
Comparative Study and Interrelationship of the Physical and Mechanical Properties of Coarse Aggregates Produced in Ogun State

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ABSTRACT

This study compares and investigates the relationship between the physical and mechanical properties of granites produced in some parts of Ogun State. Granite Samples were tested for their Specific Gravities, Water Absorptions, Moisture Contents, Aggregates Impact Value and Aggregates Crushing Value in accordance to the relevant standards. Test results were compared with relevant standards and with values from various sites. Regression analysis was used to further determine the relationship between the various properties. Results reveals that although all the samples conform to relevant codes and standards there were variations in test results from one location to the other and between the various sizes obtained from the same location. Statistical analysis reveals that there is significant positive correlation between Moisture Content and Water Absorption, no relationship between Specific Gravity and both Moisture Content and Water Absorption, while the relationship between Aggregate Crushing and Impact value is positive but not significant.

Keywords: Evaluation; physical; mechanical; properties; aggregates and standards.

1. INTRODUCTION

According to Shetty [1] aggregates are important constituents containing about 70-80 percent of the volume of concrete. It gives body and strength to the concrete, affects economy and undoubtedly has considerable impact on the properties of concrete. It is therefore very essential to know more about the aggregates which constitutes major volume in concrete so as to know more about concrete and its properties. While in their own opinion, [2] stated that aggregates take about three-quarter of the volume of concrete with the coarse aggregates taking between 50 and 60% of the concrete mix depending on the mix proportion used. Kumar et al. [3] support this assertion when it was stated by them that concrete's fresh and hardened state properties, mix proportions, and economy is strongly influenced by the properties of aggregates.

In [4] it was stated that the types, quality and general properties of aggregates determine the quality of concrete because concrete is made up of about seventy five percent of aggregates. While [1] opined that the properties of aggregates like toughness, hardness, shape, size, soundness, density, and specific gravity affect the strength of concrete. Zerdi [5], also lend credence to this by stating that the role of coarse aggregates in the development of strength in concrete is revealed in the high variation in strength between concrete and mortar of the same cement/aggregate proportion. In their own statement, [6] stated that the quality of the concrete is to a great extent determined by the quality of the coarse aggregates and therefore the compressive aggregate strength is an important factor in the selection of aggregate when considering the proportioning of constituent materials of concrete.

Aside from these, [7] as well as [8], opined that aggregate moisture content plays a part in concrete workability because if aggregates are too dry, they will absorb (steal) water from the mix. If

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aggregates are too wet, the excess moisture must be subtracted from the intended mix water quantity. [9] Highlighted some properties of aggregate to include bond, strength, toughness and hardness. According to [9], the compressive strength of concrete cannot significantly exceed the strength of the major part of the aggregate contained therein which can be determined from the crushing strength of aggregate itself prescribed by [10]. Neville and Brooks [9] Opined that the resistance of aggregate to failure by impact is referred to as the toughness and the value is obtained by determining the impact value (AIV) of bulk aggregate. The test is as described in [10].

2. METHODOLOGY

Fig. 1 is the map of the study area which is Ogun State in Nigeria. It is located between longitude 3°35'E and latitude 7°00'N with landmass of 16,980.55km² and a population of about 3,751,140.

Granite samples were procured from four different quarry sites spread across three of the four geopolitical zones of the state. The quarry sites are at Omologede along Abeokuta – Igboora road and Papa Adeosun along Abeokuta – Ibadan road in Abeokuta North Local Government Area and Odeda Local Government Area respectively, both in Egba geopolitical zone of the state. The two others are at Ishara in Remo North Local Government Area and Ago – Iwoye in Ijebu North Local Government Area in Remo and Ijebu geopolitical zones respectively.

The absence of quarry sites in Yewa/Awori geopolitical zone of the state was responsible for its exclusion.

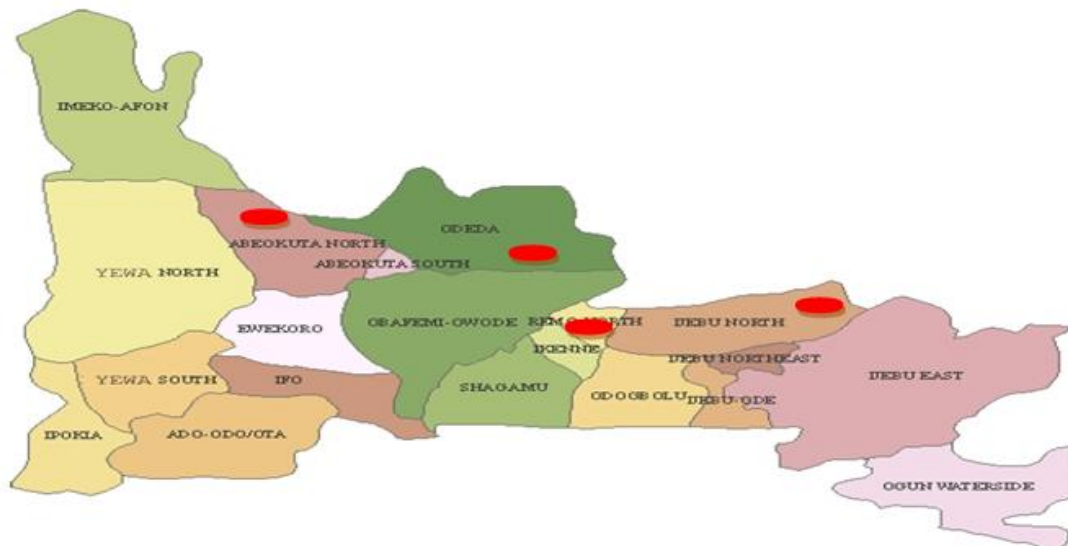


Fig. 1. Map of Ogun State indicating location of collection of samples
● Location of collection of samples

2.1 Determination of the Physical Properties of Granite

The physical properties considered for laboratory tests are specific gravity, water absorption and moisture content which was carried out in accordance with [10] and [11]. The specific gravity and absorption were then calculated using the equations 1 and 2 respectively, while the moisture content was evaluated using equation 3.

$$\text{The bulk specific gravity is } = \frac{A}{B-C} \tag{1}$$

$$\text{The percentage of absorption } = \frac{B-A}{A} \times 100\% \tag{2}$$

Where A is weight of oven-dry sample in air (g), B is weight of SSD sample in air (g) and C is the weight of SSD sample in water.

$$\text{Moisture Content (\% dry mass)} = \frac{(M_2 - M_3)}{(M_2 - M_1)} \times 100 \quad (3)$$

The result is reported to the nearest 0.1% of the dry weight.

2.2 Determination of the Mechanical Properties of Granite

While the mechanical properties tested are Aggregate Impact Value (AIV) evaluated in accordance with the specifications in [12] and Aggregate Crushing Value (ACV) evaluated in accordance with the specifications in [13].

$$\text{Percentage fines} = \frac{B \times 100}{A} \quad (4)$$

Where: A is the mass of surface-dry sample (g) and B is the mass of the fraction passing the 2.36 mm sieve (g).

2.3 Determination of the Interrelationship of the Physical and Mechanical Properties of Granite

The relationships between both the physical and mechanical properties of granite were determined using Statistical Package for Social Sciences software. The software was used to determine the correlation and regression between the Specific Gravity and Moisture Content, Specific Gravity and Water absorption, Water Absorption and Moisture Content, Aggregate Crushing Value and Aggregate Impact Value.

3. RESULTS AND DISCUSSION

The results and findings from the study are presented below.

3.1 Specific Gravity

Fig. 1 is the value of the specific gravity of all the different sizes of aggregates for all quarry sites. The values contained therein indicates that the specific gravity of all the different sizes of aggregates for all quarry sites are within the limits of 2.4 – 3.0 stated in literature [1,4,14] and [15]. The values are also above the minimum value specified in [10]. By comparison, aggregates from both Omologede and Ishara has the specific gravity of 2.78 which is the highest while that from Papa Adeosun has the least value of 2.63 for 9.5mm aggregates. In the case of 12.5mm, the highest value of 2.71 was recorded for aggregates from both Omologede and Papa Adeosun with that of Ago Iwoye recording the least value of 2.66. The highest value of 2.86 was obtained for aggregates from Ago Iwoye and the least value of 2.61 was obtained for Ishara for 19mm aggregates. For 25mm aggregates, aggregates from Omologede has the specific gravity of 2.74 which is the highest while that from Papa Adeosun has the least value of 2.68.

3.2 Moisture Content

As can be seen in Fig. 2, the moisture content for the different sizes of aggregates varies from one quarry site to another. While for 9.5mm aggregates, the aggregate from Omologede quarry site has the highest and that from Ago – Iwoye has the lowest. In the case of 12.5mm and 19mm aggregates, aggregates from Ago – Iwoye quarry site has the highest and that from Ishara has the lowest. For 25mm aggregates, aggregate from Papa Adeosun quarry site has the highest and that from Ago – Iwoye has the lowest. It can also be observed that the moisture content decreases as the aggregate size reduces for all the quarry sites except for that of Ago Iwoye where that of 12.5mm is higher than that of 9.5mm. However, the values of moisture content for all the coarse aggregate falls within the

limits stipulated in previous literatures. In [16] it was stated that the moisture content can range from less than one percent in gravel to up to 40 percent in very porous sandstone and expanded shale. The moisture content of all the aggregates obtained from the various quarry sites fall below the recommended value of 3% as specified in [17].

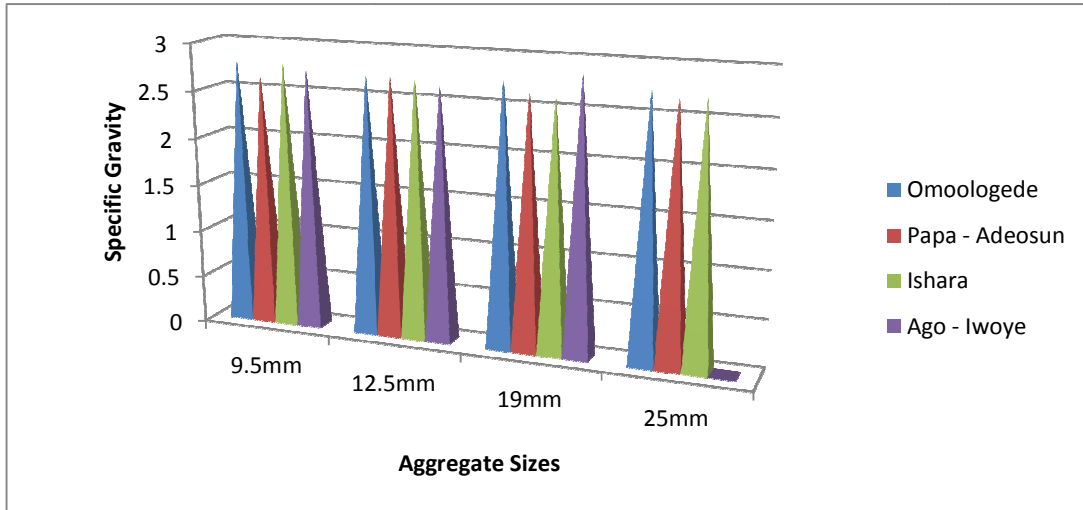


Fig. 2. Values of specific gravity of different aggregate sizes from various quarry sites

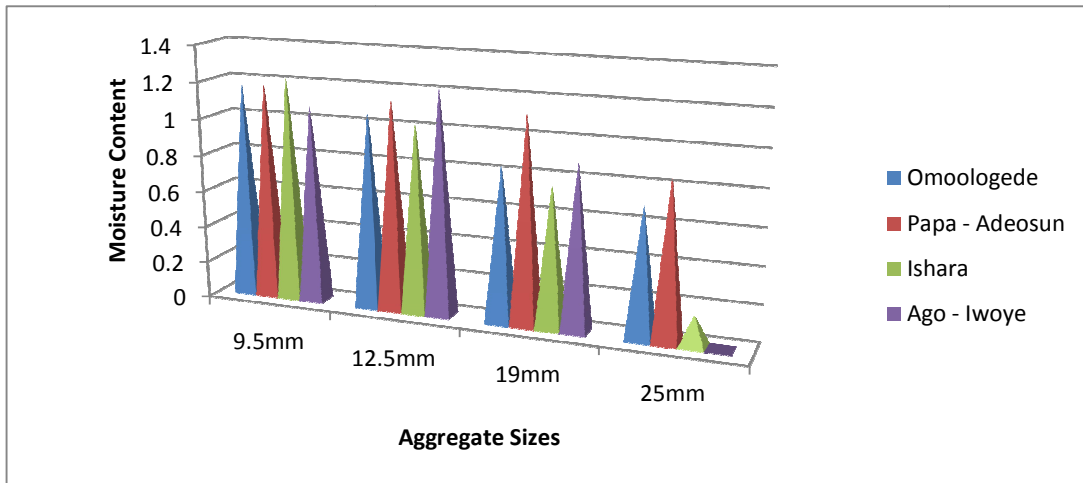


Fig. 3. Values of moisture content of different aggregate sizes from various quarry sites

3.3 Water Absorption

The values indicated in Fig. 3 indicates that the water absorption of all the different sizes of aggregates for all quarry sites are within the limits of 1%–3% stated in literature and British Standards [18,19,20,21] and [22]. It therefore follows that all the aggregates tested have very low water absorption values and hence are very suitable for concreting works. Comparatively, the aggregate from Ishara quarry site has the highest water absorption value and that from Omoologede has the lowest value for 9.5mm aggregate sizes. In the case of 12.5mm aggregates, that from Ago – Iwoye quarry site has the highest and that from Ishara has the lowest. For 25mm aggregates, aggregate from Papa Adeosun quarry site has the highest and that from Ago – Iwoye has the lowest.

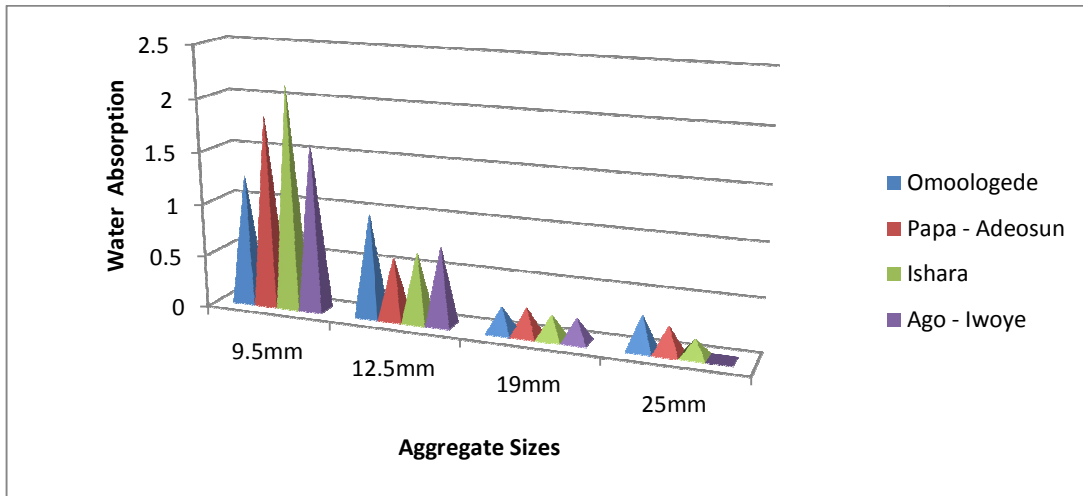


Fig. 4. Values of water absorption of different aggregate sizes from various quarry sites

3.4 Aggregate Impact Value and Aggregate Crushing Value

Values from Fig. 4 indicates that the Aggregates Impact Value of all the different sizes of aggregates for all quarry sites are lesser than 30% value stated in literature and British Standards [5,10] and specified in [6]. It therefore follows that Aggregates Impact Value of all the aggregates tested are very suitable for concreting works.

As for the Aggregate Crushing Value, all the different sizes of aggregates for all quarry sites has values that are lesser than 35% value allowed for concreting works as stated in literature [10]. The average value of the Aggregate Crushing Value for the coarse aggregates samples considered in this research is between 6.2% and 9.45%. This is considerably lower than stated values in literature therefore, it can be said that the aggregates has a considerable lower value and is therefore very suitable for concreting work. By way of comparison, aggregate from Ago Iwoye has the highest values of 28.12% and 9.45% for impact and crushing values respectively. While aggregate from Ishara has the least value of 18.12% for impact value and that from Omologede has the least crushing value of 6.21%.

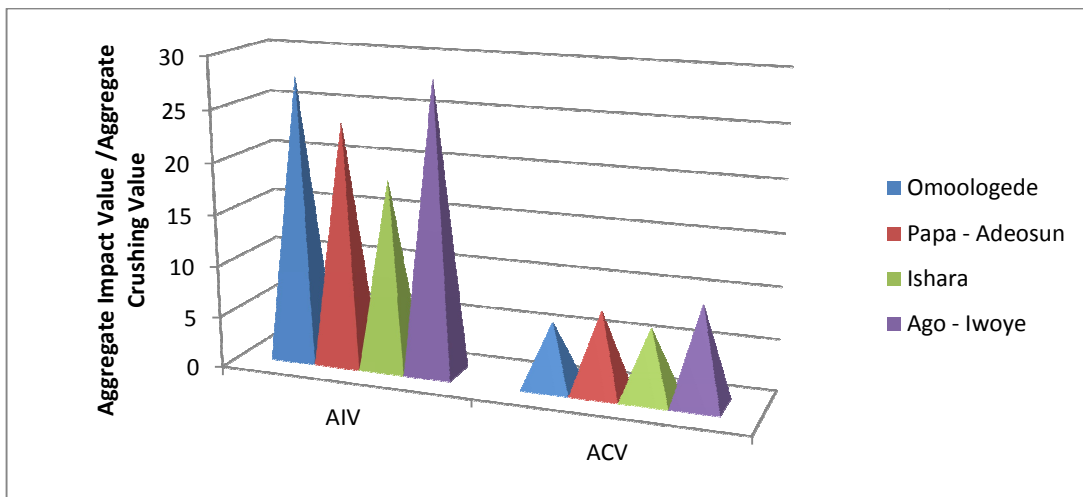


Fig. 5. Values of aggregate impact value and aggregate crushing value of different aggregate sizes from various quarry sites

3.5 Result of the Statistical Analysis

The correlation between moisture content and water absorption was both positive and significant with correlation value of $r = 0.608$. however, the adjusted r squared is low at 0.32 an indication that the repressor might not be good at predicting the values of the variables in the sample and the fit of data points might not be perfect [23]. However the regression equation obtained is

$$Y=0.6+1.42x \tag{5}$$

For the relationship between Specific Gravity and Water Absorption, both the correlation coefficient r and the adjusted r squared are very low at 0.083 and 0.070 respectively. This implies that there is no relationship between the two parameters. Nevertheless, the obtained regression equation is

$$Y=1.48+0.83x \tag{6}$$

There is also no relationship between Specific Gravity and Moisture Content as the value of both the correlation coefficient r and the adjusted r squared is 0 although the regression equation is

$$Y = 2.71+1.04x \tag{7}$$

The mechanical properties examined in the study are the aggregate Crushing Value and the Aggregate Impact Value. Statistical analysis reveals that there is an insignificant but positive correlation with r value of 0.359 and r squared value of 0.262 and regression equation of

$$Y=14.89+1.26x \tag{8}$$

4. CONCLUSION

It can be concluded from the results obtained that there are variations in both the physical and mechanical properties of aggregates varies considerably from location to location. It was also concluded that there are variations between the various sizes of aggregates at each quarry site also varies.

5. RECOMMENDATIONS

It is therefore recommended that since the physical and mechanical properties are in conformity with relevant codes and standards, they are suitable for use in concrete work. However for optimum characteristic strength, the various sizes should be combined in appropriate proportions to conform to grading requirements in relevant codes and standards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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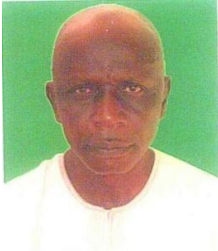


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