APPRAISING THE ENGINEERING PROPERTIES OF GRANITE FROM SOME SELECTED LOCATIONS IN SOUTH WESTERN NIGERIA

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Abstract

The use of washed and unwashed gravel for concrete production is rapidly giving way to granite in the South Western Nigeria. Due to the perceived opinion that because ofitschemicalcomposition gravel cannot withstand as muchpressure as granite. This study examines the physical and mechanical properties of the various sizes of granite obtainable in selected locations of the region. Samples were collected from three different locations in each of the five states of the zone. The gradation, moisture content, specific gravity, water absorption, aggregate crushing, impact and abrasion values of collected samples were determined in the laboratory. The sieve analysis indicates that most of the samples were poorly graded. The moisture content, specific gravity and water absorption, of all the samples are between 5.65 – 8.0, 0.16% - 2.65% and 0.06 - 1.47% respectively. While the aggregate abrasion, crushing and impact values range from 21.3 - 47.63%, 2.12 – 16.58% and 11.3 – 36.1% respectively. The conclusion is that while the physical and mechanical properties indicate that most of samples are satisfactory, the poor grading requires that the various sizes be combined in required proportion to obtain the required grading.

Keywords: Appraising, Engineering, Properties, Granite, Selected Locations

Introduction

Concrete is a composite material of construction made up of cement, aggregates, and water. It is an essential component in the building and construction industry Omopariola and Jimoh (2019). According to Nduka et. al. (2018), 90% of story buildings in Nigeria are made from reinforced concrete. Salvador and Amusu 2021 opined that the type of aggregate to a great extent determines its ultimate strength. This was corroborated by Aginam, et. al. (2013), Chen and Liu, (2004) as well as Rao and Prasad (2002), reiterating that the influence of the properties and quality of aggregates such as their compressive strength and moisture content on the properties and quality of concrete. Balsubramanian (2017) further stated that concrete consists of about 60 to 85 percent of aggregates. Of this percentage, Coarse aggregate takes the largest chunk of about 55 to 60% depending on the mix ratio. This high percentage component of coarse aggregate will definitely have a great influence on the properties and quality of concrete.

Omopariola and Jimoh 2018, described granitic rocks as intrusive igneous rocks that are widely distributed in the earth's crust. It was further stated that granite is widely used in the construction industries as dimension stone, aggregates, etc. Its texture is described as grain and interlocking, while it is crystalline, fine to coarse-grained in structure. It is used in Civil Engineering construction such as roads, houses, bridges, paving monuments curbs, river walls, pedestals, piers, and dams. (Salati and Adeyemo 2021, Balsubramanian (2017). In commercial terms, granite is not limited to granitic stones but includes stones of other igneous, metamorphic or feldspathic crystalline rocks that possess similar qualities as granite Balsubramanian (2017).

In the opinion of Omopariola and Jimoh (2018), the use of washed and unwashed gravel for concrete production is rapidly giving way to granite. This can be due to the perceived opinion that because ofitschemicalcomposition gravel cannot withstand as muchpressure as granite (Bamigboye, et. al. 2016). Ramamurthy, 2010, Yadav and Anurag (2014) further stated that granite possesses high strength, abrasion resistance and very durable. Its choice as a preferred material of construction is due to its permanent color and durability, ease of maintenance and freedom from deterioration Balsubramanian (2017). Other properties that make it a choice material for building and Civil Engineering constructions includes its hardness, durability, high heat, stain and scratch resistance. Further justification for its suitability as a construction material is the possession of variety of physical and chemical characteristics (Naeem et. al. 2014)

However, Ramamurthy (2010) stated that the physical properties of granite vary considerably as a result of the variation in the properties of the parent rock from place to place. Yadav and Anurag 2014) stated that there are considerable variations in the physical properties of rock samples collected from different locations. These variations according to Ramamurthy (2010) aredependent upon a number of factors such as lithological, geological, and environmental factors as well as the mode of formation of the parent rock.

2.0 Methodology

This study evaluates the properties of granite used for concrete production in South Western Nigeria. It involves collection of granite samples from three different locations each in the five (5) states of South Western Nigeria. The five (5) states where samples were collected are Ekiti, Ogun, Ondo, Osun, and Oyo.

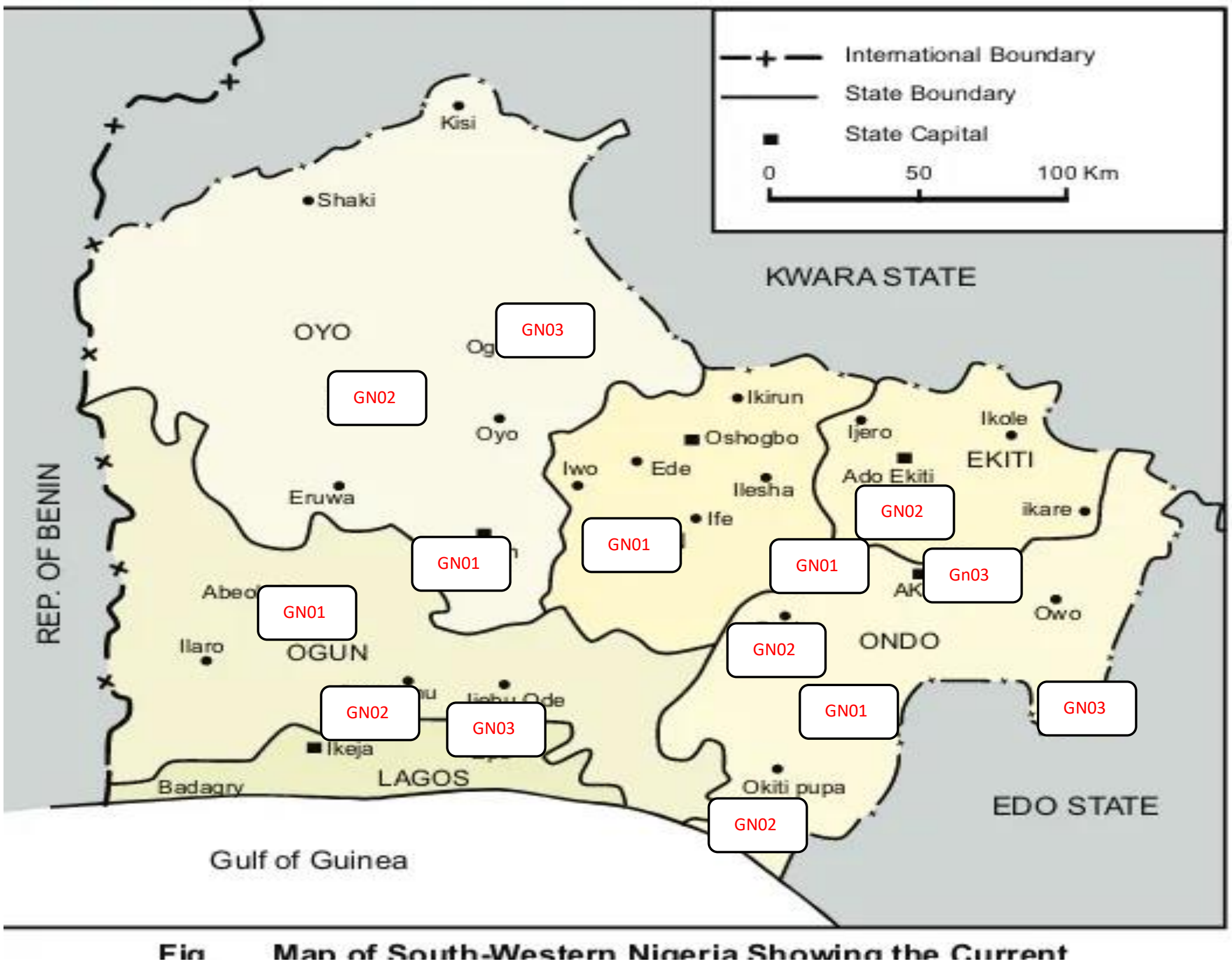


Figure 1 Map of Study Area showing the locations of collection of Granite samples
Source: https://1library.net/document/vwye40z7-yoruba-ye-mi.html

The collected samples were put in sacks and transported to the laboratory where various physical and mechanical properties of the samples were tested in accordance with laid down procedures in relevant codes of practice. Figure 1 is the map of South Western Nigeria indicating the locations where the samples were collected.

Sieve analysis was used to determine the gradation of the collected samples in accordance with BS EN 933 – 1: 1997. The values of the fineness modulus were determined from the table of the sieve analysis by dividing the cumulative percentage passing by 100. While the coefficient of uniformity and coefficient of curvature were obtained using equations 1 and 2 respectively.

The CU was calculated by the use of the formulae:

$$= \frac{D60}{D10} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where;
D60 and D10 are particle sizes.
While the coefficient of curvature (CC) was equally calculated using the formulae:

$$= \frac{(D30)^2}{D60 * D10} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where;

D60, D30 and D10 are particle sizes.

Laboratory tests on the moisture content, water absorption, and specific gravity were carried out in accordance with BS EN 1097 – 5:2000 and BS EN 1097 – 6:2000 respectively. Tests on the mechanical properties carried out are Aggregate Crushing Value, Aggregate Impact Value, and Aggregate Abrasion Values were also carried out in accordance with BS 812:110:1990, BS 112:1990, and BS 113:1990 respectively.

3.0 Results and Discussions

Most of the locations where granite samples were collected do not produce 9.5mm sizes. It is only in location 1 (Ibadan) and all the three locations in Ogun (Abeokuta, Ibara, and Ago Iwoye) where this size is available. 12.5mm are being produced in Itaogbolu and Owo in Ondo State, Ede, and Ipetu in Osun State as well as in all three locations (Abeokuta, Ibara, and Ago Iwoye) in Ogun State. Production of 19.5 mm granite is found in Ijero and Oye in Ekiti State, Abeokuta, Ishara, and Ago – Iwoye in Ogun State, Itaogbolu in Ondo State, Ede in Osun State as well as Ibadan and Iresa in Oyo State. The production of 25mm granite is found in Igede in Ekiti state, all three locations (Abeokuta, Ibara, and Ago Iwoye) in Ogun State, Ondo in Ondo State, Ede I Osun State, and all three locations (Ibadan, Iresa and Iseyin in Oyo State. The sieve analysis graph of the various sizes of granite produced is presented in Figures 2 – 5.

Gradation

Sieve Anaysis

Figure 2 reveals that the 9.5mm granite from all the locations in Ogun State are within the specified limits of BS EN 882:2004. While there is a considerable deviation from the specification in the sample from Ibadan in Oyo State. Figure 3 presents the graph of 12.5mm granite samples. From the graph it is seen that the percentage passing the 12.5 mm in all the samples collected are below that specified in the code. Only the sample from Itaogbolu is very close with 84% passing as against the required 85%. Other locations that did not deviate much are samples from Abeokuta, Ondo and Ede. All the samples have proportionate

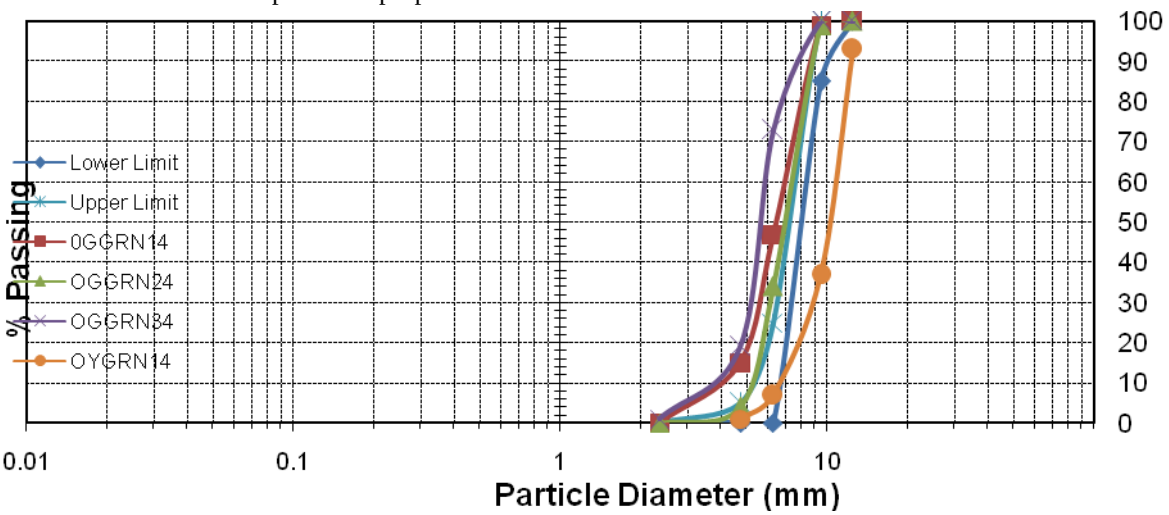


Figure 2 Sieve Analysis Curve of 9.5mm Granite

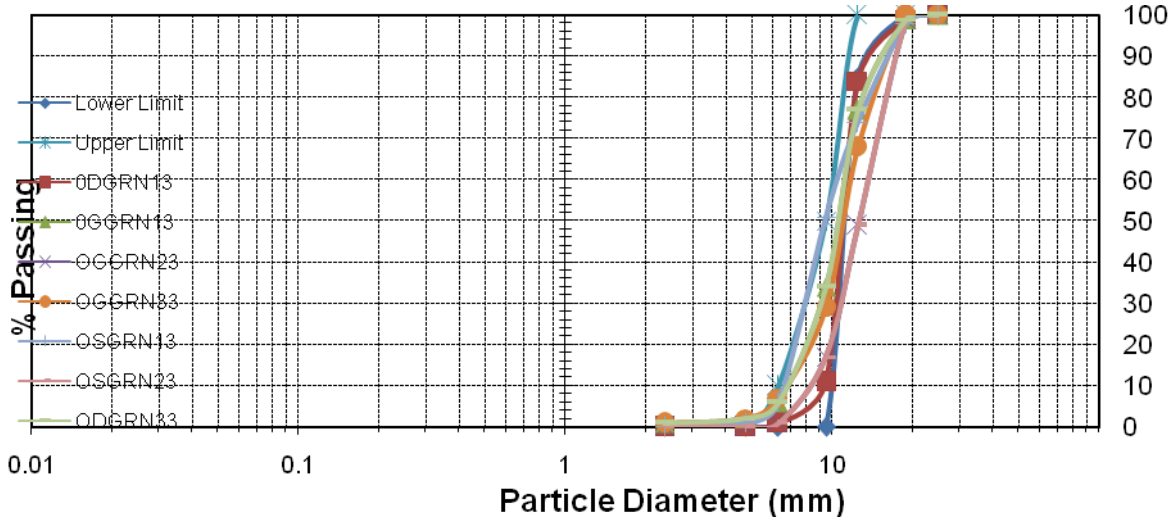


Figure 3 Sieve Analysis Curve of 12.5mm Granite

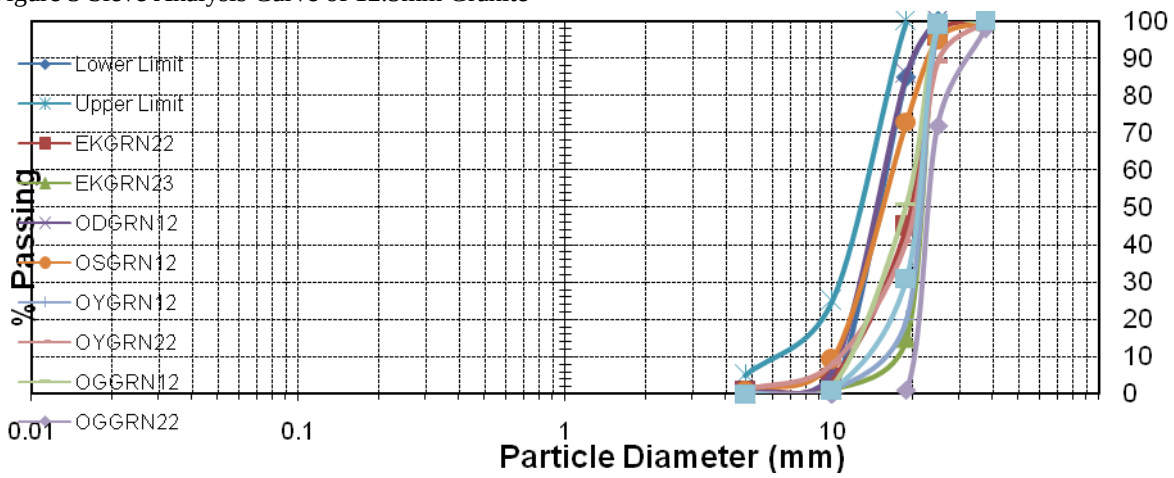


Figure 4. Sieve Analysis Curve of 19.5mm Granite

percentage passing in the lower sizes. As for the 19.5mm sizes presented in Figure 4, the percentage passing the 25mm sieve is very close to the required specification of 100% for all samples except that of Ishara and Iresa with 72% and 89% respectively. Only the sample from Itaogbolu with 86b % percentage passing the 19.5mm sieve is within the specified range of 85% - 100%. All others have lower values. Moreover, the percentage passing the lower sieve sizes of 12.5mm and 9.5mm are very low. This is an indication of gap-graded aggregate.

Although BS EN 882:2004 did not specify any range of value for 25mm aggregate, the result obtained from the sieve analysis as presented in Figure 5 shows that the predominant percentage of the sample for all locations except that of Iseyin in Oyo State are retained in sieve sizes of 19.5 mm and above. Less than 10% of the samples from these locations passes to the 12.5mm and virtually nothing is retained in the 9.5mm sieve sizes. This is also an indication that the aggregates are gap–graded.

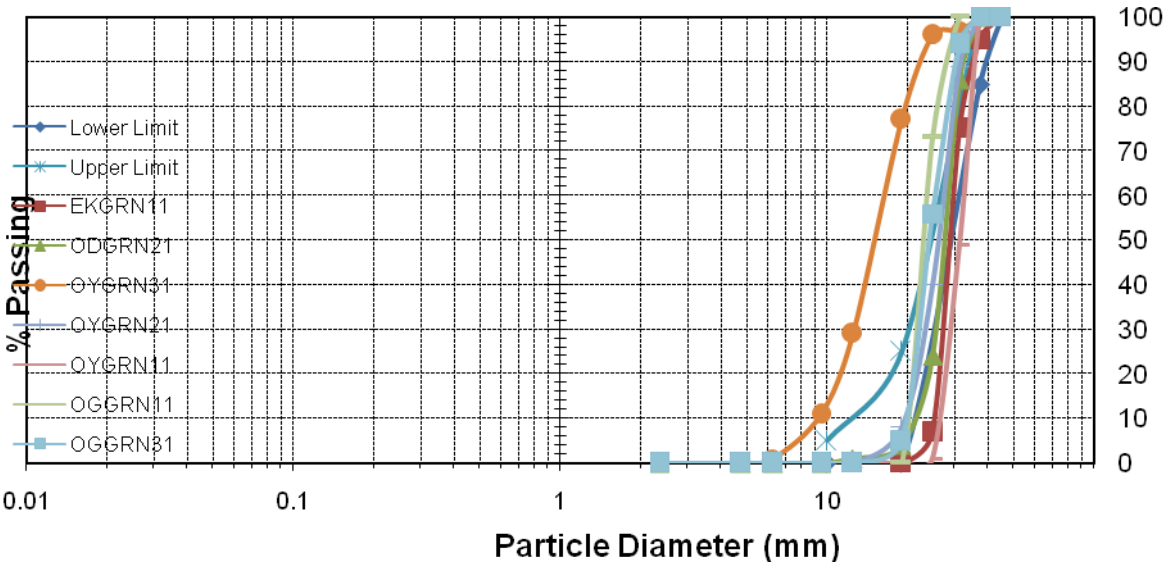


Figure 5. Sieve Analysis Curve of 25mm Granite

Fineness Modulus of Granite

The fineness modulus is an empirical value used in the determination of the mean particle size of aggregate samples. From Table 1, the value for all tested samples is between 5.86 and 8.05. This is in line with the assertion of Anupoju (2016) that the fineness modulus of coarse aggregate ranges from 5.5 to 8. In Neville and brooks (2010) it was stated that the fineness modulus is a parameter for ascertaining if there is slight variation in the gradation of aggregate grading from the same source. This is can be used to determine effect of this variation on workability of fresh concrete.

Table 1: Table of Values of Fineness Modulus of Granite, Coefficient of Uniformity and Coefficient of Curvature of Granite.

Sample Code	Fineness Modulus	Coefficient of Uniformity	Coefficient of Curvature		Sample Code	Fineness Modulus	Coefficient of Uniformity	Coefficient of Curvature
EKGRN11	8.05	1.23	0.94		ODGRN12	6.9	1.38	0.96
EKGRN22	7.84	1.33	0.96		ODGRN13	7.19	0.93	0.93
EKGRN32	7.55	1.22	1.01		ODGRN21	7.96	1.24	0.94
OGGRN11	5.9	1.15	1.05		ODGRN33	6.63	1.71	0.96
OGGRN12	6.92	1.36	0.96		OSGRN11	6.4	1.45	0.91
OGGRN13	7.2	1.71	0.96		OSGRN12	7.2	1.38	0.96
OGGRN14	7.95	1.75	0.89		OSGRN13	7.93	1.28	1.28
OGGRN21	5.86	1.2	1.01		OSGRN22	6.84	1.01	1.01
OGGRN22	6.1	1.45	0.96		OSGRN23	7.34	1.07	1.07
OGGRN23	7.2	1.44	1.08		OYGRN11	6.6	1.14	1.0
OGGRN24	7.95	1.6	0.9		OYGRN12	7.99	1.29	1.07
OGGRN31	5.8	1.35	1.01		OYGRN13	7.78	1.71	0.96
OGGRN32	6.5	1.45	1.09		OYGRN21	7.85	1.4	1.12
OGGRN33	7.95	1.86	1.1		OYGRN22	7.92	1.42	0.83
OGGRN34	7.68	1.5	1.04		OYGRN31	7.11	1.89	1.47

Coefficient of Uniformity and Coefficient of Curvature of Granite

The values of the result of the coefficient of uniformity and the coefficient of curvature as presented in Table 1 are in the range of 0.93 – 1.86 and 0.83 – 1.47 respectively. These two parameters are used in the determination of how well graded an aggregate sample is. According to Oritola et. al. (2014) the range of value of Cu must be greater than 4, while Cc should be between 1 and 3 for a well-graded coarse aggregate. Judging by these parameters, all the

granite samples tested in this study are not well graded since the value of the coefficient of uniformity for all of them is less than 4 and the value of the coefficient of curvature of most samples is less than 1.

Table 2: Table of Values of Specific Gravity, Water Absorption and Moisture Content.

Sample Code	Specific Gravity	Water Absorption	Moisture Content		Sample Code	Specific Gravity	Water Absorption	Moisture Content
EKGRN11	2.79	2.41	0.2		ODGRN12	2.83	1.38	0.96
EKGRN22	2.82	0.82	0.06		ODGRN13	2.85	0.93	0.93
EKGRN32	2.79	2.2	0.19		ODGRN21	2.83	1.24	0.94
OGGRN11	2.78	0.25	0.85		ODGRN33	2.8	1.71	0.96
OGGRN12	2.71	0.26	1.12		OSGRN11	2.79	1.45	0.91
OGGRN13	2.75	0.59	1.14		OSGRN12	2.72	1.38	0.96
OGGRN14	2.74	1.83	1.18		OSGRN13	2.7	1.28	1.28
OGGRN21	2.78	0.16	0.69		OSGRN22	2.78	1.01	1.01
OGGRN22	2.7	0.22	0.76		OSGRN23	2.81	1.07	1.07
OGGRN23	2.61	0.66	1.02		OYGRN11	2.84	1.14	1.0
OGGRN24	2.7	2.13	1.22		OYGRN12	2.78	1.29	1.07
OGGRN31	2.71	1.42	0.22		OYGRN13	2.72	1.71	0.96
OGGRN32	2.68	1.17	0.21		OYGRN21	2.76	1.4	1.12
OGGRN33	2.74	2.41	0.21		OYGRN22	2.77	1.42	0.83
OGGRN34	2.71	2.65	0.22		OYGRN31	2.76	1.89	1.47

Physical Properties of Granite

Specific Gravity of Granite

According to Patel (2019) the specific gravity of aggregate is an indication of the strength and quality of the aggregate. The result of the specific gravity of all the tested samples lies within the range of 2.61 and 2.85 as presented in Table 2. This is in line with the stated values of 2.5 to 3.0 (**Arumugam, 2014) and the minimum value of 2.6 in** BS EN 882:2004**. It then follows that all the samples are strong and** very suitable for use in concreting work.

Water Absorption of Granite

Results of the value of the water absorption of granite sample presented in Table 2 varies from 0.2% for 25mm in location one in Osun State to 2.65% for 9.5mm in location four. Samples for 25mm from location one in Ekiti State, 19mm from location three in Ogun State and location one in Osun State, 12.5mm in location one in Osun State and location three in Ogun State as well as 9.5mm from location one in Osun State and location two and three in Ogun State did not conform to specified value of 2% as stipulated in BS EN 882:2004. However, BS**8007:1987 specifies that aggregates should comply with either** BS EN 882:2004 **or BS 1047 and have an absorption value as measured in accordance with** BS EN 882:2004**, generally not greater than 3%. While some of the values are above the specified value in** BS EN 882:2004**, all the samples are in accordance with the specified value in BS 8007:1987.**

Moisture Content of Granite

The value of the moisture content of all the granite samples obtained from all locations in all the five states considered in the study as presented in Table 2 falls within the range of 0.06% and 1.47%. These values are well below the specified maximum value of 3% stated in BS 8007:1987. This implies that the moisture content of all the aggregates is satisfactory. They are thus suitable for concrete production.

Mechanical Properties

The results of the mechanical properties comprising Aggregate Abrasion, Aggregate Crushing Value, and Aggregate Impact Value of all the granite samples are presented in Table 3

Aggregate Abrasion Value of Granite

From the result presented in Table 3, the granite samples that conform to the 30% abrasion values are 25mm samples from location two in Ondo and location three in Ogun State, 19mm samples from location two in Ekiti State, 12.5mm samples from location three in Ogun State and 9.5mm samples from location three in Ogun State. These according to Shetty (2005) are suitable for use in concreting works for wearing surfaces. All others whose values are more than 30% but less than 45% State except 25mm samples from location three in Oyo State and 12.5mm samples from location three in Ondo State can be used for concreting works other than wearing surfaces. However, 25mm samples from location three in Oyo State and 12.5mm samples from location three in Ondo State whose values are more than 45% are not suitable for use for any concreting work.

Aggregate Crushing Value of Granite

In Table 3, the aggregate crushing value of all the granite samples in all the locations in all the five states considered in this study is within the range of 2.12% for 25mm sample in Ondo in Ondo State to 16.58% for 19.5mm sample in Oye in Ekiti State. In BS 882:1992, Shetty 2005, Neville and brooks, 2010 it was stated that a lower numerical aggregate crushing value indicates a very strong aggregate. Furthermore, Shetty (2005) stated that the crushing value of 30% is allowed for concreting works on road pavements while 45% is permitted for other structures.From the result presented, it can be inferred that all the samples collected are very strong and suitable for use as aggregates for concrete production going. The result also shows that the 25mm sample in Ondo in Ondo State is the strongest while the 19.5mm sample in Oye in Ekiti State is the weakest.

Aggregate Impact Value of Granite

The Aggregate Impact Value for all samples as presented in Table 3 ranges from 11.3% to 36.1 %. All the aggregate impact value of the sample from all locations in Ekiti, Ondo, Osun, Oyo, and locations one and two in Ogun State conforms to the specification of less than 30% stipulated in BS 882:1992. Only the 19mm granite samples from location two in Ogun State fail to conform to the specification in BS 882:1992. It follows that all the samples except 12.5mm granite samples from Ago-Iwoye in Ogun State are fit for use for concrete with wearing surfaces with respect to the Aggregate Impact Value because they have values that are less than the specified value of 35% Shetty (2005). However, the 12.5mm granite samples from Ago – Iwoye in Ogun State is fit for use for the production of concrete other than wearing surfaces since the AIV value is less than 45% as stated in Shetty (2005).

Table 2: Table of Values of Aggregate Abrasion Value, Aggregate Crushing Value and Aggregate Impact Value.

Sample Code	Aggregate Abrasion Value	Aggregate Crushing Value	Aggregate Impact Value		Sample Code	Aggregate Abrasion Value	Aggregate Crushing Value	Aggregate Impact Value
EKGRN11	33.2	3.77	22.5		ODGRN12	30.7	5.4	19.6
EKGRN22	25.4	5.31	18		ODGRN13	31.6	6	21.8
EKGRN32	40.08	16.58	28.7		ODGRN21	21.9	2.12	11.3
OGGRN11	33.2	7.82	20.43		ODGRN33	49.33	9.46	24.4
OGGRN12	36.6	8.9	22.47		OSGRN11	41.5	4.84	21.6
OGGRN13	35.6	9.4	23.51		OSGRN12	43.6	8.67	28.1
OGGRN14	34.3	11.1	26.21		OSGRN13	36.2	9.3	27.2
OGGRN21	38.7	6.7	17.86		OSGRN22	33.4	4.77	19.5
OGGRN22	34.6	7.5	18.32		OSGRN23	30.4	5.65	20.2
OGGRN23	35.03	8.4	19.06		OYGRN11	33.45	4.04	16.4
OGGRN24	40.6	9.2	21.01		OYGRN12	33.7	6.23	18.4
OGGRN31	33.9	3.06	18		OYGRN13	35.3	7.12	21.5
OGGRN32	36.1	3.48	36.1		OYGRN21	36.4	5.36	19.2
OGGRN33	42.1	4.14	26.6		OYGRN22	38.03	7.3	22.3
OGGRN34	37.5	4.65	21.9		OYGRN31	47.63	7.06	14.2

Conclusion and Recommendations

From the result of tests carried out on the collected samples of granite from all locations it can be concluded that all the samples are not well graded but gap graded. However, all the samples from all the locations comply with the specifications of BS EN 882:2004 as regards specific gravity, water absorption, moisture content, aggregate crushing value and aggregate impact value. Nonetheless, Aggregate Abrasion Value of some of the samples make them unfit for concreting work meant wearing surfaces but for concreting works other than wearing surfaces. It is therefore recommended that the various sizes be combined in appropriate proportions to make them well packed.

References

Anupoju 2016, https://theconstructor.org.finenessmodulus retrieved on 12/02/2022

Aginam C H, Chidolue C A and Nwakire C (2013), Investigating the effects of coarse aggregates types on the compressive strength of concrete *International Journal of Engineering Research and Applications* 3 (4) 1140–44

Arumugam., (2013) "Effect of Specific Gravity on Aggregate Varies the Weight of Concrete Cube "SSRG *International Journal of Civil Engineering (SSRG-IJCE)* – Volume 1 Issue3 August 2014, pp 1 – 8.

Bamigboye G. O., Ede A. N, Umana U. E., Odewumi T. O., and Olowu A. O., (2016) Assessment of Strength Characteristics of Concrete Made from Locally Sourced Gravel Aggregate from South-South Nigeria, *British Journal of Applied Science & Technology*, 12(5): pp 1-10, 2016,

Balsubramanian A. (2017), Properties Of Building Stones**,** Technical Report,Centre for Advanced Studies in Earth Science University of Mysore, Mysore-6 , August 2017

British Standard Institute, BS 812: Part 110, (1990). "Methods for Determination of Aggregates Crushing Value", British Standard Institution London.

British Standard Institute, BS 812: Part 112, (1990). Determination of Aggregates Impact Value", British Standard Institution London.

British Standard Institute, BS 812: Part 113, (1990). "Methods for Determination of Aggregates Abrasion Value", British Standard Institution London.

British Standard Institutes, BS 8007:1987, *Code of practice for the design of concrete structuresfor retaining aqueous liquids*

British Standard Institutes, BS EN 882:2004, *Specification for aggregates from natural sources forconcrete*

British Standard Institutes, *BS EN 933-1*:2012 Tests for geometrical properties of aggregates Determination of particle size distribution. Sieving method

British Standard Institu-+tes, BS EN 1097-6:2000, *Tests for mechanical and physical propertiesof aggregates. Determination of particle density and water absorption,*

British Standard Institu-+tes, BS EN 1097-6:2000, *Tests for mechanical and physical propertiesof aggregates. Determination of particle Water Content by Drying, in a Ventilated oven*

Chen, B, and Liu J, (2004), Construction and Building Materials. 18(8), pp 585 – 590.

Nduka DO, Fabgenle OI, Joshua O, Ogunde AO, Omuh IO (2018) ComparativeAnalysisofConcreteStrengthUtilizingQuarry-Crushedand Locally Sourced Coarse Aggregates. International Journal of Mechanical Engineering and Technology 9(1):609–617.

Naeem, M., Khalid, P., Sanaullah, M., &Zia ud Din. (2014). Physio- mechanical and aggregate properties of limestones from Pakistan. *Acta Ge- odaetica et Geophysica*, *49*(3), 369-380.

https://doi.org/10.1007/s40328-014-0054-8Accessed on 23/06/2022

Neville A. M. & Brooks J.J. Concrete Technology, 2nd edition. Prentice Hall 2010

Omopariola S.S., Jimoh A.A. 2018, Variation in the Physico-Mechanical Properties of Granitic Aggregates in Ogun State, Nigeria. NIJOTECH

Omopariola S. S., and Jimoh A. A, 2019, Optimized Aggregates Gradations for Concrete Mix Designs for Resilient Building ConstructionKano 19

Oritola Sikiru, Saleh Abd. Latif, Mohd Sam Abdul Rahman, Comparison of different forms of gravel as aggregate in concrete, Leonardo Electronic *Journal of Practices and Technologies* Issue 25, July-December, 2014 p. 135-144

Patel Hemali, https://gharpedia.com/blog/specific-gravity-of-coarse-aggregates-test/ Accessed 16/08/2022

Rao G.A. and Prasad B.K.R. (2002), Cement and Concrete 32(2) http://www.civil.iitm.ec.com. Accessed on 11/03/2018

Ramamurthy T.: Engineering in rocks for slope, foundations and tunnels, second ed., PHI Learning Pvt. Ltd., New Delhi, 2010.

Salati L K, Adeyemo J T, 2021, A study on the physical and mechanical properties of a granite outcrop for a quarry at Onikoko community, Oyo State, South-Western Nigeria, Mining of Mineral Deposits Volume 15 (2021), Issue 1, 27-34

Salvador K. A and Amusu O. R, Proportional Examination of Pf Mechanical Composition of Concrete Produced with Washed and Unwashed Gravel Current Trends in Civil & Structural Engineering, Volue 7 Issue 1 2021

Shetty M.S. ConcreteTechnologyTheory and PracticeS. Chand & Company Ltd. Ram Nagar, New

Delhi - 110 055, 2005

Yadav R. K. and Anurag A., (2014), A Study on Variation in Mineralogical and Strength Characteristics of Some Granitic Rocks, *International Journal of Engineering Research & Technology (IJERT)* Vol. 3 Issue 1, January – 2014