



Effect of the Characteristic Properties of Pit Sand in Ilaro Metropolis on the Compressive Strength of Concrete

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ABSTRACT

Fine aggregate is an important constituent material of concrete occupying about 28 – 30% by volume depending on the mix proportion. It is readily available in Ilaro and Metropolis with variations in its properties especially in texture and colour when obtained from different sources. Since the properties of aggregates greatly influence the properties and quality of concrete, it is necessary to appraise the properties of pit sand and determine its effect on the compressive strength of concrete. Sieve analysis was carried out to determine the grading of the samples. The physical properties determined through laboratory tests are specific gravity, water absorption, moisture content, percentage silt content, and bulking of the samples obtained from six different locations in Ilaro and Metropolis. Correlation analysis was carried out to determine the relationship between each of the properties and the compressive strength of concrete cubes produced from the samples obtained from each of the locations. The result of the correlation analysis indicates that the correlation coefficient of the compressive strength with each of the properties are: 1.0, - 0.251, -0.377, 0.754, and 0.698 respectively. This implies that there are positive high correlation between the compressive strength of concrete and specific gravity, percentage silt content and bulking. While the correlation with moisture content and water absorption is negatively low.

KEYWORDS: Characteristics; Compressive; Concrete; Strength; Pit – Sand; Properties.

1. INTRODUCTION

Omopariola 2021 stated that concrete is a composite mixture of mineral matter. These mineral matters in the form of particles or aggregates which are held together by a binding material to give them solidity and strength. According to Matawal (2013), it is one of the major components of construction with a wide range of use in Civil Engineering contracts. It is used in the construction of Civil Engineering structures such as residential, and commercial buildings, bridges, abutments, dams, highways, e.t.c. Its major constituent materials are fine aggregates (sand) and coarse aggregates (gravel or granite), cement and water. According to Alexander and Mindes 2010, fine aggregates provide volumetric stability, restraint to creep and shrinkage, and reduction in the thermal movement of concrete. It also reduces the tendency to wear and abrasion, as well as a reduction in moisture-related deformations. Aginam, Chidolue, and Nwakire (2013), Zerdi (2014), and Bahabri (2016) are of the opinion that the quality, strength, durability, and structural performance of concrete are greatly influenced by the quality of aggregates.

Fine aggregate is an important constituent material of concrete, it occupies about 28 – 30% by volume depending on the mix proportion. It is readily available in Ilaro and environment with variations in its properties especially in texture and colour when obtained from different sources. Since the properties of aggregates greatly influence the properties and quality of concrete, it is necessary to appraise the properties of pit sand and determine its effect on the compressive strength of concrete. Otunyo and Okechukwu 2017 defined sand as a composition of finely divided rock and mineral particles that occurs naturally in granular forms. It is made up of silica (silicon oxide, SiO₂), it is classified according to its origin as either natural or artificial. According to Akinboboye et. al., natural fine aggregates is further classified according to the sources as pit sand, river sand, and sea sand. While artificial sand consists of crushed rocks. Krishna, (2017) defined pit sand as a naturally occurring sand that is coarse in texture and has superior binding properties. It is extracted by digging or burrowing to a depth of about 2-3m into the ground. (Dammo et.al. 2014) gave some of the characteristics of pit sand that make it an excellent material for concrete production as its sharpness and angularity and non –

hygroscopic. Abraham (2015) described pit sand as being rough-grained and obtained from the pit by digging 1 – 2m below the soil. It was further stated that is the most widely used type of sand and well-suited for construction due to its being free from salt hence it is not deliquescent. Tulashie et. al. (2017) averred that pit sand is better than sea sand. Akinboboye et al. 2015 opine that coarse-grained sand that passes through a sieve of the clear opening of 7.62mm is suitable for concrete production It was further stated that the fineness modulus should be within the range of 2.5 and 3.5 with a minimal quantity of clay and percentage silt content of not more than 8%. Usman et. al and Faizan et. al. (2018) stated that the variations in the geological formation, geographical locations, and environmental conditions from one location to the other will equally result in variations in the composition and properties of sand depending on the local rock sources from which they are formed. Consequently, it is also expected that this will have a definite effect on the properties and quality of concrete produced thereby.

2. MATERIALS AND METHODS

Samples of pit sand were obtained from six different locations in Ilaro. The six different burrow pits are Amosun, Ebute, Egbo, Idogo, Itolu, and Oja – Odan. The cement used was the Dangote brand of cement of grade 42.5 N which was purchased from a store in Ilaro township. Portable pipe-borne water free from impurities obtained from the laboratory was used for the wet mixing of the concrete.

Samples of the pit sand obtained from six different burrow pits were taken to the laboratory to determine their physical properties. Tests on physical properties that were carried out are grading tests, specific gravity, water absorption, moisture content, percentage silt content and bulking. These tests were carried out in accordance with BS BS 1881:111, (1983) BS 1881:112, (1983), BS 812:103 – 2, (1983) and BS 812:110, (1990) respectively. From the sieve analysis, values of fineness modulus, coefficient of uniformity and coefficient of curvature were obtained.

Upon the determination of the properties, concrete cubes were cast and the 28-day compressive strength was determined. The procedure for the concrete production involves batching by weight using a mix proportion of 1:2:4. A higher value of water/cement ratio of 0.6 was used because the study was carried out during the dry season when the sand was dry. The mixing of constituent materials was done manually due to the small quantity of concrete required for the test. Slump test was carried out to determine the workability of the fresh concrete mix in accordance with BS 1881:108, 1983. A total of 72 cubes of 150 x 150 x 150mm were produced for the compressive strength test. The concrete cubes were demoulded after 24

hours after which they were removed and placed in the curing tank at room temperature. The cubes were removed from the curing tanks after 7, 14, 21, and 28 days. They were left for about 20 minutes to allow the water to drain off from the surface before they were taken to the compressive testing machine to determine the 7,14,21, and 28 days compressive strength respectively.

3. RESULTS AND DISCUSSIONS

3.1 Properties of Sand from the different Locations

3.1.1 Gradation

Based on the result of the sieve analysis as presented in Figure 1, samples from all the locations exhibit the same curve pattern which is in line with are in line with the curve pattern obtained from the standard grading in BS EN 882 (2004). It also shows that they all fall within the curves of lower and upper limits of the values in the code. Values of the fineness modulus (FM) for samples from all the location ranges between 2.51 to 3.75. This is in conformity with 2.00 to 4.00 specified in BS EN 12350 – 2: (2009). According to Ravindra et. al. 2017, Higher FM is an indication of coarseness. In specific terms when compared with the values of the fineness modulus as presented in Table 1, samples from Egbo and Itolu can be classified as class C (coarse sand). While samples from Ebute, Itolu, and Oja Odan are in class M (medium sand) and that of Amosu is in class F (Fines sand). Since all the samples are within the range of values of the lower and upper limits of the values in the code, they are all suitable for concreting works.

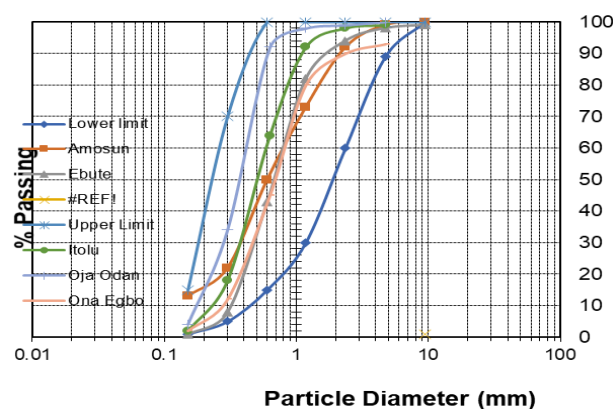


Figure 1 Sieve Analysis Graph of Samples from all locations

The range of values for the coefficient of uniformity (C_u) and the coefficient of curvature (C_c) is from 0.8 to 5.5, and 0.8 to 3.0 respectively as presented in Table 1. The values of C_c for sands obtained from Amosun, Ebute, Egbo, and Itolu are between 1 and 3 and in line with the specification of $1 > C_c > 3$ in ASTM D 2487 (2000) hence they are satisfactory. But that of Idogo and Oja Odan are less than 1

falling short of the specification. However, since the values samples are less than 6 as specified in the above code, they can thus be classified as poorly graded.

3.1.2 Specific Gravity

From the result of the specific gravity presented in table 1, samples from Amosun, Egbo, Idogo, and Itolu are within the range of 2.5 to 3.0 stated in Neville 2011, While that of Ebute at 2.3 is lower than 3 and that of Oja Odan at 3.27 is higher than 3. By comparison with the values of the compressive strength of concrete produced with samples from these locations, it can be seen that the specific gravity is closely related to the compressive strength. This agrees with the assertion of Amuda, Uche, and Amuda, (2014); Abas, Salema, and Pandey (2015) that the specific gravity of aggregates is closely related to their strength. Sand with higher specific gravity has higher strength and vice versa.

Table 1: Result of the Test of Physical Properties of all Samples

Location	L1	L2	L3	L4	L5	L6
CC	3.0	1.0	1.1	0.8	0.9	1.1
CU	5.5	2.7	4.4	2.8	2.6	0.8
Fineness Modulus	2.51	2.77	3.75	2.72	3.27	2.72
Specific gravity	2.84	2.3	2.5	2.65	2.60	3.27
Moisture Content %	8	11.1	4	5	7	4
Water absorption	12.7	11.1	6.8	7.7	4.2	3.8
Bulking	17.6	11	11.1	21.1	11.1	14.3
% Silt content	5.26	4.10	4.1	4.1	5.95	7.61

3.1.3 Moisture Content and Water Absorption

The moisture content of a soil sample is an indication of how much water is present in the soil sample. It is the criterion for the determination of the required water/cement ratio to be used in the wet mixing process of the constituent materials of concrete. On the other hand, the water absorption value gives an insight into the amount of water the concrete can absorb. From Table 1, the range of values for the two parameters are 4 – 11.1 and 3.8 – 12.7 respectively. The water absorption values of all the samples are more than the specified value of 3% stated in BS 8007. This is an indication that concrete produced from these sands will be porous as a result of the requirement of additional water to produce a concrete mix that is workable (Shah et al., 2014, Omopariola, 2021).

3.1.4. Percentage Silt Content.

From the result of the percentage silt content presented in Table 1, the range of values for all the locations is from 4.1 to 7.61. Since they are less than the 8% specified in BS EN 993 – 1: (1997), they are okay for concrete production

of Cu for all because they are not likely to affect the bonding between the cement and the aggregates.

3.1.5 Bulking

Bulking of sand is the increase in volume due to an increase in moisture. Its effect is pronounced when volume batching is used because it will result in a reduced quantity of sand thus affecting the mi ratio of the constituent materials of concrete. However, its effect becomes insignificant when weight batching is used. Values of bulking of sand from all the six locations to be from 11 and 21.7.

3.2 Test on Fresh and Hardened Concreting

3.2.1 Slump Test

The slump value of the wet concretes that were made from sand from all the locations is presented in Table 2. From the table, all the samples have true slump values ranging from 20mm and 38mm. The slump values of all the mixes are of low workability and according to Lyons 2007, they can be used for foundation concrete and reinforced concrete with light reinforcements.

Table 2: Slump Value of Fresh Concrete for all Locations

Location	L1	L2	L3	L4	L5	L6
Slump Values (mm)	8	10	10	8	16	6
Compressive strength (N/mm ²)	32.1	23.4	25.24	27.28	26.86	32.59

3.2.2 Compressive Strength of Concrete

Figure 2 presents the chart of the compressive strength at 7, 14, 21, and 28 days. The chart indicates a progressive increase in strength with an increase in the number of days of curing. The graph also shows the same for all the locations. The bar chart of the 28-day compressive strength for all the samples is presented in figure 6. sSamples from

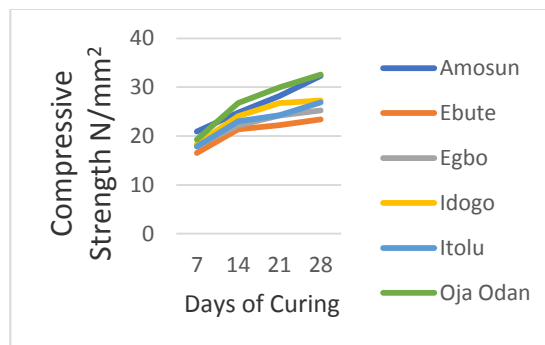


Figure 2 Chart of 7-, 14-, 21-, and 28- Days Compressive Strength of Cubes for all locations

Amosun and Oja Odan have compressive strength above class M30 grade of concrete, while samples from Idogo, Itolu and Egbo fall within the range of class M25 – M30 and Ebute has a value of M20 – M25. Comparatively, the values of the compressive strength agree with the assertion of Amuda, Uche and Amuda, 2014; Abas, Salema and Pandey (2015) who stated that the specific gravity of aggregates is closely related to their strength. The sand from Oja Odan with the highest specific gravity has the highest compressive strength and the sample from Ebute with the least specific gravity has the lowest compressive strength.

3.3 Correlation Analysis

Spearman correlation analysis was used to evaluate the extent of the effect of each of the properties on the compressive strength of concrete produced from the samples of pit sand obtained from the six locations. The result of the correlation analysis is presented in Table 3.

S/N	Variables	Correlation Coefficient
1.	Specific Gravity & Compressive Strength	1.0
2.	Water Absorption & Compressive Strength	-0.251
3.	Moisture Content & Compressive Strength	- 0.377
4.	Percentage Silt Content & Compressive Strength	0.754
5.	Bulking & Compressive Strength	0.698

From the table, the correlation coefficient of specific gravity with the compressive strength is 1.0, this indicates a perfect positive correlation implying that a higher value of specific gravity results in a higher value of compressive strength. This is in agreement with the assertion of Amuda, Uche and Amuda, 2014; Abas, Salema and Pandey (2015) who stated that the specific gravity of aggregates is closely related to their strength. On the other hand, water absorption and moisture content exhibit a low negative correlation of – 0.257 and – 0.377 respectively. This indicates that an increase in moisture content and water absorption value of pit sand results in a reduction of compressive strength. This is in agreement with the findings of Shen and Xu (2019) that the compressive strength of concrete is significantly affected by the moisture content of aggregates. It was further stated that this effect is related to porosity. The coefficient of correlation for percentage silt content and bulking with the compressive strength are 0.755 and 0.698 respectively. This represents a high positive correlation between the two properties. The correlation between the percentage silt content and the compressive strength is in line with the findings of Tauseef, Manjit (2018) noting that there is an

increase in the compressive strength of concrete when silt fine content is at about 5%, Higher values of silt content above this value will result in decreases in the value of the compressive strength.

4.0 CONCLUSION

Observations from test results indicates that the properties of pit sand affect the compressive strength of concrete. Higher values of specific gravity produce stronger concrete. Similarly, lower percentage silt content and lower value of bulking equally results in higher values of compressive strength of concrete. Conversely, higher values of moisture content and water absorption causes a reduction in the value of the compressive strength. Conclusively, it can be stated that the the compressive strength of concrete does not depend on a single factor but on the various properties of pit sand from which it is made.

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