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STRENGTH PERFORMANCE OF CONCRETE MADE WITH AGGREGATES MINED FROM IBIONO IBOM, AKWA IBOM STATE

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ABSTRACT

Purpose: This paper assesses the suitability of aggregate obtained from Use Ikot Amama and AfahaItiat both in Ibiono Ibom Local Government Area of Akwa Ibom State for concrete production. The paper also compared the evaluated engineering properties of these gravels with conventional granite from Akamkpa in Cross River State.

Design/methodology/approach: The study examined three samples of aggregates; two unwashed gravels from Use Ikot Amama and AfahaItiat both in Ibiono Ibom Local Government Area and crushed granite from Akamkpa in Cross River State. Concrete mix 1:2:4 with water to cement ratio of 0.55 was adopted and the specimens prepared tested up to curing age of 28 days. Particle size analysis, aggregate crushing value and Aggregate impact, water absorption, compressive strength and flexural strength tests were conducted on the concrete cube specimens. Concrete cube of 150mm were cast for each test and three specimens in each case were tested up to 28 days.

Findings: The results indicated the mean compressive strength of 24.07N/mm² for AfahaItiat follow by 19.56N/mm² for Use Ikot Amama compared to the crushed granite which gave 26.96N/mm² at 28days. It furthers indicated that AfahaItiat gravel has the highest Impact value while Use Ikot Amama had the highest crushing value.

Research limitations/Implications: The challenge facing the usages of these aggregates is adequate strength characterization.

Practical implications: The result of the study revealed that the minimum compressive strength from both Use Ikot Amama and AfahaItiat were greater the minimum limit of 17 N/mm² specified by ASTM 330 for lightweight concrete at 28days.

Originality/value: The study concluded that gravels obtain from AfahaItiat performed better and suitable for structural normal weight concrete applications.

Keywords: Gravels, Strength, Concrete, Coarse Aggregates

1. INTRODUCTION

Concrete is a composite material which is made up of cement, fine aggregate, coarse aggregate and water. The quality of concrete is influenced among others by the choice of coarse aggregate used in its production (Olajunoke and Lasisi, 2014). Aggregates occupies about 60-70% of total volume of concrete mix and add to the improvement of

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the concrete such as, workability of a fresh concrete, controls shrinkage, prevent cracks, stabilize the volume and minimise void (Alexander and Mindes, 2005; Bamigboye, et al., 2016a).

Economically, the material constituents' cost of concrete is highly influenced by the cost of the aggregates (Bamigboye, et al., 2016b, Shi et al., 2018) and therefore, the availability of aggregates is critical to the economical sustainability of concrete. The need for locally sourced and abundantly available coarse aggregate for concrete production is essentially a promising strategy in construction cost reduction.

Naturally occurring aggregates are abundant in many parts of Nigeria, for instance its vast deposit in Ile-Ife area of Osun state, are mined and used for concrete production (Olajumoke and Lasisi, 2014), vast deposit of gravel is available in some communities of Akwa Ibom State particularly in Use Ikot Amama, AfahaItiat in Ibiono Ibom Local Govt. Area and in some communities in Ini Local Govt. Area of the State. However, gravel deposits are characterized by some geographical and climatic characteristics of the locality (Poole and Sims, 2003).

2. Literature Review

2.1. Overview of gravels aggregate concrete.

Several studies have been conducted on the use of gravels as coarse aggregate in concrete. Tiwari et al., (2016) estimated gravels to make up one half of the total concrete coarse aggregates used in the North America. Bamibgoye et al., (2016) exploited the economic benefits of gravel as a substitute to granite in concrete production. Their study revealed that higher composition of gravel significantly improves compressive strength of concrete. Gideon et al., (2016), assessed the strength characteristic of concrete made from locally sourced gravel aggregate from south-south Nigeria and reported that the concrete made with washed gravel has the highest compressive strength than that of unwashed gravel at 5-20mm size. Aginsm, et al., (2013) studied the strength of concrete made from three different types of coarse aggregate namely, crushed granite, washed gravel and unwashed gravel at 20mm maximum size. They proposed that concrete made from crushed granite gives the highest value followed by concrete from washed gravel and then unwashed gravel which leads to the conclusion that the strength of concrete depends on the internal structure, surface nature and shape of aggregates. Sulymon, et al., (2017) posited that the sources of gravel mostly influenced the compressive, flexural and split-tensile strength of concrete. Jimoh and Awe (2007) conducted a test on two samples mix of quarry dust with granite of 20mm maximum, gravel of 28mm aggregate sizes and sand, they concluded that the use of quarry dust and granite of 20mm maximum size combined with gravel of 28mm aggregate size and sand improved the concrete strength by 34% over the strength of concrete. Nduka et al., (2018) comparative analysis of concrete strength utilizing quarry-crushed and locally Sourced coarse aggregates recommended sieving and washing of gavel aggregates prior to usage as well as further investigation on strength enhancement.

The challenge facing the usages of some locally sourced coarse aggregate like gravel is the strength characterization, as their sourced affects their strength properties (Sulymon et al., (2017). Many studies have been conducted on the use of locally sourced gravel in concrete from different part of Nigeria, but literature is scarce on the use of gravel from Use Ikot Amama and AfahaItiat in Ibiono Ibom hence this study.

3. MATERIALS AND METHODS

The gravel (coarse aggregate) used to produce the concrete was sourced from quarry sites (unwashed) at Use Ikot Amama (U) and AfahaItiat (A) both in Ibiono Ibom Local Government Area of Akwa Ibom State in Nigeria. These locations were selected due to the deposits of these stones in abundant quantities. The conventional granite (coarse aggregate) used for comparison was obtained from Akamkpa in Cross River State. Sharp sand was used as fine aggregate. The ordinary Portland cement (Dangote brand) conforming to BS EN 197-1 specification was used as the binder. Portable tap water fit conforming to BS EN 1008 specification was used in mixing and curing of the concrete. Preliminary investigation such as particle size distribution, aggregate crushing value and aggregate impact value were conducted on the coarse aggregate samples to ascertain their conformity to relevant standards. Mix proportion of 1:2:4 with 0.55 water to cement ratio by weight was adopted. The mixture was thoroughly mixed to a concrete of uniform consistency. The wet mixture was cast in 150mm cube mould in accordance with BS 1881: Part 108 (2011) and covered with jute bag. The specimens were demoulded after 24 hours and cured in water at a temperature of 28 degree Celsius and thereafter tested for water absorption and compressive strength at ages up to 28 days as per the provision of BS 12390-3(2009) while the flexural strength was obtained empirically from its compressive strength proposed in BS 8110 (1995) $Fr = 0.60 \sqrt{F_c}$. Where F_r = modulus of rapture (Flexural Strength) at 28days in N/mm^2. F_c = cubes compressive strength at 28days in N/mm^2.

4. PRESENTATIONAND DISCUSSION OF RESULTS

4.1. Particle Size Analysis

The result for granite, Use Ikot Amama and AfahaItiat gravels are shown in the particle size distribution curve in Figure 1 showing the grading relationship between the three samples. For granite 25.3% and 73.1% passed size16mm and 4.75mm respectively. Samples from Use Ikot Amama recorded 39% and 85.3% while AfahaItiat had 2% and 81% for 16mm and 4.75mm respectively. The particle size distribution curve in Figure 1 showed that the from Use Ikot Amama were very simple to the conventional granite grading while samples from AfahaItiat deviated from the grading trend. Similarly, the coefficient of curvature (Cc) and coefficient of uniformity (Cu) results for granite, Use Ikot Amama and AfahaItiat gravel were 9 and 3, 6 and 2.8, 4 and 2 respectively, indicating that the samples are generally uniformly graded satisfying BS EN 933-1(2012).

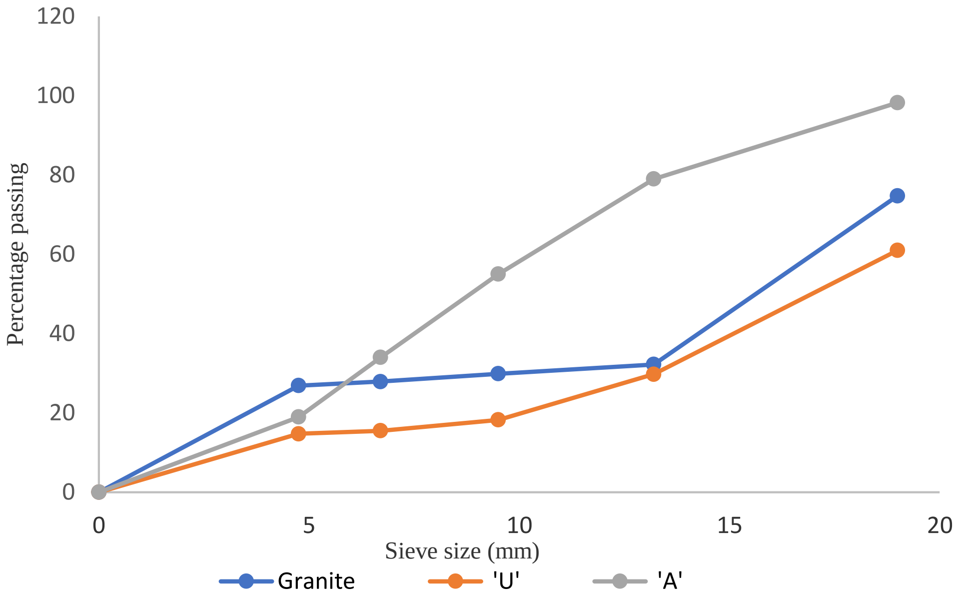

Figure 1: Particle size distribution curve

4.2. Aggregate Crushing Value (ACV)

Aggregate crushing value is expressed as a percentage of the original mass of the aggregate samples. The lower the value, the stronger the aggregate, that is greater the ability to resist crushing. From the result as shown in Figure 2, the study reveals that the ACV of samples obtained from Use Ikot Amama and AfahaItiat are within the permissible range for normal concrete, hence, they are suitable for concrete production. The value lies within maximum prescribed value of 45 % for normal concrete usage (BS 882-1992).

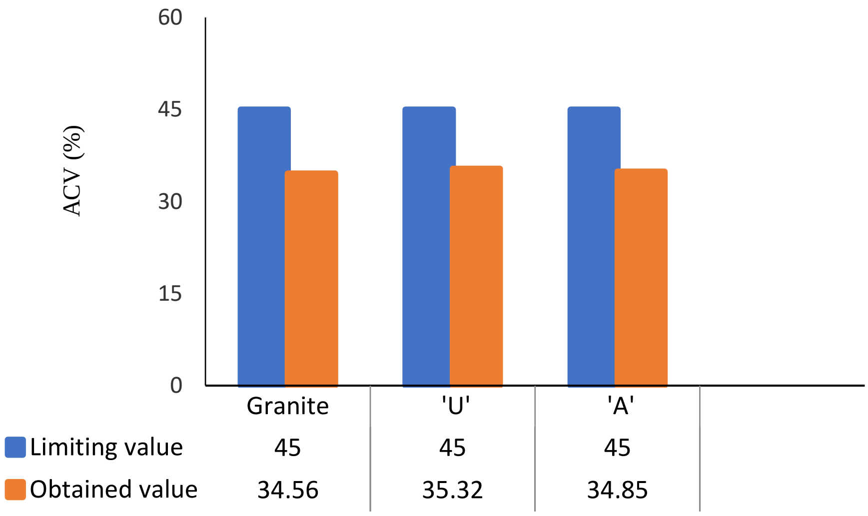

Figure 2: Aggregate crushing value chart

4.3. Aggregate Impact Value (AIV)

The Aggregate impact value obtained for all the samples passed marginal limits proposed by most standards with values less than the maximum 30% suitable for general purpose concrete works (ASTM: C33; BS 812-112) as shown in Figure 3.

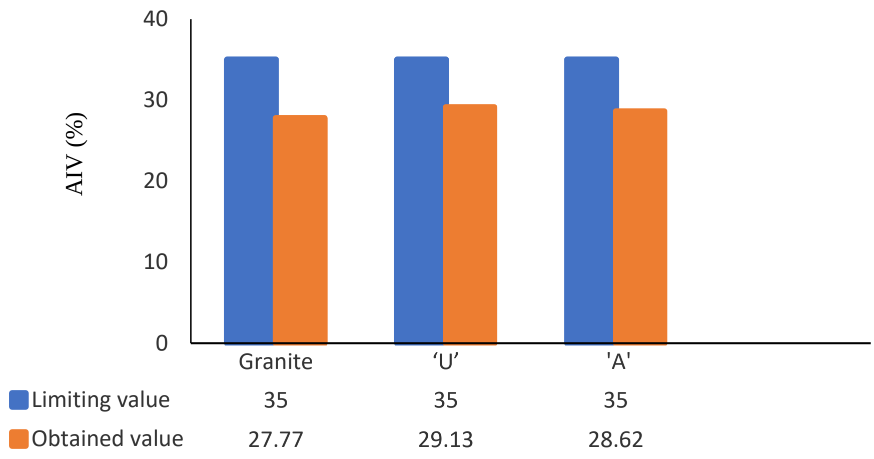

Figure 3: Aggregate impact value chart

4.4. Water Absorption

The results of mean water absorption of the concrete specimens produce with different coarse aggregates are presented in Table 1. The results indicated that Use Ikot Amama had the least percentage of water absorption while values obtained from AfahaItiat samples were very similar to conversional granite samples used as control in all curing ages. The increased water absorption observed with AfahaItiat samples are quite similar to the treads reported by Nduka et al, (2018). Generally, the values obtained were well lower than 10% proposed by Sulymon, et al, (2017) for a good concrete.

Table 1: Mean water absorption of concrete specimens

Days	Granite	'U'	'A'
7	3.03	1.27	3.73
14	5.78	2.70	5.87
28	8.05	6.33	8.46

4.5. Compressive Strength

The compression strength of the samples is shown in Figure 4. It can be observed that samples from AfahaItiat had the highest compressive strength after 28 days with 24.07 N/mm² followed by Use Ikot Amama with 19.56 N/mm². However, their respective compressive strengths are less than the control specimen's compressive strength of 26.96 N/mm² after 28 days. In all the samples the compressive strength trend increased with increase in curing age as observed by Raheem and Bamigboye (2013). since the differences is not much, it can be used in place of granite in some engineering works. The values obtained for both Use Ikot Amama and AfahaItiat samples were far greater than an average of 15.93N/mm^2 compressive strength for concrete made with unwashed gravel across southern regions in Nigeria by Nduka et al, (2018). Furthermore, these values were greater the minimum limit of 17 N/mm² specified by ASTM 330 for lightweight concrete at 28days, hence suitable for normal weight concrete applications.

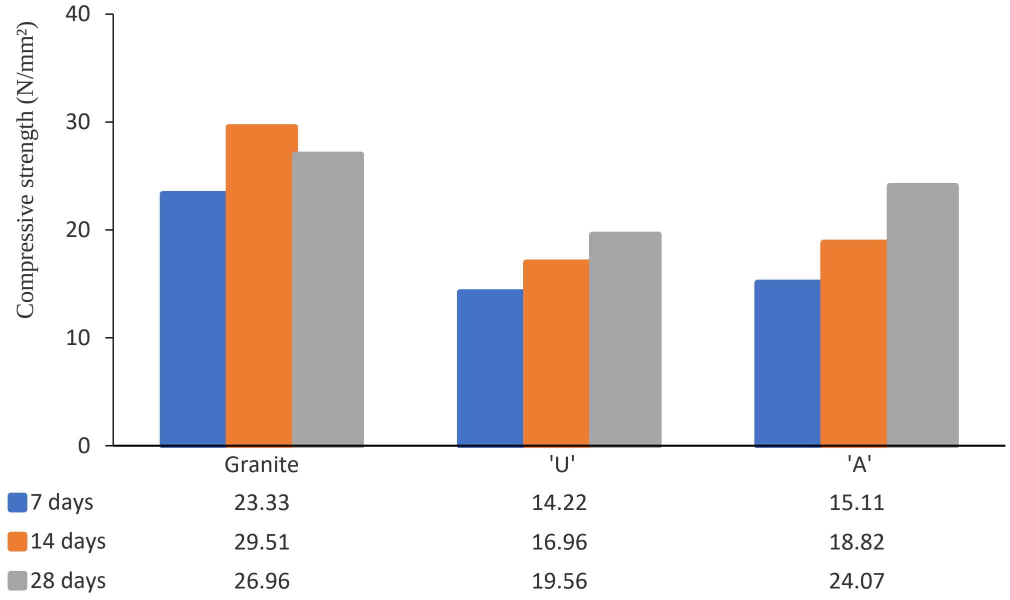

Figure 4: Compressive strength variation against the curing ages for each aggregate

4.6. Flexural Strength

The flexural strength of concrete produced with Granite, Use Ikot Amama and AfahaItiat gravel are shown in Table 2. It can be observed that the concrete with AfahaItiat gravel had a flexural strength value of 2.94 N/mm^2 at 28 days. The value obtained from Use Ikot Amama samples was 2.65 N/mm² just slightly lower than 2.67 N/mm² reported Olajunoke and Lasisi, (2014) for washed gravel. Generally, all fall within the permissible values flexural strength values reported by Sulymon, et al, (2017).

Table 2: Flexural strength of concrete at 28 days curing age

Sample	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)
Granite	26.96	3.12
'U'	19.56	2.65
'A'	24.07	2.94

5. CONCLUSION

This study assessed strength performance of concrete made using unwashed gravel as coarse aggregates sourced from Use Ikot Amama and AfahaItiat, both in Ibiono Ibom Local Government Area and compared the results with the conventional granite as control. The following conclusion was drawn from the study.

- The coefficient of curvature and uniformity from the sieve analysis showed that the aggregates are generally uniformly graded.
- The study reveals that the aggregate crushing value (ACV) of samples obtained from Use Ikot Amama and AfahaItiat are within the permissible range for normal concrete, hence, they are suitable for other normal weight concrete production.
- The Aggregate impact value (AIV) obtained for all the samples passed marginal limits proposed by most standards with values less than the maximum 30% suitable for general purpose concrete works.

- The results indicated that Use Ikot Amama samples had the least percentage of water absorption while values obtained from AfahaItiat samples were very similar to conversional granite samples used as control in all curing ages. It can be observed that samples from AfahaItiat had the highest compressive strength after 28 days with 24.07 N/mm² followed by Use Ikot Amama with 19.56 N/mm². these values were greater the minimum limit of 17 N/mm² specified by ASTM 330 for lightweight concrete at 28days, hence suitable for normal weight concrete applications.
- It can be observed that the concrete made with AfahaItiat gravel had the highest flexural strength of 2.94 N/mm² after 28 days.

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