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A COMPARATIVE STUDY OF THE QUALITY OF VARIOUS ROAD AGGREGATE TYPES IN ABUJA, NIGERIA.

Mbaezue, N.D.[1], Ndububa, E.E. [2],Kolawole, O.S.[3], Aminu, A.E.[4]
1,2,3 (Department of Civil Engineering, University of Abuja, Nigeria)
E-mail:[1]donaz11@yahoo.com,
[2]emmanuel.ndububa@uniabuja.edu.ng,[3]saysampy@gmail.com,[4]aminosele1@gmail.com

Abstract

This study investigates the suitability of various aggregate types from the different rock forms available in the Federal Capital Territory (FCT) of Nigeria, Abuja for road construction. The aggregate samples were collected from two Area Councils viz: Abuja Municipal (AMAC) and Kuje Area Council. The precise locations were Kasada andWaru village in AMAC and Kuje town in Kuje Area Council. The Samples were tested for their Aggregate Crushing Value (ACV), Aggregate Impact Value (AIV), Los Angeles Abrasion (LAA), Water Absorption and Specific Gravities (WA & SG) in accordance with relevant testing Standards. The test results for Metamorphic, Sedimentary and Igneous rock samples respectively were ACV: 22.8%, 22.9%, 32%, AIV: 23.3%, 22.0%, 35%, LAA: 44.4%, 31.4%, 48%, WA:0.4%, 0.5% , 0.6% and SG: 2.7, 2.6, 2.7. Test results reveal that all the samples satisfy the respective standards. It was therefore concluded that, these different rocks are suitable as road construction aggregates since their physical and mechanical properties as tested meet the specifications in the relevant codes.

K**eywords: Crushing Value, Impact Value, Los Angeles Abrasion, Water Absorption**

1.0 Introduction

Aggregates form the prime materials used in pavement construction. They have to bear stresses occurring due to the wheel loads on the pavement. On the surface course they also have to resist wear due to abrasive action of traffic. They are used for the construction of both Portland Cement Concrete and Asphaltic Cement Concrete roads[1]. Therefore the properties of the road aggregates are of considerable significance to the highway engineer.

To ensure that construction aggregates are fit for the purpose and meet the requirements of the specifications, it is important to have an understanding of the geology of the parent rocks, the production processes, and standards as well as the appropriate test methods for the evaluation of their suitability.

Construction aggregates are defined as hard granular materials which are suitable for use in construction either alone or in combination of cement, lime or a bituminous binder [2].

There are three main types:

- Natural aggregates
- Manufactured aggregates
- Recycled aggregates [2, 3].

Natural Aggregates: this type of aggregate are obtained from mineral sources, often referred to as ‘primary aggregate

Manufactured Aggregates: are those ones derived from industrial processes as a by-product, often referred to as ‘secondary aggregate

Recycled Aggregates: this type of aggregates are recovered from material previously used in construction

The coarse aggregate when tested by the methods described in B.S 812 [9] shall have properties not exceeding the values shownin Table 1.

Table 1:Aggregate Specification for Dense Bitumen Macadam, Asphaltic Base and Wearing Courses

Pavement Course	Aggregate Crushing Value (%)	Water Absorption (%)
Dense Bitumen Macadam Base	30	1.5
Dense Bitumen Macadam Wearing Course		
Asphalt Concrete Base-Coarse	30	0.5
Asphalt concrete Wearing Course	30	0.5
	30	0.5

BS 812

The weight of the test sample for water absorption shall depend upon its average specific gravity and shall be as follows:

Table 2: Ranges In Specific Gravity

Range in Specific Gravity	***Weight of Samples (g)***
Over *2.8*	*5 500*
2.4 to 2.8	5000
2.2 to 2.39	*4 500*
Less than 2.2	4 000

Source: IS: 2384

Table 3: Aggregate Crushing Classifications

Exceptionally Strong Aggregates	< 10
Strong Aggregate	> 10 < 35
Weak Aggregates	> 35

Source: Principles and Practices of Highway Engineering

2. Methodology:

Abuja is a city found in Abuja Federal Capital Territory, **Nigeria**. It is located 9.057850 latitude and 7.495080 longitude and it is situated at elevation 476 meters above sea level. Abuja has a population of 776,298. It operates on the West African Time (WAT time zone). It has a **land** area of 8,000 square Kilometers. It is bounded on the north by Kaduna State, on the west by Niger State, on the east and south-east by Nasarawa State and on the south-west by Kogi State.

Aggregates samples were collected from three major site within two local government area of the state. It was collected from Waru village in AMAC Local Government area and Kasada village of Guabe province of Kuje Local Government Area.

The method used in carrying out this research work is laboratory tests.The laboratory test which includes the Aggregate Impact test, Aggregate Crushing Value test, Los Angeles Abrasion test, Specific Gravity and Water Absorption test.

The physical properties considered for laboratory tests are Aggregate Impact test, Aggregate Crushing Value test, Los Angeles Abrasion test, specific gravity and water absorption which was carried out in accordance with codes and standards. The following processeswas followed in calculating the test result to achieved the result for this comparative analysis.

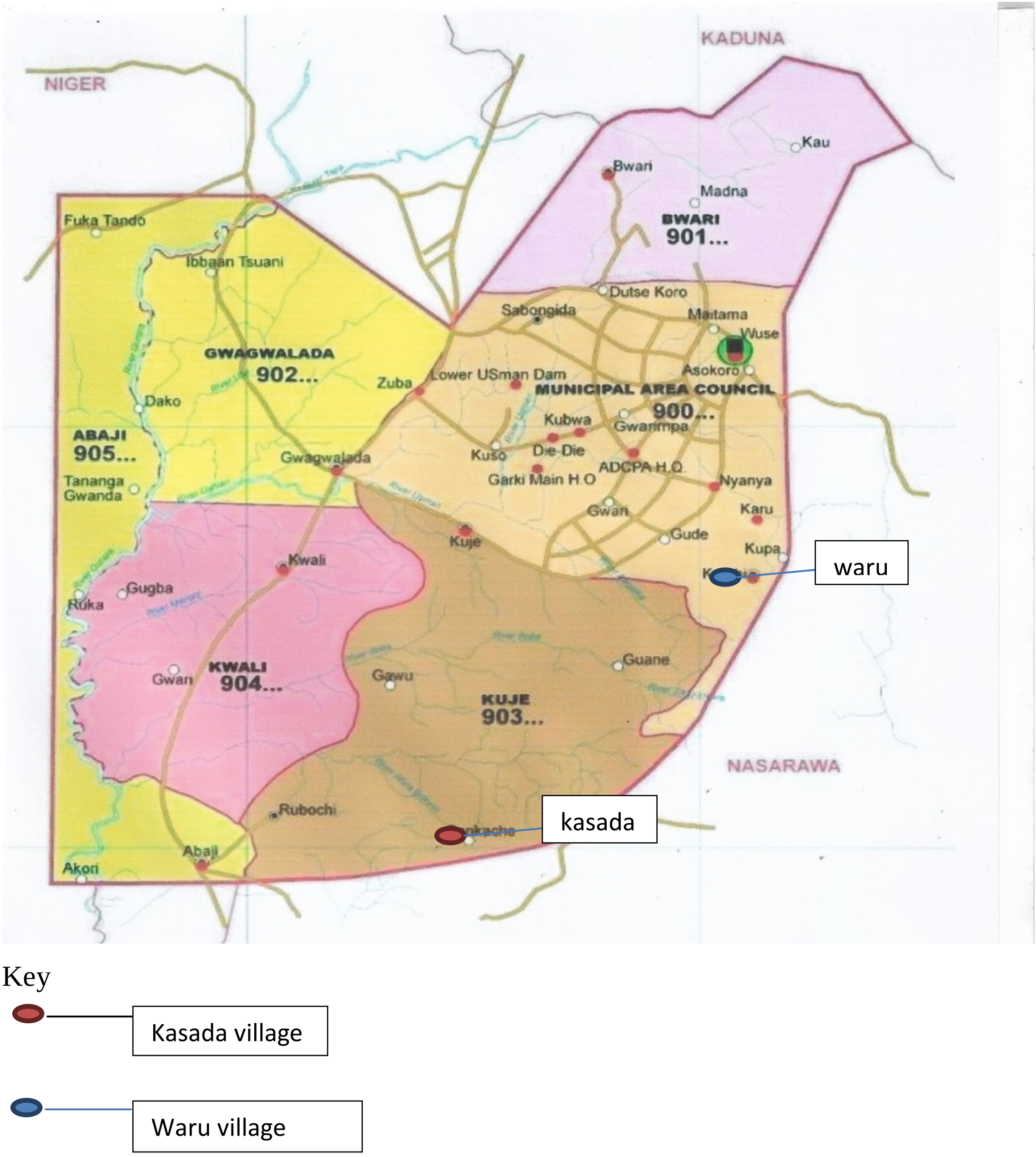

Fig 1: Map of Abuja (F.C.T.) Showing sampling locations

2.1. Aggregate Crushing Value

Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions. It is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements. Crushing value of aggregates indicates its strength. Lower crushing value is recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance.

Aggregate crushing value will be calculated as;

$$ACV=\frac{e}{c}\, x\, \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

Where; e= the weight of aggregate passing the sieve.

c= the weight of aggregate sample

2.2Aggregate Impact Value

The aggregate impact value gives a relative measure of the resistance of the aggregate tosudden shock or impact.

Aggregate Impact value will be calculated as;

$$AIV=\frac{z}{l}\, x\, \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

Where;z= the weight of aggregate passing the sieve

l= the weight of aggregate sample alone

2.3 Los Angeles Abrasion

The Los Angeles abrasion test measures the degradation of a coarse aggregate sample that is placed in a rotating drum with steel spheres

In Los Angeles Abrasion wear was calculated from

$$\text{Percentage Wear} = \frac{p1-p2}{p1}\, x\, \frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3$$

Where;

P1= Original material weight

P2=Final weight of material passing

2.4 Water Absorption and Specific Gravity

Apparent specific gravity is the ratio of the weight of dry aggregate to the weight of water having a volume equal to the solid volume of the aggregate excluding its permeable pores [4].

Bulk specific gravity is the ratio of the weight of dry aggregate to the weight of water having a volume equal to the volume of the aggregate including both its permeable and impermeable pores [4].

The water absorption is obtained fromformula 3.4 as follows:

$$WA = \frac{c}{a} x \frac{100}{1} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .3.4$$

Where, WA = Water Absorption.

and

c= b – a

a= weight of sample before soaking

b = weight of sample after soaking

c= weight of saturated sample in water

In like manner Specific Gravity is obtained from formulae 3.5 as follows;

$$SG = \frac{a}{b-c} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

Where SG = Specific gravity

a= weight of sample before soaking

b = weight of sample after soaking

c= weight of saturated sample in water

3.Results and Discussion:

In engineering analysis of road aggregate, both the physical and mechanical characteristics are necessary and backed up with standard for their design and construction. The above tables; (1, 2 & 3)in comparison with the summary test result will helped us arrives at a definite conclusion.

Table 4:Summary Table ForResults of Aggregate Crushing Value

Aggregate Crushing Value	**Metamorphic** Test result (gm)	**Sedimentary** Test result (gm)	**Igneous** Test result (gm)
Wt of mould assembled in grams A	12150	12150	12150
Wt of mouldassm + aggregates, in grams **B**	15660	15600	15397
Wt of aggregates, in grams **C**	3510	3450	3247
Wt of aggregates retained in **BS** sieve No 7 after crushing to 400 KN, in grams **D**	2710	2660	2220
Wt of aggregates passing **BS** sieve 7, in grams **=E**	800	790	1025
AggregatesCrushing value,% :	22.8%	22.9%	31.60

Aggregates Crushing value

Sedimentary= (E/C) X 100 = (790 /3450) x 100/1 = 22.9%

Metamorphic = (E/C) X 100 = (800 /3510) x 100/1 = 22.8%

Igneous = (E/C) X 100= (1025 /3247)x 100/1= 31.60%

Table 4.1 Result Summary:

	Metamorphic Test result (gm)	**Sedimentary** Test result (gm)	**Igneous** Test result (gm)
Aggregates Crushing value,% :	22.8%	22.9%	31.60%

From table 4 above, the weight of aggregate retained on the sieve No 7 after crushing and calculated with above discussed formula, the aggregate crushing value was 22.8 %, 22.9% and 31.6% which confirmed these materialssuitable as materials for road construction in accordance with the standards stated earlier.

Table 5: Summary Table for the Los Angeles Abrasion Test Value

LOS ANGELES ABRASION VALUE	**METAMORPHIC**	**SEDIMENTARY**	**IGNEOUS**
Description	**Test**	**Test**	**Test**
ORIGINAL WEIGHT**(P1)**	5000	5000	5000
WEIGHT RETAINED ON No 12 **–Final weight –(p2)**	2780	3430	2424
NO OF CHARGERS	12	12	12
% WEAR	44.4%	31.4%	48%

NOTE: a. preliminary separation:-sieve through sieve coarser than 1.7mm sieve (No 12).

b. sieve: the finer portion through sieve No 12 –material retained on sieve 12 is the final weight **(P2).**

Percentage Wear = $\frac{p1-p2}{p1}\ x\ \frac{100}{1}$

Metamorphic $= \frac{5000-2780}{5000}\ x\ \frac{100}{1} = 44.4\%$

Sedimentary $= \frac{5000-3430}{5000}\ x\ \frac{100}{1} = 31.4\%$

Igneous $= \frac{5000-2424}{5000}\ x\ \frac{100}{1} = 48.0\%$

Table 5.1: Summary Result

LOS ANGELES ABRASION VALUE	**METAMORPHIC**	**SEDIMENTARY**	**IGNEOUS**
% WEAR	44.4%	31.4%	48%

The result shows that, a sample weighed 5000g was subjected to 500 revolution with 12 chargers, the final aggregate retained on the sieve No 12 (1.7mm) was processed by the above stated formula, the percentage wear was calculated to be 44.4% , 31.4%, and 48% respectively which was fair according to the standard ASTHO T312,and suitable for road construction at different level, the metamorphic and igneous samples are best for the base course while the sedimentary type is suitable for bituminous course.

Los Angeles Abrasion value for base course, Maximum value of 40% is allowed,for Bituminous courses, Maximum of 30% to 35% is specified[3].

TABLE 7: Summary Table For Aggregate Impact Value Test

Aggregate Impact Test	Metamorphic Test result (gm)	Sedimentary Test result (gm)	Igneous Test result (gm)
Wt of mould assembly, in grams **A**	2927.0	2927.0	2927
Wt of mouldassy + aggregates, in grams **B**	3509.2	3595.0	3235
Wt of aggregates, in grams **L**	582.3	668	308
Wt of aggregates retained in **BS** sieve No 7 after loading with 15 blows of 13.5Kg (30lb) hammer falling thro' 375mm (15"), in grams **D**	439.3	525.3	203
Wt of aggregates passing **BS** sieve No 7, in grams **Z**	141.1	139.3	105.0
AggregatesImpact value,(%)	24.2	20.9	34.1
AVERAGE	23.3%	22.0%	35%

Metamorpic AIV= $\frac{z}{l} x \frac{100}{1} = \frac{141.1}{582.3} x \frac{100}{1} = 24.2\%$

SedimentaryAIV= $\frac{z}{l} x \frac{100}{1} = \frac{139.3}{668} x \frac{100}{1} = 20.9\%$

Igneous AIV= $\frac{z}{l} x \frac{100}{1} = \frac{105.0}{308} x \frac{100}{1}$ =34.1%

Result summary of AIV	Metamorphic Test result (gm)	Sedimentary Test result (gm)	Igneous Test result (gm)
AVERAGE Aggregate Value (%)	23.3%	22.0%	35%

Aggregate Impact value test is carry out mainly to determine the resistance of the aggregate to sudden shock or impact using 1/2″ aggregate size. The result shows that, the summary of the percentage weight of aggregate retained on the sieve No 7 after loading with 15 blows of 13.5kg hammer thro' 375mm (15") are 24.2%, 20.9%, 34.1% for metamorphic, sedimentary and igneous sample respectively, which shows that both metamorphic and sedimentary meet the criteria for surfacing and igneous sample satisfy the sub-based condition. According to the AASTHO T 312, this was also consideredsuitable for road construction.

For low aggregate, maximum of 50% aggregate impact value is allowed when used in sub-based course and 30% limit when used for surfacing.[3]

TABLE 8: Summary Table For The Water Absorption And Specific Gravity Test

Water Absorption and Specific Gravity Test		Metamorphic Test Result (19mm)	Sedimentary Test Result (19mm)	Igneous Test Result (19mm)
Wt before soaking	A	526.0	532.6	1005.1
Wt After soaking	B	527.9	535.1	1010.0
B-A =C	C	1.9	2.5	4.9
C / A(%)	D	0.36	0.47	0.49
	F	0.4%	0.5%	0.5%

ABSORPTION IN PERCENTAGE			
Bulk Specific Gravity (B.S.G)	2.689	2.564	2.711

In water absorption and bulk specific gravity test, the higher the specific gravity, the denser the rock and stronger the aggregate. [3]

With the result summary of this test, it shows that water absorption percentage is between 0.4% and 0.5% which actually show that it meet the criteria for the wearing course, as well as their specific gravity is of good record as it pass 2.5 abit.

CONCLUSION

The strength of the aggregates which were evaluated by a series of composite tests including Aggregate Impact Value (AIV), Los Angeles Abrasion Value (LAAV), Aggregate Crushing Value (ACV) and Water Absorption and Specific Gravity (WA & SG) was confirmed suitable for the construction of road.

REFERENCES

[1] British Geological Survey (2019).Construction Aggregates:Mineral Planning Factsheet.

[2] BarksdaleR.D. Pollard C.O., Siegel T., andMoeller S., Evaluation of the Effect of Aggregate on Rutting and Fatigue of Asphalt, Technical Report FHWA-AG-92-8812, Georgia Department of Transportation, Atlanta, 1992.

[3]KadyaliL.R. andLal N.B. Principles and Practices of Highway Engineering (including Expressways and Airport Engineering), Khanna Publishers Delhi-6.

[4]Baker RobertF. and ByrdL.G. Handbook of Highway Engineering,VanNostrandBeinHold Company, New York Cincinnat Toronto, London Melbourne.

[5]OguaraT. M. Highway Engineering, Pavement Design, Construction and maintenance.Mathouse Engineering Series.

[6]AASHTO T312, American Association of State Highway and Transportation Officials. Standard Method of Test for Preparing and Determining the Density of Asphalt Mixture Specimens by *Means* of the Super pave Gyratory Compactor.

[7]AASHTO T96: American Association of State Highway and Transportation Officials. Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine,

[8]ASTM C131: American standard for testing and materials. Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine,

[9]BS 812: British Standard. Specification Limits for Materials and Workmanship (F.M.W.)

[10]BS 882: British Standard. Specification for aggregates from natural sources for concrete,

[11 IS:2386 (Part IV): Indian Standard Methods of Test for Aggregates for Concrete (IS : *2386-1963*) *Part IV*.Methods of Test for Aggregates for Concrete.