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Appraisal of the Compressive Strength of Concrete Produced with Pit Sand and Gravel in Ilaro and Environ

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Abstract

There are different types of aggregates and they are obtained from different sources with variation in their properties. It is expected that this variation in types and sources will have a definite effect on the properties of concrete. This study is aimed at determining the compressive strength of concrete made with pit – sand and gravel. Pit sand obtained from six different sources were used to produce concrete cubes. The 7, 14, 21 and 28days compressive strength of the cubes were determined. Results obtained ranged between14.57N/mm2. and 19.50 N/mm2. These results are in the range of M15 to M20. Hence it is recommended that the use of concrete made with pit sand and gravel should be limited to structures where plain or ordinary concrete is required.

Keywords, Broken waste glass, Workability, Compressive Strength, Water absorption.

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1. Introduction

Building collapse is a common phenomenon all over the world that predates modern civilization. It is saddening to note that despite the advancement of technology, not much has been done to curb this menace. One of the major reasons attributed to the many incidents of building collapse is the use of poor-quality concrete. This statement is supported by Ajagbe et. al. (2018), who stated that the report of the committee that investigated the collapse of the collapse of a two-storey building under construction at Ologuneru in Ido Local Government area of Ibadan city revealed that poor quality of aggregates materials was used for the production of concrete. Furthermore, Oke (2011) posited that more than 50% of cases of building collapse in Nigeria is caused by the poor quality of materials. The effect of the use of substandard materials for concrete as the leading cause of building collapse in Nigeria was reiterated by Ayininuola and Olalusi (2004), Ede (2011).

Concrete is a major component in the construction industry whose performance in service greatly influences the durability and serviceability of structural elements made with it Omopariola (2020). Bamigboye et. al. (2016) defined concrete as a composite material consisting of cement, fine aggregate (sand), coarse aggregates (gravel or granite) and water. It is versatile engineering material commonly used for construction. It is produced by thorough mixing of water, cement, fine and coarse aggregates in the required proportion (Apebo, Iorwuab and Aguwamba, 2013). According to Zerdi (2014), concrete is an initially plastic and workable mixture when wet. Bhatt, Macginley and Choo (2014) opine that concrete plays a major role in all building structures. Its versatility and capability of being moulded to take up the shapes required for the various structural forms make it unarguably the most important building material. Proper adherence to specification and construction procedures makes it durable fire resistant and useable for the construction of various forms of standard structures such as single storey and multistorey buildings, containment and retaining structures and bridges.

The quality, strength, durability and structural performance is to a large extent influenced by the properties of its constituent materials. Bahabri (2016), Zerdi (2014), Aginam, Chidolue and Nwakire (2013). Other factors that affect the quality of concrete according to them are aggregates quality, the propriety of batching and the thorough mixing procedure of constituent materials. Abdullahi (2006) gave the specification for the quality of aggregates as stated in BS 882, (1992) that it must be clean, sharp, and free from salt and organic contaminants. Other requirements are that it should consist of particles with adequate strength, free from materials that will cause deterioration to concrete and be resistant to exposure condition. According to Krishna, (2017) pit sand is a naturally occurring type of sand that is coarse in texture. It is obtained by extraction through the process of burrowing up to a depth of about 2-3m into the ground. It is non – reactive with atmospheric moisture because it is free from salts. It has a red-orange colour because of the presence of iron oxide around the grains. It is sharp and angular thus making it an excellent material for mortar or concrete work (Dammo, Deborah, Aghidi, Isa, and Falmata, 2014) However it is necessary to ensure that it does not contain clay, other organic materials and coating of oxide of iron.

Due to the absence of rivers where river sand possesses the quality required for concreting work, the high cost of transportation of such sand and the availability of pit sand, the use of pit sand for construction work is predominant in Ilaro and environ. According to Faizan et. al. (2018), variations in properties and quality can occur due to geographical locations and environmental conditions. The aim of the study, therefore, is to determine whether concrete produced with sand abstracted from different locations in Ilaro and environ meets up with the required compressive strength as specified in relevant codes and standards.

2. Materials and Methods

As stated in the literature review, the constituent materials of concrete are cement, fine aggregate, coarse aggregates and water. Consequently, these are the materials used in this study. Dangote cement grade 42.5 N procured from a store in Ilaro township was used. While pit sand obtained from six different burrow pits in Ilaro and environ as fine aggregates. The locations are Amosun near Owode, Idogo, Itolu, Egbo, Ebute and Oja – Odan. The gravel that was used as coarse aggregate procured from a local dealer in Ilaro. While portable pipe-borne water-free for impurities was used for both the mixing and the curing.

The pit sand obtained from burrow pits were subjected to laboratory tests to determine their suitability for concrete production. The tests carried out are sieve analysis, specific gravity, water absorption, moisture content, bulking and percentage silt content. The fineness modulus, coefficient of uniformity and coefficient of curvature was determined from the data obtained from the sieve analysis. A total of seventy – two concrete cubes (of size 150 x 159 x 150mm) were produce consisting of twelve cubes from each location. The mix ratio adopted was 1,2,4, constituent materials were batched by weight and the water-cement ratio of 0.6 was used. Mixing of constituent materials was done manually due to the small number of cubes cast per location. The workability of the fresh concrete mix was determined by carrying out a slump test following BS 1881,108, (1983). The demoulding of concrete cubes was done after 24 hours. Curing was done in a curing chamber at room temperature. All these procedures were carried out in accordance with BS 1881,111, (1983) BS 1881,112, (1983), BS 812,103 – 2, (1983) and BS 812,110, (1990). The compressive strength of the cubes is determined at 7, 14, 21 and 28 days using the compressive strength testing machine.

3.1 Properties of Sand from the different Locations

The result of the grading test reveals that samples from all the locations the same curve patterns as that of standard grading under BS 882 (1992). However, based on the cumulative percentage passing when compared with the specified value in the code, only the sample from Ebute can be classified as class C. While those from Oja Odan and Itolu falls within class M Amosun and Idogo are in class F. However, according to BS 882, 1992, where some sands conform to the overall limits but not within the additional limits of class C, M or F., an assurance by the supplier that the required concrete quality will be achieved by the use of the material must be obtained.

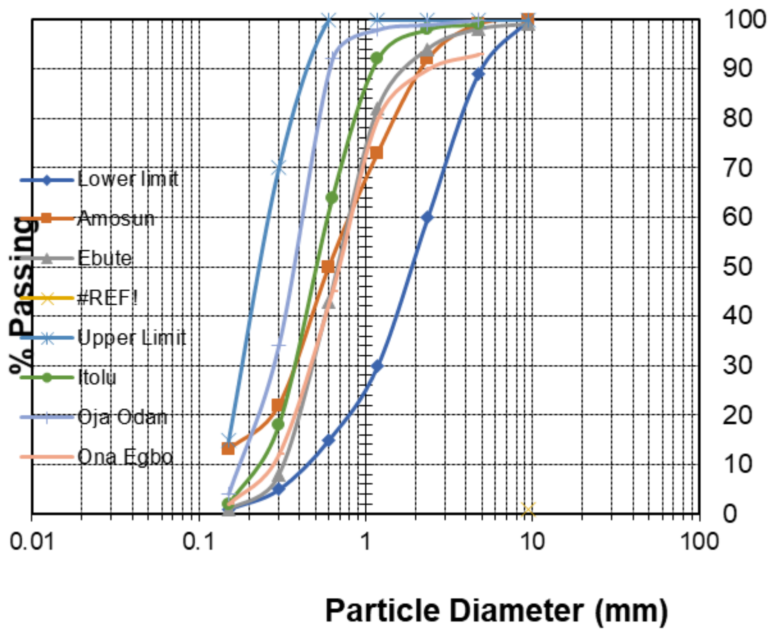

Figure 1 Sieve Analysis Graph of Samples from all locations

In Table 1, the fineness modulus of samples from all the locations is within 2.51 to 3.75. The sample from Amosun has the least value of 2.51, while that of Egbo has the highest value. This conforms with the assertion of BS EN 12350 – 2, (2009) which states that the FM of fine ranges from 2.00 to 4.00. The fineness modulus of aggregates is used in specifying how fine or coarse aggregates are. High FM is an indication of coarseness, while low value is an indication of its coarseness. It thus implies that the sample from Egbo is the coarsest and that of Amosun is the finest. Fine aggregate with lower fineness modulus requires more paste and thus more workable Dhir et. al. (2015). The range of values of the coefficient of uniformity and coefficient of curvature is from 0.8 – 5.5 and 0.8 to 3.0 respectively. Since the value of samples from Amosun, Egbo is greater than 4, it indicated that the soil is well-graded while Ebute, Idogo, Itolu, & Oja Odan is less than 4, the soil is poorly or uniformly graded.

According to Neville (2011), the values for the specific gravity of aggregates acceptable for concrete production should be within the range of 2.5 to 3.0. From the results obtained in this study, while sand from Owode, Idogo, Oja Odan. Itolu and Egbo are within the stipulated range, the sand obtained from Ebute has a lower value. It implies that concrete produced with sand from Ebute will be weak hence it is not recommended for concrete production. The strength of aggregates is related to their specific gravity, the higher the Specific Gravity, the higher the strength (Amuda, Uche and Amuda, 2014, Abas, Salema and Pandey (2015). From table 1, the value of the specific gravity for all samples tested is between 2.3 and 3.17. The sample from Ebute had the lowest value of 2.3 while that of Oja Odan had the highest value of 3.27.

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

Location	Amosun (L1)	Ebute (L2)	Egbo (L3)	Idogo (L4)	Itolu (L4)	Oja Odan (L5)
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

From Table 1, the values of water absorption for all the samples range from 3.8 – 12.7. These values are higher than the 3%. specified in BS812,1992. This is an indication of high porosity and can lead to the deterioration of concrete. This is because of the additional water that will be required to produce workable concrete in line with the required water/cement ratio (Shah et al 2014). The results of the moisture content of samples from all locations as presented in Table 1 ranges from 4 to 11.1. These are higher than the specified values of 3% stated in relevant standards and literature. This does not prevent their use in concreting work because the reason why the moisture content of sand is determined is to know the amount of moisture present so that provision can be made for it when determining the water/cement ratio of the concrete mix.

The range of values of the percentage silt content of sand from all the six locations as indicated in Table 1 is from 4.1 in Ebute to 7.61 in Oja - odan. It implies that since the values are lower than the 8% specified in BS 812,103, 1983, they are not likely to be susceptible to the effect of the high percentage silt content of sand on concrete. Hence, they are suitable for concreting works subject to their conformity to other criteria. Table 1 gives the range of values for bulking of sand from all the six locations to be from 11 and 21.7. Although there is no specified limit for bulking of sand in literature, codes or standard, BS 1881,102 (1983) classified sand with bulking values above 15% as fine while those below are regarded as coarse sand. Consequently, sand from Ebute, Egbo, Idogo and Itolu can be classified as coarse sand while that of Amosu and Idogo can be classified as fine sand. It is noteworthy to state that bulking of sand is not a parameter used in concrete mix design but it is useful when batching is to be done by volume.

3.2 Test on Fresh and Hardened Concreting

Slump Test

From table 2, concrete mixes produced from samples obtained from all the locations exhibit true slumps of between 6mm and 16mm.

Table 2, Slump values of fresh concrete from all Locations

Location	Amosun	Ebute	Egbo	Idogo	Itolu	Oja - Odan
Slump Values (mm)	8	10	10	8	16	6

Compressive Strength of Concrete

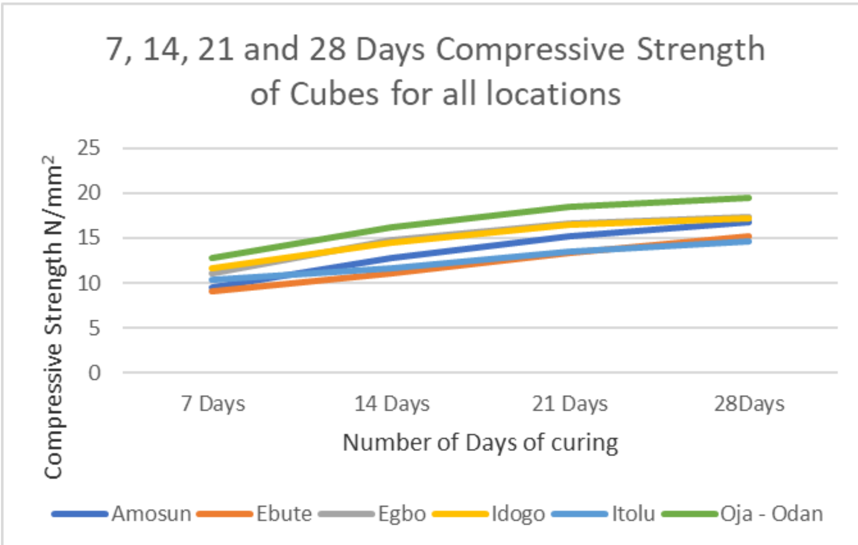

Figure 2 Chart of 7, 14, 21 and 28 Days Compressive Strength of Cubes for all locations

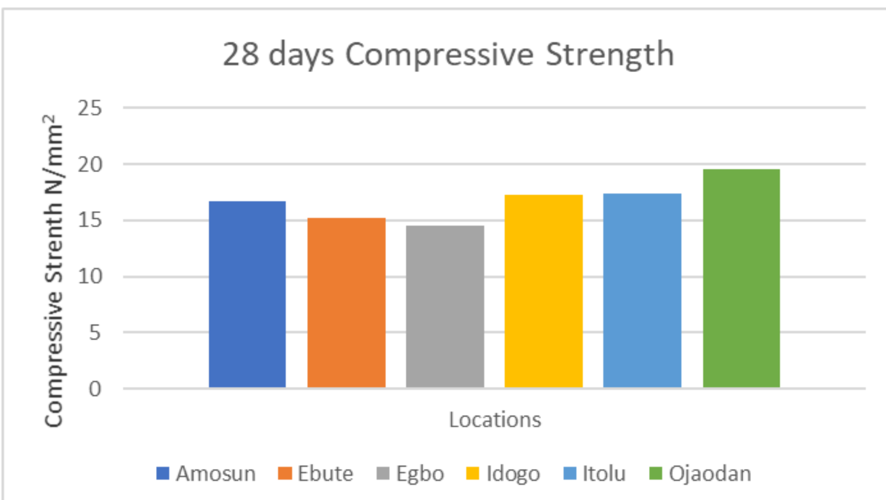

Figure 3 Bar chart of 28 Days Compressive Strength of Cubes for all locations

Figure 2 depicts the results of the compressive strength of cubes for all locations after curing for a period of 7, 14, 21, and 28 days. From the charts, the compressive of cubes increases progressively from 7 days to 28 days. It is notable to state that the graph of all the samples follows the same trend.

Figure 3 is the bar chart of the 28 days compressive strength for all the samples. Sample from Oja – Odan has the highest compressive strength of 19.5N/mm2, while that of Ebute has the lowest value of 14.57N/mm2. From the foregoing, it can be stated that the compressive strength of concrete products with pit sand and gravel falls within the range of class M15 – M20. Hence the use of a combination of pit sand in Ilaro and environ should be limited to concrete requiring compressive strength of class M15 – M20. This according to Mudavath (2018) implies that it can only be used in plain concrete structures such as Levelling course, bedding for footing, concrete roads, and not in the construction of reinforced concrete structures which requires Class M20 and above.

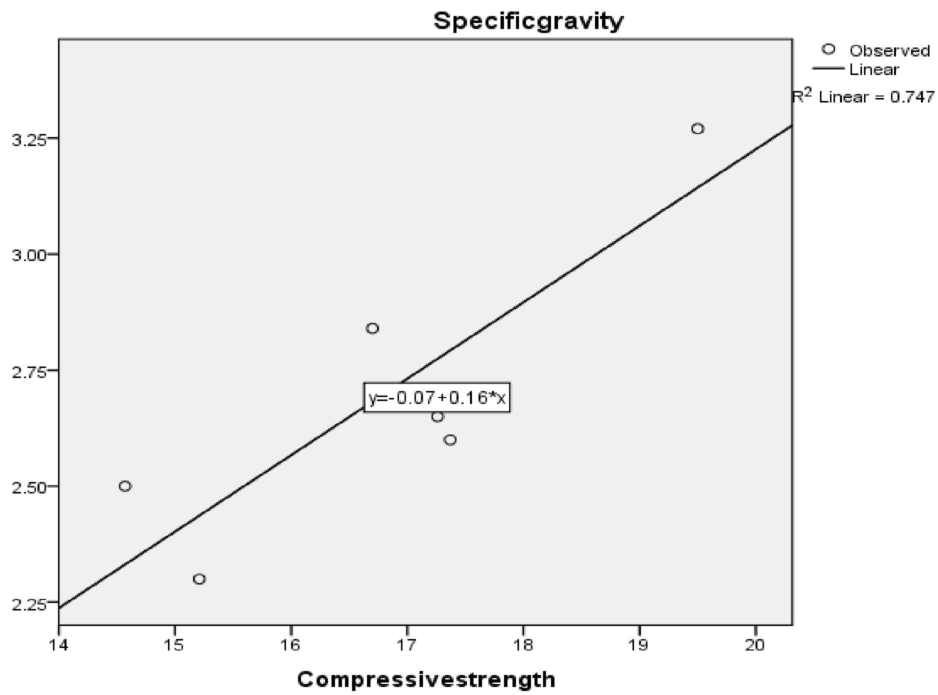

Figure 4. Graph of Regression Analysis of Compressive Strength against Specific Gravity

Figure 4 shows the graph of regression analysis of compressive strength against specific gravity. The regression analysis gives a correlation coefficient of 0.865. This is a high positive correlation which implies that the compressive strength of concrete increases as the specific gravity of sand increases. It is in agreement with the assertion of Shah et al. that the specific gravity, the higher the compressive strength. Furthermore, the regression equation obtained from the regression graph is a linear equation with

$$Y = - 0.07 + 0.16x \quad \ldots\ldots(1).$$

4. Conclusion

The results obtained from tests on sand from various locations affirms the fact that the properties of sand vary from one location to the other. Comparatively, from the results obtained from tests on sand from various locations and the corresponding compressive strengths, it can be concluded that variation in the strength of concrete does not depend on a single factor but a combination of factors. It can also be concluded that the use of pit sand available in Ilaro and environ with gravel as coarse aggregate will produce concrete with compressive strength in the range of M15 – M20. Consequently, it is recommended that this combination should only be used exclusively for plain concrete where this class of concrete is required.

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