongoing commercial quarrying operations, comprehensive engineering characterisation data for Rukuba granite following standardised testing protocols remains limited in the published literature.

This investigation addresses this knowledge gap by conducting systematic physico-mechanical characterisation of Rukuba granitic rocks to evaluate their suitability as construction aggregates for the rapidly developing North-Central region of Nigeria.

2.0 Location and Geology of Study Area

The study site is situated at Rukuba in the Jos-Bukuru region of North-Central Nigeria. The reported coordinate (9°56′06″N, 8°53′33″E) represents the central sampling point at the active quarry face from which the field samples were collected; precise boundary coordinates for the full quarry lease were not available to the authors at the time of sampling. This area forms part of the Nigerian Younger Granite Ring Complexes within the regional Basement Complex. The entire Younger Granite province represents anorogenic alkaline felsic intrusive igneous rocks occurring as ring complexes, whose emplacement has been linked to the repeated reactivation of lithospheric shear zones and transcurrent faults (Vincent et al., 2022).

The geochemical and structural characteristics of related ring complexes in the region, including the Ropp Complex, have been described by Odewumi (2020), providing regional geological context for the Rukuba intrusive suite.

The Rukuba geology comprises felsic rocks with associated mafic intrusions that locally form hybrid lithologies. Characteristic mineralogy includes quartz, feldspar, biotite, amphiboles, and the accessory phase zircon (Kamaunji et al., 2023; Vincent et al., 2022). The ring complexes exhibit structural control by basement faults and fractures, with the Rukuba granite displaying features including joints, fractures, and intrusive contacts (Opara et al., 2015). The rocks occur as massive ridges and fragmented boulders across the landscape, as illustrated in the geological map of the study area (Figure 1).

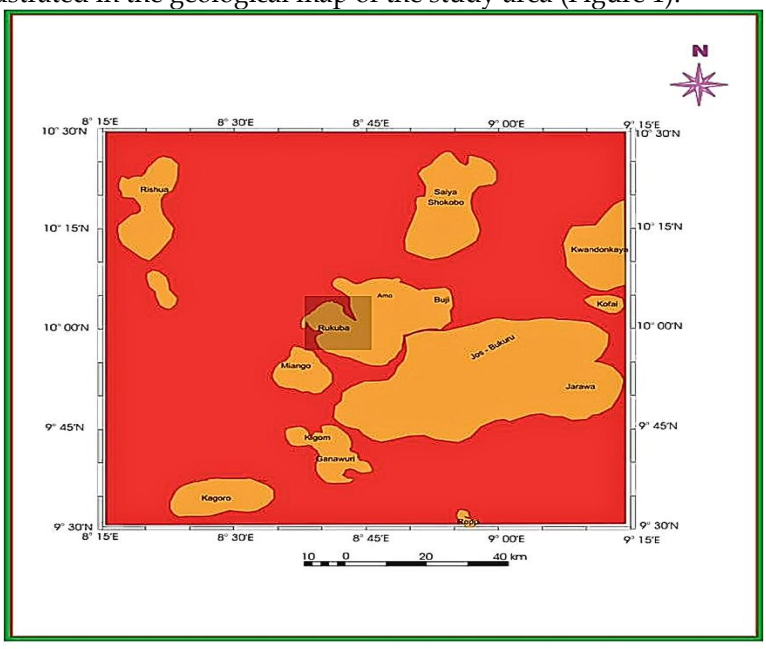


Figure 1: Geological map of the study area

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3.0 Materials and Methods

All laboratory testing and sample preparation for this study were conducted using the facilities of the Departments of Mining Engineering, Civil Engineering, and Building, University of Jos, Nigeria. Equipment calibration and testing procedures strictly adhered to the relevant AASHTO, ASTM, and British Standards (BS) protocols as detailed in the following subsections.

3.1 Sample Collection and Preparation

Five representative rock samples (R1–R5) were collected from spatially distributed locations within the active quarry, with sampling stations separated by approximately 40–60 metres across different quarry benches to ensure adequate representation of the commercially exploited granite body. ASTM D75/AASHTO T2, Standard Practice for Sampling Aggregates (ASTM International, 2019), specifies sample mass according to the nominal maximum particle size of the material rather than a fixed number of sampling stations; in this study, five stations were retained because they corresponded to the accessible, actively worked faces at the time of sampling, and each station yielded a block mass sufficient to satisfy the minimum sample-mass requirement of ASTM D75/AASHTO T2 for the test-size fractions used. Fresh, unweathered granitic rock blocks weighing 50 to 100 kg were extracted from outcrop exposures at each station. Careful selection excluded samples exhibiting visible signs of surface weathering or alteration. All samples received immediate field identification and were transported to the geomechanics laboratory (Department of Mining Engineering, University of Jos), where they were stored under ambient laboratory conditions (23 ± 2 °C) to minimise moisture uptake prior to testing (ASTM International, 2013).

Laboratory processing involved visual inspection of intact blocks followed by trimming to remove any weathered surfaces, fractures, veins, or other discontinuities that could influence mechanical behaviour. Only sound portions displaying uniform texture and lacking obvious defects were retained for subsequent analysis. Rock blocks were cleaned with distilled water to eliminate dust and loose particles.

Sample preparation employed a jaw crusher (Retsch BB200), operated in accordance with ASTM D75/AASHTO T2 sample-reduction guidance, to reduce rock blocks into coarse fragments, which were then sieved to obtain specific size fractions: 10 to 12.5 mm for ACV and AIV testing, graded fractions of 4.75 to 19 mm for LAAV testing, and intact cylindrical cores of approximately 54.7 mm diameter extracted using a diamond-tipped core drill for UCS determination.

3.2 Physical Property Tests

3.2.1 Specific gravity

Specific gravity determination followed AASHTO T85/ASTM C127 and BS 812: Part 2 (BSI, 1995). Representative subsamples of the 10 to 12.5 mm fraction were oven-dried at 105 ± 5 °C for 24 hours until achieving constant mass, then cooled in a desiccator for 30 minutes. Oven-dry mass (A) was recorded to 0.1 g precision. Samples were subsequently immersed in distilled water at 23 ± 1 °C for 24 hours to achieve saturated surface-dry (SSD) condition. Following saturation, samples were towel-dried to SSD state and weighed in air and in water using a calibrated balance with wire-basket apparatus. Specific gravity was calculated as (BSI, 1995):

$$SG = \frac{A}{B-C} \quad (1)$$

where A represents oven-dry mass (g), B denotes saturated sample mass in air (g), and C indicates saturated sample mass in water (g). Five replicate tests were performed with the mean value reported.

3.2.2 Water absorption

Water absorption testing utilised the same oven-dried samples following AASHTO T85/ASTM C127 and BS 812: Part 2 (BSI, 1995). After recording oven-dry mass (A), samples underwent 24-hour immersion in distilled water at 23 ± 2 °C. Surface moisture was removed to achieve SSD condition before recording mass B. Water absorption was calculated as (BSI, 1995):

$$WA(\%) = \frac{(B-A)}{A} \times 100 \quad (2)$$

where A represents oven-dry mass and B indicates saturated-surface-dry mass. Five replicate measurements were conducted with mean values reported.

3.2.3 Bulk density

Both loose and compacted bulk densities were determined following ASTM C29/C29M (AASHTO T19), by measuring the aggregate mass required to fill a standardised cylindrical container of known volume under loose and compacted conditions respectively. Values were calculated as:

$$\rho_b = \frac{M}{V} \quad (3)$$

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where ρb represents bulk density (kg/m³), M denotes sample mass (kg), and V indicates sample volume (m³).

3.3 Mechanical Property Tests

3.3.1 Aggregate crushing value (ACV)

ACV testing followed BS 812: Part 110 (BSI, 1990a). Aggregate passing the 12.5 mm sieve and retained on the 10 mm sieve was oven-dried at 105 °C to constant mass. A 2.5 kg sample was placed in a standardised cylindrical steel mould (152 mm internal diameter, 130 mm height) and compacted in three equal layers using 25 strokes per layer with a tamping rod. A 400 kN compressive load was gradually applied over 10 minutes using a compression testing machine (ELE International, model ADR-Auto). Material passing the 2.36 mm sieve after crushing was collected and weighed. ACV was calculated as (BSI, 1990a):

$$ACV(\%) = \frac{W_1}{W_2} \times 100 \quad (4)$$

where W1 represents crushed fines mass and W2 denotes original dry sample mass. Five replicate tests yielded reported average values.

3.3.2 Aggregate impact value (AIV)

AIV determination followed BS 812: Part 112 (BSI, 1990b). Aggregate within the 14 mm to 10 mm size fraction was oven-dried at 105 °C to constant mass. Samples were placed in cylindrical metal cups and subjected to 15 standardised hammer blows. Particles passing the 2.36 mm sieve were subsequently weighed. AIV was calculated as (BSI, 1990b):

$$AIV(\%) = \frac{W_1}{W_2} \times 100 \quad (5)$$

where W1 represents fines mass after impact and W2 denotes original dry sample mass. Five tests were performed with mean values reported.

3.3.3 Los Angeles abrasion value (LAAV)

LAAV testing followed ASTM C131 (ASTM International, 2006). A 5 kg graded sample comprising 12.5 to 19 mm fraction (2.5 kg) and 9.5 to 12.5 mm fraction (2.5 kg) was oven-dried, weighed, and placed in a Los Angeles abrasion machine with 11 steel spheres (total mass 5.25 kg). The apparatus was rotated at 30 to 33 rpm for 500 revolutions. Following testing, aggregate was removed, washed over a 1.70 mm sieve, and oven-dried. LAAV was calculated as (ASTM International, 2006):

$$LAAV(\%) = \frac{W_2 - W_1}{W_2} \times 100 \quad (6)$$

where W2 represents initial mass and W1 denotes final retained mass. Five replicate tests yielded reported average values.

3.3.4 Uniaxial compressive strength (UCS)

UCS testing followed ASTM D7012 (ASTM International, 2014) and the ISRM suggested method for laboratory uniaxial compression testing (Xie et al., 2025). Cylindrical core specimens were extracted from intact rock blocks using a diamond core drill and trimmed to achieve height-to-diameter ratios of 2.5 to 3.0 for 54.7 mm diameter cores. Specimen ends were ground flat and perpendicular to the core axis. Diameter and length measurements were recorded using a Vernier caliper (±0.1 mm precision), and mass was determined using a precision balance (±0.1 g). Prepared cores underwent uniaxial compression in a servo-controlled testing machine (Controls Advantest 9, 3000 kN capacity), with continuous loading at 0.7 MPa/s until failure. Peak failure load (Pmax) was recorded, and compressive strength was calculated as (ASTM International, 2014):

$$\sigma c = \frac{P_{max}}{\pi(d/2)^2} \quad (7)$$

where σc represents compressive strength (MPa), Pmax denotes maximum failure load (N), and d indicates specimen diameter (mm). Five specimens were tested with mean UCS values reported.

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4.0 Results and Discussion

Systematic physico-mechanical investigation of Rukuba granitic rock yielded consistent results across five representative samples. All values are reported with mean and standard deviation, evaluated against AASHTO, BS 812, and ASTM specification limits, and discussed in the context of relevant literature.

4.1 Physical Properties

Physical property results are summarised in Table 1. Specific gravity measurements ranged from 2.63 to 2.67 with a mean value of 2.65 ± 0.02, comfortably within the 2.4–2.9 range typical of normal-weight structural aggregate.

Water absorption ranged from 0.42% to 0.67% with a mean of 0.55 ± 0.11%. These values are well below the 1.0% maximum threshold prescribed for high-quality aggregates in concrete structures (Neville & Brooks, 2010). Loose bulk density ranged from 1466 to 1520 kg/m³ (mean: 1485 ± 29 kg/m³), while compacted bulk density ranged from 1585 to 1650 kg/m³ (mean: 1615 ± 28 kg/m³). Both values exceed the 1400 kg/m³ minimum specified for structural applications (BSI, 1995).

Table 1: Physical properties of coarse aggregates from Rukuba quarry

Sample	Specific Gravity	Water Absorption (%)	Loose Bulk Density (kg/m³)	Compacted Bulk Density (kg/m³)
R1	2.64	0.45	1485	1615
R2	2.67	0.42	1520	1650
R3	2.66	0.67	1512	1632
R4	2.65	0.59	1468	1595
R5	2.63	0.62	1466	1585
Mean	2.65	0.55	1485	1615
SD	0.02	0.11	29	28
Standard limit	2.4–2.9	<1.0	>1400	>1400

Note: SD = Standard Deviation

A specific gravity of 2.65 ± 0.02 fits neatly within the 2.4–2.9 window typical of structural aggregate under AASHTO T85/ASTM C127 and BS 812: Part 2. This is broadly in line with what has been measured elsewhere in Nigeria's basement complex: Kolawole et al. (2019) obtained 2.44–2.67 for Minna granite, and Amuda et al. (2014) recorded 2.61–2.70 at Kajuru. The very modest spread across the Rukuba samples (CV of just 0.75%) was expected given that the biotite granite here carries little mafic or heavy mineral material; density variation requires mineralogical contrast, and there is not much of it at this site, consistent with the broader link between rock microstructure and functional aggregate performance described by Ahmad et al. (2021).

Water absorption averaging 0.55 ± 0.11% comes in well under the 1.0% ceiling in BS 812: Part 2. By comparison, some Nigerian granites have returned values as high as 2.13% (Omopariola & Jimoh, 2018), so the Rukuba figure points to a rock with genuinely low porosity and minimal weathering at depth. This matters in concrete production because aggregate that soaks up mix water throws off the water-to-cement ratio, with direct consequences for strength control. The slightly elevated reading of 0.67% for R3 is still well within specification; it probably reflects a localised fracture or minor discontinuity in that part of the face, nothing that would affect the bulk of production.

Bulk density readings of 1,485 kg/m³ (loose) and 1,615 kg/m³ (compacted) both clear the 1,400 kg/m³ floor set by BS 812: Part 2, and sit in the same range as Ghanaian granite aggregate data reported by Buertey et al. (2016). The ratio of compacted to loose density, at roughly 1.09, is typical of an angular to sub-angular crushed product, and angular aggregate interlocks better in pavement courses than rounded material does, which is a useful attribute for road construction.

4.2 Mechanical Properties

Mechanical property results are presented in Table 2. These strength characteristics provide critical assessment criteria for aggregate suitability in road construction and structural applications.

4.2.1 Aggregate crushing value

ACV measurements ranged from 18.7% to 21.7% with a mean of 20.2 ± 1.2%. Sample R5 exhibited the minimum value (18.7%) while sample R2 displayed the maximum (21.7%).

With a mean ACV of 20.2 ± 1.2%, Rukuba granite sits comfortably below the BS 882 ceiling of 30% for general concrete use and close to the stricter 25% limit for wearing surfaces. This is also consistent with what Kolawole et al. (2019) found for Minna granite (17.46–21.00%), which comes from the same broad geological

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province. A CV of 5.9% means that a quarry operator could expect consistent ACV month-on-month without having to test every load.

4.2.2 Aggregate impact value

AIV measurements ranged from 17.0% to 19.7% with a mean of 18.4 ± 1.2%. Sample R2 exhibited the minimum value (17.0%) while sample R3 displayed the maximum (19.7%).

An average AIV of 18.4 ± 1.2% is well short of the 25–30% limits in BS 812: Part 112 for road-surfacing and general concrete use respectively. Aggregate practitioners generally regard anything below 20% as strong under dynamic loading, and the 10–20% range is considered excellent for heavy pavement and reinforced concrete work (Afolagboye et al., 2016; Alabi et al., 2017). One notable detail is how close the ACV and AIV averages are to each other, differing by less than two percentage points, suggesting the rock responds similarly whether the load is applied gradually or as an impact. That consistency is what one would expect from a compositionally uniform intrusive rock. A CV of 6.5% is again reassuringly tight.

4.2.3 Los Angeles abrasion value

LAAV measurements ranged from 22.3% to 26.0% with a mean of 24.0 ± 1.6%. Sample R1 exhibited the minimum value (22.3%) while sample R2 displayed the maximum (26.0%), as illustrated in Figure 2.

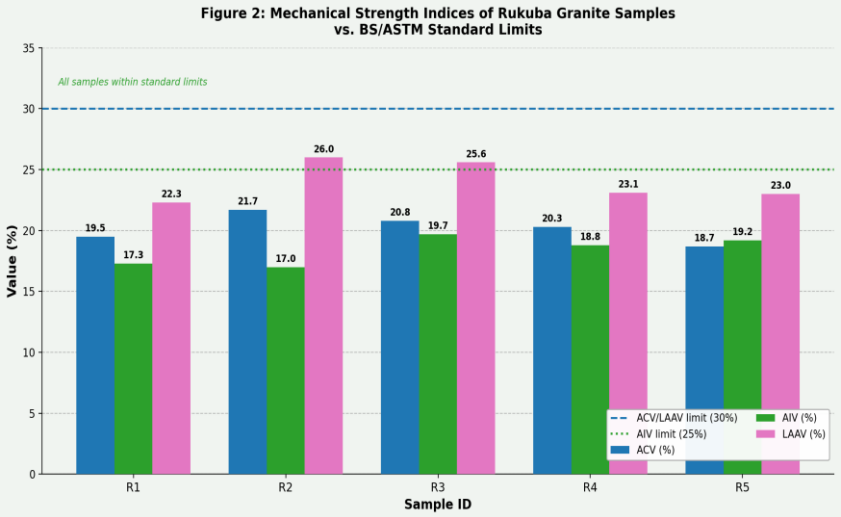


Figure 2: Mechanical strength indices (ACV, AIV and LAAV) of Rukuba granite samples compared with BS and ASTM standard limits

LAAV of 24.0 ± 1.6% is far below the ASTM C131 highway-agency limit of 40% and also within the more stringent BS 812 indicative threshold of around 30% for demanding wearing-course applications. Low abrasion loss is particularly relevant for road wearing courses, where surface polishing under traffic reduces skid resistance, and for railway ballast, where gradual wear alters particle shape and can compromise track geometry. The slightly higher value for R2 (26.0% against 22.3% for R1) probably reflects minor differences in crystal size or feldspar content at that sampling point; both values remain within specification.

4.2.4 Uniaxial compressive strength

UCS measurements ranged from 149 to 172 MPa with a mean of 162 ± 9 Mpa. Sample R4 exhibited the minimum value (149 Mpa) while sample R2 displayed the maximum (172 Mpa).

Table 2: Mechanical properties of coarse aggregates from Rukuba quarry

Sample	ACV (%)	AIV (%)	LAAV (%)	UCS (MPa)
R1	19.5	17.3	22.3	158
R2	21.7	17.0	26.0	172
R3	20.8	19.7	25.6	164
R4	20.3	18.8	23.1	149
R5	18.7	19.2	23.0	167
Mean	20.2	18.4	24.0	162
SD	1.2	1.2	1.6	9
Standard limit	<30	<25	<30	≥100 MPa

Note: SD = Standard Deviation; lower values for ACV, AIV, and LAAV indicate better aggregate performance

A mean UCS of 162 ± 9 MPa puts Rukuba granite firmly in the very strong category under the ISRM rock strength classification. It falls within the 95.76–169.70 MPa spread documented by Amuda et al. (2014) for

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basement granites elsewhere in Nigeria, and is consistent with the strength anisotropy patterns reported for Southwestern Basement Complex granite and granodiorite by Emioge et al. (2023). A CV of about 5.6% rounds off a picture of a mechanically uniform and predictable material.

4.3 Comparison with Other Nigerian and Regional Sources

Placing the Rukuba data alongside results from other characterised Nigerian and regional sites demonstrates the quality of the material. Omopariola and Jimoh (2018) documented considerable variability across Ogun State granite quarries, with specific gravity and water absorption both size- and site-dependent; some sites only just made specification. Salati and Adeyemo (2021), studying granite at Onikoko in Oyo State, South-Western Nigeria, reported properties within acceptable international standards but noted the importance of site-specific testing given the variability observed across different outcrops. Similarly, Olatunji et al. (2023) found metamorphosed granite in Ilorin, Kwara State, to possess high engineering properties suitable for road construction, further demonstrating the broad aggregate potential of Nigeria's basement granites. Aghamelu (2023) showed, for volcaniclastic aggregates in Abakaliki, that natural moisture content is a strong predictor of weathering-related decline in water absorption, crushing resistance, and soundness, reinforcing the present study's emphasis on sampling fresh, unweathered material. Beyond Nigeria, Buertey et al. (2016) reported comparable physico-mechanical performance for granite aggregate from quarries near Accra, Ghana, and Ruki et al. (2025) similarly found that locally sourced rock aggregates in Sarawak, Malaysia met pavement specification once weathering grade and source locality were properly accounted for, underlining that the geological controls identified for Rukuba granite mirror patterns observed across other tropical basement and volcanic terrains. Further afield, Arif et al. (2013) reported broadly comparable physico-mechanical behaviour for granitic rocks of the Ambela Granitic Complex in northwestern Pakistan, indicating that the property ranges observed for Rukuba granite are consistent with granite-derived aggregate performance internationally. The distinguishing feature of the Rukuba dataset across these comparisons is not just that the means pass the standards, but that the spread is consistently narrow, which translates directly into predictable production quality and simpler quality-control regimes.

The most directly relevant comparison within the Jos Plateau is with Dung et al. (2021), who examined the Mista Ali granite, another Younger Granite outcrop a short distance away, reporting ACV of 19.6% and AIV of 17.8% with compressive strengths exceeding 140 MPa. Their specific gravity of 2.64 and water absorption of 0.49% are very close to the present findings. However, they did not report LAAV or UCS values across all samples. Abalaka and Odumu (2025), in the most recent study on Jos Plateau aggregate, characterised Fobur biotite-granite and confirmed its suitability for road construction, establishing a consistent pattern of high mechanical performance across multiple outcrops within the same ring complex. The current study complements and extends these findings by providing a more complete physico-mechanical dataset for the Rukuba locality, including LAAV and UCS, making it one of the more comprehensive published characterisations of Younger Granite aggregate from the Jos Plateau to date. These property-level results also connect to quarry-scale production concerns: Adegboye and Idowu (2026) linked geomechanical properties and joint-density controls to blast fragmentation outcomes across Precambrian granitic gneiss and Younger Granite quarries in Plateau State, indicating that the structural features noted for the Rukuba outcrop are consequential beyond laboratory characterisation, extending into fragmentation behaviour at the production stage.

4.4 Suitability for Construction Use

Taken as a whole, the results support use of Rukuba granite aggregate in the following applications:

(i) Structural concrete including reinforced and prestressed members: the specific gravity, water absorption, ACV, and UCS combination satisfies BS EN 12620:2002+A1:2008 (BSI, 2008) requirements for structural concrete aggregate.

(ii) High-strength concrete (target cube strength above 60 MPa): the low ACV and high UCS give confidence that the aggregate will not be the weak element in a high-stress concrete matrix, which is a necessary condition for achieving higher strength grades.

(iii) Flexible pavement at all structural levels, from wearing course to sub-base: the AIV of 18.4% and LAAV of 24.0% meet BS and ASTM requirements across the board.

(iv) Railway ballast, drainage blankets, and engineered fill: the bulk density and low water absorption values are appropriate for drainage performance and load carrying in geotechnical roles.

5.0 Conclusion

This investigation demonstrates that the physico-mechanical characteristics of Rukuba granitic rocks render them highly suitable for use as construction aggregates. The aggregate samples exhibit favourable

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properties including specific gravity of 2.65 ± 0.02, low water absorption (0.55 ± 0.11%), and appropriate bulk density (1615 ± 28 kg/m³, compacted). Engineering characterisation revealed ACV of 20.2 ± 1.2%, AIV of 18.4 ± 1.2%, LAAV of 24.0 ± 1.6%, and UCS of 162 ± 9 MPa.

All aggregate strength indices satisfy AASHTO, BS, and ASTM requirements for engineering construction, including structural concrete, high-strength concrete production, flexible pavement construction, and related applications.

Aggregates produced from Rukuba granitic rocks possess the necessary characteristics for pavement and concrete construction applications due to their low porosity (inferred from minimal water absorption) and high crushing resistance. This study characterises material from five spatially distributed sampling locations within the Rukuba quarry. While the sampled material satisfies international aggregate specifications, implementation of systematic quality control testing is recommended as quarrying operations progress to different benches, to ensure consistent aggregate quality for commercial production.

The findings will guide selection of high-strength aggregates for construction of durable infrastructure projects, providing valuable information for sustainable infrastructure development in Nigeria where reliable construction materials are essential.

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