ISSN 2229-5518

An Evaluation of the Physical and Mechanical Properties of Coarse Aggregates Produced in Ogun State, Nigeria.

[1]Omopariola S.S., [2]Dr Jimoh A.A.

Abstract— Coarse aggregate has been said to have strong influence on the properties, mix proportion and economy of fresh and hardened concrete. Personal on-site experience reveals that single size aggregates produced in some parts of Ogun State do not conform to grading requirements specified in [1]. This prompted the desire to investigate the compliance of the physical and mechanical properties of the aggregates to relevant standards. Samples of 9.5mm, 12.5mm, 19mm and 25mm aggregates were collected from four different quarry sites spread across the state. The 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 reveals that all the samples conform to [2], [3], [4] and [5] respectively. It was therefore concluded that although the aggregates do not conform to grading specification in [1], but the physical and mechanical properties of all the aggregates tested meets the specified requirement in [2], [3], [4] and [5].

Keywords: Evaluation, Physical, Mechanical, Properties, Aggregates.

———————— ◆ ————————

1 Introduction

Concrete has been defined as versatile engineering material which consists of cementing substance, aggregates, water and some amount of entrained air [6]. It was affirmed to be the most important building material that plays a part in all building structures concrete whose properties includes its versatility, durability, fire resistance and capability of being moulded to take up the shapes required for the various structural forms, when the correct specification and construction procedures are adhered to [7]. In [8], 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.

[9] opined that between 70 and 80 per cent of the volume of concrete is occupied by aggregates. Consequently, it should be expected to exercise profound influences on concrete properties and performance. [10] were of the opinion that aggregates strongly influence concrete's fresh and hardened state properties, mix proportions, and economy. According to [11] the properties of aggregates like toughness, hardness, shape, size, soundness, density, and specific gravity affect the strength of concrete. [9] highlighted the role that aggregates plays in concrete as including provision of necessary property of volumetric stability of concrete, exercise of important influence on concrete strength and stiffness, provision of rigidity and durability.

2 METHODOLOGY

The Study area is Ogun State in Nigeria. It is located between longitude 3°35′E and latitude $7^0$00′N with landmass of 16,980.55km^2 and a population of about 3,751,140 (see figure 1). The procurement of granite was made from four different quarry sites spread across three of the four geopolitical zones of the state. The quarry sites are at Omoologede 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.

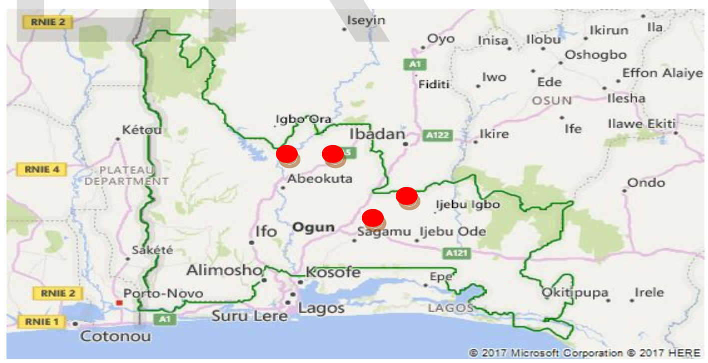

Figure.1: Map of Ogun State Indicating Location of collection of samples

Location of collection of samples

2.1 Specific Gravity and Water Absorption Test

The sample used for the test was thoroughly washed to remove dust or other coatings from the surface of particles and dried to constant weight at about 110^o C, cool in air at room temperature for about 3 hours. The sample was then immersed in water for 24hours. It was then removed from water and rolled on a large absorbent cloth until all visible films of water are removed, although the surfaces of particles still appear to be damp. The larger fragments were carefully wiped individually to avoid evaporation during the drying

- 1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail: hfeforchrist@yahoo.com
- 2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail: alaojimoh4real@yahoo.com

operation. The sample in the saturated surface-dry (SSD) condition was weighed to the nearest 0.5g and immediately placed in the wire basket to determine the weight in water. The container was thoroughly shaken while it was immersed so as to remove all entrapped air before it was weighed. The sample was again oven dried to a constant weight at a temperature of 110°C and allowed to cool to the room temperature after which it was again weighed to the nearest 0.5 g. The specific gravity and absorption were then calculated as follows:

The bulk specific gravity is $= \frac{A}{B-C}$.. (1)

The percentage of absorption $= \frac{B-A}{A} \times 100\%$.........................(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.

2.2 Moisture Content Test

The moisture content of the coarse aggregate was done in accordance with the specifications in [12]. A container plus lid was weighed to the nearest 0.1g and the weight was recorded on the test sheet as (mass M_1). The sample was then placed in the container and the container with the sample was then weighed to the nearest 0.1g. The weight was recorded on the test sheet as (mass M_2). The container and the sample and lid were then placed in the oven to be dried at a temperature of 105+/-5°C for a period of 24 hours. After this, they were removed from the oven and allowed to cool for about 1hour after which they were weighed to the nearest 0.1g and the weight obtained was recorded on the test sheet as (mass M_3). The moisture content was calculated from the formulae:

Moisture Content (% dry mass) = $\frac{(M2-M3)}{(M2-M1)} \times 100$....................(3)

Where, M_1 = weight of empty container, M_2 = weight of container + sample and M_3 = weight of container + oven dry sample. The result is reported to the nearest 0.1% of the dry weight.

2.3 Aggregate Impact Value (AIV)

Aggregate Impact Value was obtained in accordance with the specifications in [4]. The material for the standard test consists of aggregate passing a 12.5 mm sieve and retained on a 10.0 mm sieve. The sample was surface dried for a period about 4 hours at a temperature not exceeding 110°C. The material was then allowed to cool down to room temperature before the test was carried out. Thereafter, the cylindrical measure was filled up in about three equal layers with each layer tamped 25 times with rounded end of the tamping rod. The net weight of the aggregates in the measure was determined to the nearest gram and this weight of the aggregates was used for carrying out duplicate test on the same material.

The bottom plate of impact machine was placed flat on the floor so that the hammer guide columns can be positioned vertically. The cup was fixed firmly in position on the base of the machine and the whole of the test sample from the cylindrical measure was transferred to the cup and compacted by tamping with 25 strokes. The hammer was raised until its lower face was 38 cm above the upper surface of the aggregates in the cup, and allowed to fall freely on the aggregates. This was repeated for 15 times with each time being delivered at an interval of not less than one second. The crushed aggregate from the cup was poured into 2.36 mm sieve until no further significant amount passes through. The fraction of the crushed aggregates passing the sieve was weighed to a degree of 0.1g accuracy and the retained fraction of the crushed aggregates on the sieve was also weighed.

2.4 Aggregate Crushing Value (ACV)

The material for the standard test consists of aggregate passing a 12.5mm sieve and retained on a 10.0 mm sieve. The aggregate sample was first oven dried at a temperature of about 110°C after which it was allowed to cool down to room temperature before the test was carried out. The depth of the material in the cylinder was 100mm for one test after tamping which was obtained by filling the cylindrical measure in three layers of approximately equal depth, with each layer being tamped 25 times from a height of approximately 50 mm above the surface of the aggregate with the rounded edge of the tamping rod and finally levelled off with the aid of the tamping rod. The mass of material of the test sample was determined and recorded as mass A.

The cylinder of the test apparatus was then placed on the base plate and the test sample was added in three layers and each layer was subjected to 25 evenly distributed strokes from the tamping rod dropping from a height of approximately 50 mm above the surface of the aggregate. The surface of the aggregate was carefully levelled and the plunger was inserted so that it rests horizontally on this surface. Adequate care was taken to ensure that the plunger does not jam in the cylinder. The apparatus was then placed with the test sample and plunger in position, between the platens of the testing machine after which the machine was loaded at a uniform rate as possible so that the required force 400 KN is reached in 10min. The load was then released and the crushed material was removed by holding the cylinder over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray.

The fine particles adhering to the inside of the cylinder was transferred to the base plate and the underside of the plunger to the tray by means of a stiff bristle brush. The whole of the sample on the tray was then sieved on the 2.36 mm sieve until no further significant amount passes in 1 min. The weight of the fraction passing the sieve was then recorded as mass B. The whole procedure was thereafter repeated, starting from testing, using a second sample of the same mass as the first sample. The ratio of the mass of fines formed to the total mass of the sample in each test was then expressed as a percentage and the result was recorded to the first decimal place

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

- 1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail: hfeforchrist@yahoo.com
- 2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail: alaojimoh4real@yahoo.com

ISSN 2229-5518

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).

2.4 Analysis of Result Using ANOVA Method

The one-way ANOVA was used to analyse the variance of the results of the Aggregate's Impact and the Aggregate's Crushing value of aggregates obtained from all the quarry sites because only one factor was under consideration. The differences within that factor were determined by using the technique which involves the following steps as stated in [13]:

(i) The mean of each sample $\bar{x}_1, \bar{x}_2, \bar{x}_3, \ldots\ldots\ldots\ldots \bar{x}_n$ were obtained when there are k samples

(ii) The mean of the sample means were also calculated using equation (5)

$$\bar{\bar{x}} = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3 + \ldots\ldots\ldots\ldots \bar{x}_n}{No\ of\ samples\ (k)} \ldots\ldots\ldots\ldots (5)$$

(iii) The sum of squares for variance between the samples (or *SS* between) were obtained by taking the deviations of the sample means from the mean of the sample means and the square of such deviations were calculated and multiplied by the number of items in the corresponding sample after which their total were obtained using the following equation (6):

$$SS\ between = n_1(\bar{x}_1 - \bar{\bar{x}})^2 + n_2(\bar{x}_2 - \bar{\bar{x}})^2 + n_k(\bar{x}_k - \bar{\bar{x}})^2 \ldots\ldots\ldots\ldots (7)$$

(iv) The result obtained from step (iii) above was then divided by the degrees of freedom between the samples to obtain variance or mean square (*MS*) between samples using equation (8) below:

$$MS\ between = \frac{SS\ between}{(K-1)} \ldots\ldots\ldots\ldots (8)$$

(v) The sum of squares for variance within samples (or *SS* within) was obtained by summing up the squares of the deviations of the values of the sample items for all the samples from corresponding means of the samples using equation (9)

$$SS\ within = \sum(X_{1i} - \bar{X}_1)^2 + \sum(X_{2i} - \bar{X}_2)^2 + \ldots + \sum(X_{2i} - \bar{X}_k)^2 \ldots..(9)$$

$i = 1,2,3\ldots\ldots\ldots$

(vi) The result obtained from step (v) was then divided by the degrees of freedom within samples to obtain the variance or mean square (*MS*) within samples from equation (10)

$$MS\ within = \frac{SS\ within}{(n-k)} \ldots\ldots\ldots\ldots (10)$$

where (n – k) represents degrees of freedom within samples,

n = total number of items in all the samples i.e., $n_1 + n_2 + \ldots + n_k$ ……………(11)

k = number of samples.

(vii) The sum of squares of deviations for total variance equal to the total of the results obtained from steps (iii) and (v) above i.e., SS for total variance = *SS* between + *SS* within. This was calculated using equation

$$SS\ for\ total\ variance = \sum(X_{ij} - \bar{\bar{X}} \ldots\ldots\ldots\ldots (12)$$

$i = 1, 2, 3 \ldots\ldots\ldots;\quad j = 1, 2, 3 \ldots\ldots\ldots$

(viii) Finally, *F* – ratio was worked out from equation as follows:

$$F - ratio = \frac{MS\ between}{MS\ within} \ldots\ldots\ldots\ldots (13)$$

Then a table of analysis of variance was set up as in Table 4.31 and 4.32. By comparing the calculated F – ratio with the critical values of F-distribution (at 5 per cent) obtained from Appendix 4a [12] judgment of whether the difference among several sample means is significant or is just a matter of sampling fluctuations was made.

Two-way ANOVA technique was used to analyse the variance of the results of the specific gravity, moisture content and water absorption of all the aggregates obtained from the various quarry sites as well as the compressive strength of the different sizes of aggregates for the various brands/grades of cement. This is because the data were classified on the basis of two factors i.e. the different sizes of aggregate and the various quarry sites on the one hand and the compressive strength and the various brands/grades of cement on the other hand. The various steps employed are as follows:

(i) Firstly, the sum of the values of individual items in all the samples were calculated and called *T*.

(ii) The correction factor was then calculated using the formula:

$$Correction\ factor = \frac{(T)^2}{n} \ldots\ldots\ldots\ldots (14)$$

(iii) The square of all the individual items were obtained and the sum was also calculated and the correction factor was subtracted from this total to obtain the sum of squares of deviations for total variance using equation .

Sum of squares of deviations for total variance or total *SS* = $\sum X_{ij}^2 - \frac{(T)^2}{n} \ldots\ldots\ldots\ldots (15)$

(v) The sum of different columns were calculated and the square of each column total were obtained and the squared values of each column were divided by the number of items in the concerning column. The sum of squares of deviations for variance between columns or (*SS* between columns) was obtained by subtracting the correction factor from the total obtained earlier.

(vi) The same process was used to obtain the sum of squares of deviations for variance between rows (or *SS* between rows) = Sum of squares of deviations for residual or error variance calculated by subtracting the result of the sum of the result obtained from step (v) and (vi) from the result of step (iv) as stated above implying that: Total *SS* – (*SS* between columns + *SS* between rows = *SS* for residual or error variance.

(vii) Degrees of freedom (d.f.) was worked out as in the equation:

d.f. for total variance = (c . r – 1)+

d.f. for variance between columns = (c – 1)

d.f. for variance between rows = (r – 1)

d.f. for residual variance = (c – 1) (r – 1)

where c = number of columns

r = number of rows

(ix) ANOVA table was then set up as in Table 4.28 – 4.30 and

• 1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail: hfeforchrist@yahoo.com
• 2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail: alaojimoh4real@yahoo.com

ISSN 2229-5518

4.33 – 4

3.0 RESULTS AND DISCUSSION

The results and findings from the study are presented below

3.1 SPECIFIC GRAVITY

Figure 2 shows the value of the specific gravity of all the different sizes of aggregates for all quarry sites. The values contained in the figure indicates that the specific gravity of all the different sizes of aggregates for all quarry sites are within

Figure 2 Values of Specific Gravity of all Aggregate sizes from all Quarry Sites

Table 1 Analysis of variance for Specific Gravity for the various sizes of aggregates and different Quarry Sites

Source of variation	SS	Df	MS	F-	5% F-Limit
Between different aggregate forms	0.023	(4-1) = 3	$\frac{0.023}{3}$ = 0.008	$\frac{0.008}{0.006}$ = 1.33	F (3,9) = 3.86
Between varieties of cements	0.002	(4-1) = 3	$\frac{0.002}{3}$ = 0.007	$\frac{0.007}{0.006}$ = 1.17	F (3,9) = 3.86
Residual factor/ Error	0.053	9	$\frac{0.053}{9}$ = 0.006		
Total	0.078	15			

the limits of 2.4 – 3.0 stated in literature [13]; [8], [14] and [15]. The values are also above the minimum value specified in [16].

Table reveals that the calculated F – ratio of 1.33 is for the different sizes of aggregates and 1.17 for the various quarry sites whereas the critical value obtained from Appendix 4(a) [12] is 3.86. This implies that there are no significant differences in the sample means for both the different aggregate sizes from the various quarry sites. Lines of the graphs in figure 4.38 overleaf cross one another at points A – E, thus it can be concluded that there is definite interaction or inter-relationship between the two factors that is different sizes of aggregates from the various quarry sites.

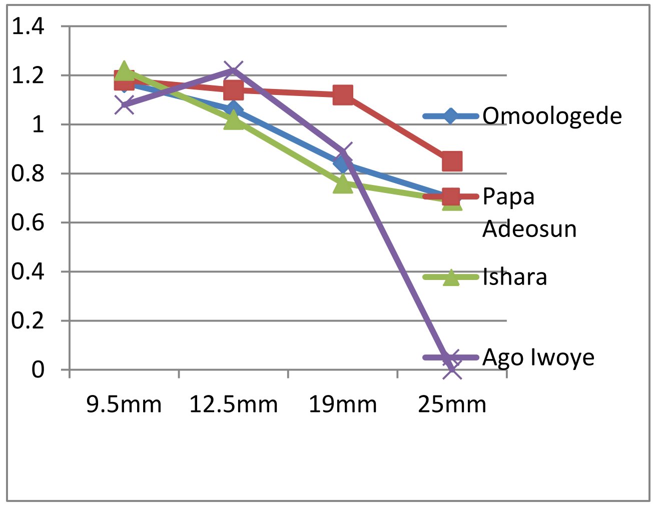

Figure 6 Analysis of variance for Specific Gravity for the various sizes of aggregates and different Quarry Sites

3.2 Moisture Content

As can be seen in Figure 3 the moisture content reduces with the sizes of the aggregates, for samples collected from all the quarry sites. However, the values of moisture content for all the coarse aggregate falls within the limits stipulated in previous literatures. In [17] 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. **T**he moisture content of all the aggregates obtained from the various quarry sites fall below the recommended value of 3% as specified in [1].

Table 2 reveals that the calculated F – ratio of 5.75 for the different sizes of aggregates and 33.25 for the various quarry sites are greater than the table value of 3.86. This implies that there are significant differences in the sample means for both the different aggregate sizes from the various quarry sites. The lines of the graphs in Figure 7 crosses one another, thus it can be concluded that there is definite interaction or inter-relationship between the two factors that is different sizes of aggregates from the various quarry sites.

- *1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail:* hfeforchrist@yahoo.com
- *2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail:* alaojimoh4real@yahoo.com

Figure 3 Values of Moisture Content of all Aggregate sizes from all Quarry Site

Table 2 Analysis of variance for Moisture Content for the various sizes of aggregates and different Quarry Sites

Source of variation	SS	Df	MS	F-	5% F-Limit
Between different aggregate forms	0.07	(4-1) = 3	$\frac{0.07}{3}$ = 0.023	$\frac{0.023}{0.004}$ = 5.75	F (3,9) = 3.86
Between varieties of cements	0.4	(4-1) = 3	$\frac{0.4}{3}$ = 0.133	$\frac{0.133}{0.004}$ = 33.25	F (3,9) = 3.86
Residual factor/ Error	0.04	9	$\frac{0.04}{9}$ = 0.004		
Total	0.51	15			

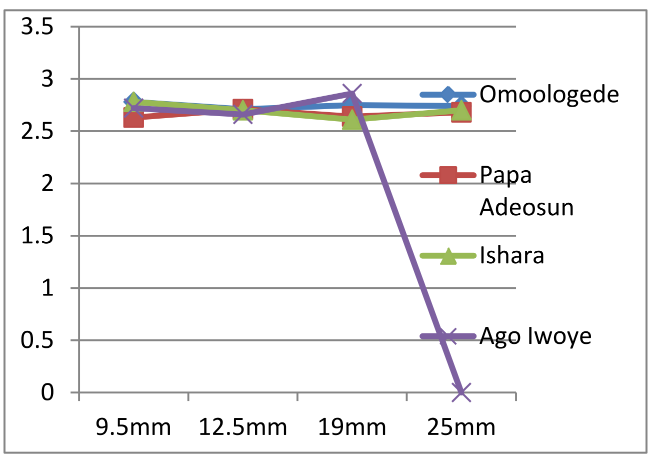

Figure 7 Analysis of variance for Moisture Content for the various sizes of aggregates and different Quarry Sites

3.3 Water Absorption

The values contained in Figure 4 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 [19], [12], [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.

From Table 3 the calculated F – ratio of 3.4 for the different sizes of aggregates is less than the table value of 3.86. This is an indication that is no difference in the sample means, therefore, it can be concluded that the difference in the water absorption values of different sizes of aggregates is insignificant. On the other hand the calculated F – ratio of 36.4 for the various quarry sites is greater than the table value of 3.86 is an indication that there are differences in the sample means, therefore, it can

Figure 4 Values of Water Absorption of all Aggregate sizes from all Quarry Sites

Table 3 Analysis of variance for Water Absorption for the various sizes of aggregates and different Quarry Sites

Source of variation	SS	Df	MS	F-	5% F-Limit
Between different aggregate forms	0.05	(4-1) = 3	$\frac{0.05}{3}$ = 0.17	$\frac{0.17}{0.05}$ = 3.4	F (3,9) = 3.86
Between varieties of cements	5.45	(4-1) = 3	$\frac{5.45}{3}$ = 1.82	$\frac{1.82}{0.05}$ = 36.4	F (3,9) = 3.86
Residual factor/ Error	0.47	9	$\frac{0.47}{9}$ = 0.05		
Total	5.97	15			

- *1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail:* hfeforchrist@yahoo.com
- *2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail:* alaojimoh4real@yahoo.com

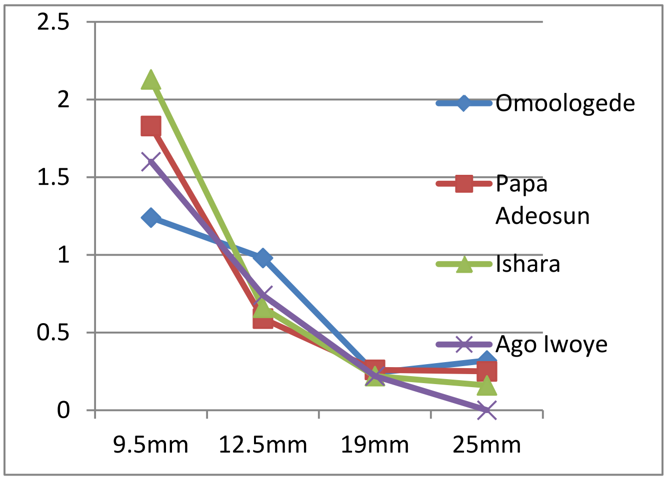

Figure 8 Analysis of variance for Water Absorption for the various sizes of aggregates and different Quarry Sites

be concluded that the difference in the water absorption values of the various quarry sites. As can be observed in Figure 8, the lines of the graph crosses one another, this is an indication that there is definite interaction or inter-relationship between the two factors that is different sizes of aggregates from the various quarry sites.

3.4 Aggregate Impact Value

Figure 5 indicates that aggregate samples from Ago – Iwoye has the highest aggregate impact value of 28.12%, this is closely followed by that of Omoologede with a value of 27.55% and then that of Papa Adeosun with a value of 23.51%. The sample from Ishara has the lowest value of 18.30%. The Aggregates Crushing Value of 9.45% for Ago Iwoye is the highest, that of Papa Adeosun is next with a value of 7.82% and that of Ishara of 6.70% was next and that of Omoologede has the lowest value of 6.21%.

Figure 5 Values of Aggregates Impact Value and Aggregates Crushing Value of all Aggregate sizes from all Quarry Sites.

According to [24] aggregates with 25 percent aggregate impact value is to be used for heavy – duty concrete floor finishes while aggregates with 30 percent. Aggregate impact value is to be used for concrete pavement wearing surfaces, and aggregates with 25 percent aggregate impact value is to be used for other concrete surfaces. While [13] refers to the specification in [23] which states that Aggregate Impact Value shall not exceed 45 percent by weight for concrete other than wearing surface and 30 percent by weight for concrete for wearing surfaces such as runways roads and pavements. According to Construction aggregates: evaluation and specification, the lower the value of AIV the stronger the aggregate. It was also added that AIV less than 30% is usually required for concrete works. [4] specification for the maximum AIV for concrete shall be 30%. However, the average value of the Aggregate Impact Value for the coarse aggregates obtained in this study is between 18.30% and 28.12%. This implies that all the coarse aggregate samples are in conformity with the requirements in relevant literatures, standards and codes of practice.

3.5 Aggregate Crushing Value

Indications from Figure 5 above reveals that the Aggregate Crushing Value of all the different sizes of aggregates for all quarry sites are considerably lesser than 35% value allowed for concreting works as stated in literature [13]. 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. Table 1 reveals that the calculated F – ratio of 1.33 for the different sizes of aggregates and 1.17 for the various quarry sites are lesser than the table value of 3.86. This implies that there are no significant differences in the sample means for both the different aggregate sizes from the various quarry sites. The lines of the graphs in Figure 6 crosses one another at points A and B, thus it can be concluded that there is definite interaction or inter-relationship between the two factors that is different sizes of aggregates from the various quarry sites.

Table 4 Analysis of variance for Aggregates Impact Value for aggregates at the different Quarry Sites

Source of variation	SS	Df	MS	F-	5% F-Limit
Between samples	123.519	(4-1) = 3	$\frac{123.519}{3}$ = 41.173	$\frac{41.173}{0.001}$ = 41,173	F (3,4) = 6.39
Within samples	0.005	(4-1) = 4	$\frac{0.005}{4}$ = 0.001		
Total	123.523	7			

- 1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail: hfeforchrist@yahoo.com
- 2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail: alaojimoh4real@yahoo.com

Values from Table 4 reveals that the calculated F – ratio of 41,173 for the aggregates obtained from the various quarry sites is greater than the table value of 6.39. This is an indication that there is a significant difference in the sample means, therefore, it can be concluded that the difference in the aggregates impact values obtained from the various quarry sites significant.

Source of variation	SS	Df	MS	F-	5% F-Limit
Between samples	12.402	(4-1) = 3	$\frac{12.402}{3} = 4.134$	$\frac{4.134}{0.001}$ = 4,134	F (3,7) = 6.39
Within samples	0.005	(4-1) = 4	$\frac{0.005}{4} = 0.001$		
Total	12.407	7			

Table 5 Analysis of variance for Aggregates Crushing Value for aggregates at the different Quarry Sites

Values from Table 5 reveals that the calculated F – ratio of 4,134 for the aggregates obtained from the various quarry sites is greater than the table value of 6.39. This is an indication that there is a significant difference in the sample means, therefore, it can be concluded that the difference in the aggregates impact values obtained from the various quarry sites significant.

4.0 CONCLUSION

Test results reveals that the values of the specific gravity of all the aggregate samples are higher than the minimum value specified in [3], that of the moisture content of all the aggregates obtained from the various quarry sites fall below the recommended value of 3% as specified in [1], while 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 [20], [12], [21] or [22], and [23]. Furthermore, the value of the Aggregate Impact Value is less than 30% required for concreting works in accordance with [4] and the Aggregate Crushing Value is less than the specified requirement of 35% in [5]. It can therefore be concluded that the physical and mechanical properties of all the aggregates tested are very suitable for concreting works.

REFERENCES

1. British Standard Institutes, BS 882:1992, *Specification for aggregates from natural sources for concrete,* 1992.
2. British Standard Institute, BS 812: Part 2, (1995). “Methods for Determination of Density”, British Standard Institution London.
3. British Standard Institute, BS 812: Part 109, 1990, “Methods for Determination of Aggregates Moisture”, British Standard Institution London, 1990.
4. British Standard Institute, BS 812: Part 110, 1990 “Methods for Determination of Aggregates Crushing Value”, British Standard Institution London, 1990.
5. British Standard Institute, BS 812: Part 112, 1990, “Methods for Determination of Aggregates Impact Value”, British Standard Institution London, 1990.
6. Apebo N.S. Iorwuab, M.B. & Agunwamba, J.C. Comparative Analysis of the Compressive Strength of Concrete with gravel and Crushed Over Burnt Bricks as Coarse Aggregate, Nigerian Journal of Tecknology (NIJOTECH) Vol. 32, No. 1, 2013, pp 7-12.
7. Bhatt P., Macginley T.J. And Choo B.S. Reinforced Concrete Design, Theory and Examples 2nd Edition. Spoon Press, United Kingdom, 2014.
8. Neville A. M. Properties of Concrete, 5th edition. Pearson Education Limited, 2011.
9. Alexander and Mindess, Aggregates in Concrete, Modern concrete technology series, 2010
10. Kumar P. R. and Rao K. M.V., A Study on the Effect of Size of Aggregate on the Strength and Sorptivity Characteristics of Cinder Based Light Weight Concrete, Research Journal of Engineering Sciences, Vol. 1(6), 27-35, (2012)
11. Ajamu S.O., Ige J.A. And Oloyede Effect of Coarse Aggregate Size on the Compressive Strength and Flexural Strength of Concrete Beam, International Journal of Engineering Research and Application 5,(4), pp 67-75, 2015.
12. Kothari, C.R., Research Methodology: Methods And Techniques, 2nd Edition, New Age International (P) Limited, Publishers New Delhi
13. Shetty M.S. Concrete Technology Theory and Practice S. Chand & Company Ltd. Ram Nagar, New Delhi - 110 055, 2005.
14. Arumugam, B. Effect of Specific Gravity on Aggregate Varies the Weight of Concrete Cube, International Journal of Civil Engineering (SSRG IJCR), volume 1 Issue 3, pp 1-9, 2014.
15. Nemati, K.M., Concrete Technology, Aggregates for Concrete, pp 1-16, 2015.
16. British Standard Institute, BS 812: Part 103, (1992). “Methods for Determination of Particle Size Distribution”, British Standard Institution London.
17. http://www.enggpedia.com/civil engineering-encyclopedia/dictionary
18. http://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=910
19. British Standard Institutes, BS EN 1097-6:2000, *Tests for mechanical and physical properties of aggregates.*

- *1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail:* hfeforchrist@yahoo.com
- *2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail:* alaojimoh4real@yahoo.com

ISSN 2229-5518

Determination of particle density and water absorption, **British Standard Institution, London,** 2000**.**

20. British Standard Institutes, BS 12620: 2002, *Aggregates for concrete,* **British Standard Institution, London,** 2002**.**
21. British Standard Institutes, BS 1047:1983, *Specification for air-cooled blast furnace slag aggregate for use in construction*, 1983.
22. British Standard Institutes, BS 8007: 1987, *Code of practice for the design of concrete structures for retaining aqueous liquids,* 1987.
23. IS 383 – 1970 Specification for Coarse and Fine Aggregates from Natural Sources for Concrete Second Revision
24. Neville A. M. & Brooks J.J. Concrete Technology, 2nd edition. Prentice Hall, 2010.

- *1 Sunday Omopariola is currently pursuing Phd program in civil engineering in University of Ilorin , Nigeria. E-mail:* hfeforchrist@yahoo.com
- *2 Alao Jimoh is a Phd holder currently a lecturer in the Civil engineering Department in University of Ilorin, Ilorin, Nigeria. E-mail:* alaojimoh4real@yahoo.com