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PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE MADE WITH LOCAL GRAVEL FOR SUSTAINABLE CONSTRUCTION: CASE STUDY OGUN AND OYO STATES, NIGERIA

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ABSTRACT

The study focus on assessment of normal concrete made with gravel obtained from Ogun and Oyo States, Nigeria. In this vein, gravel types from four commonly used mining pits namely: Iyana Abib, Sabo, Alamutu and Igbo-Ora were considered. The method of study was purely experimental. The conventional mix ratios used were 1:2:4 and 1:3:6. The grading of fine and coarse aggregates were determined using sieve analysis, while the tests performed on fresh concrete were slump and compaction factor. Compressive strength test was executed on the hardened concrete. Concretes were made using 150 mm concrete cubes. The concrete was tested on the 3, 7, 14, 21 and 28 days. The average compressive strength obtained for 1:2:4 mix ratio were 25.3 N/mm^2 (gravel from Igbo-Ora), 23.7 N/mm^2 (gravel from Alamutu), 19.7 N/mm^2 (gravel from Sabo) and 13.5 N/mm^2 (gravel from Iyana-Abib). Also, the average compressive strength on the 28 days obtained for 1:3:6 mix ratio were 20.5 N/mm^2 (gravel from Igbo-Ora), 19.5 N/mm^2 (gravel from Alamutu), 15.4 N/mm^2 (gravel from Sabo) and 9.9 N/mm^2 (gravel from Iyana-Abib). Minimum requirement of 20 N/mm^2 by BS 8110:1997 and ACI 318:2008 for 1:2:4 mix ratio was satisfied by gravel from Igbo-Ora and Alamutu. Also gravel from Igbo-Ora, Alamutu and Sabo satisfied 15 N/mm^2 minimum requirement by BS 8110:1997 and ACI 318:2008 for 1:3:6 mix ratio. It was concluded that gravel from Igbo-Ora produced the highest strength for both 1:2:4 and 1:3:6 mix ratio and is recommended for construction work where granite is not available or uneconomical.

Keywords: Concrete, Gravel, Granite, Cement, Compressive Strength, Sustainable Construction.

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1. INTRODUCTION

Concreting which is a major process prominently used in building works, comprises of a mixture of (fine, coarse aggregates, binders, water and sometimes activities) to form a paste suitable for use. Concrete is a composite material most commonly used in the construction industry as well as in civil engineering works. Yang and Huang [1] concluded that the physical and chemical constituents of concrete properties determine the behavior of composite materials. One of the important properties of concrete is the ease with which it can be mould into different shapes before hardening occurs. Concrete is expected to meet some certain requirement in order to predict its efficiency for use which is good workability, adequate water content ratio and required strength. Aggregate which is a prominent material (Usually hard) constitute over 75% of the total concrete mass thus aggregates play crucial role in concrete volume and strength [2]. The size, surface texture and shapes of aggregates plays vital role in the performance and design of concrete mixes [3, 4]. Aggregate classified as fine and coarse aggregates are differentiated by their size (grades of aggregates). Fine aggregate includes sand, silt while coarse aggregates includes gravel and granite. In term of economy granite is very expensive because of crushing processes its undergo while gravel is much more affordable. Ede et al., [5] reported that availability of aggregates and cost are important when selecting aggregates for construction work. One of the major reason which encourages the use of locally sourced materials for construction is to reduce cost infrastructural which makes building affordable to low-middle class earner [6], but the methods must be structurally and mechanically verified to establish the strength and durability of concrete [7]. Aggregate that contribute immensely to concrete efficiency must be sufficiently free from constituents, which can react harmfully with the cement, be well graded and have very small or no moisture content [8]. It should be noted that the type of coarse aggregates and cement paste play significant roles on the concrete strength at the interfacial zone [9]. Dahunsi [10] reported that aggregate is an economical filler materials and at the same time improves the durability of concrete but plays no part in chemical reactions which occurs within the concrete. Gravel aggregate usage has gone beyond normal concrete production [11, 12] established that gravel aggregates such as semi-crushed and rounded aggregates could be used to produce self-compacting concrete, while [13] found that aggregate characteristic should be considered in determining the fresh and hardened concrete performances. Gravel aggregates is underutilized compere to granite in construction industries, Nigeria, the chemical composition of gravel is one of the reasons behind its low usage compared to granite [14]. Kostmatka [15] make it clear that clear that almost fifty percent of coarse aggregates used in North America, Portland cement concrete are gravel aggregate the reminder are granite. Some of the problems associated with gravel aggregates are land use conflicts and its occurrence because it can be found where nature placed it not where people need it. The choice of gravel for construction works depend greatly on the following factors but not limited to closeness of gravel source to the place of use, cost which depend greatly on the easy with which it could be minedand availability of transport facilities. This study investigated the characteristic strength of concrete produced using gravel obtained from major gravel sites in Ogun and Oyo States as coarse aggregate.

2. MATERIALS AND METHODS

Materials used for this study are ordinary Portland cement (OPC) of grade 42.5R with density of 3140 kg/m^3, local river sand obtained from river Ogun (Longitude 3.352E, Latitude 7.122N) in Ogun state, Nigeria, was used as fine aggregate, while gravel obtained from four major borrow pits in Ogun and Oyo State namely; (Sabo (Longitude 3.325E, Latitude 7.153N), Alamutu (Longitude 3.331E, Latitude 7.217N), Igbo – Ora (Longitude 3.289E, Latitude 7.472N) and Iyana-Abib (Longitude 3.256E, Latitude 7.43N)) represented by A, B, C and D were used as coarse aggregate as shown in Figure 1. The grading of both fine and coarse aggregates was determined by sieve analysis in line with [16]. Batching by weight was adopted using 1:2:4 and 1:3:6 mix ratio respectively. Slump test was carried out on each concrete specimen to determine concrete consistency in line with [17]. Concrete cubes of different gravel aggregate obtained from different burrow pits were tested on varying days to determine the compressive strength of concrete produced using compression machine in line with [18].

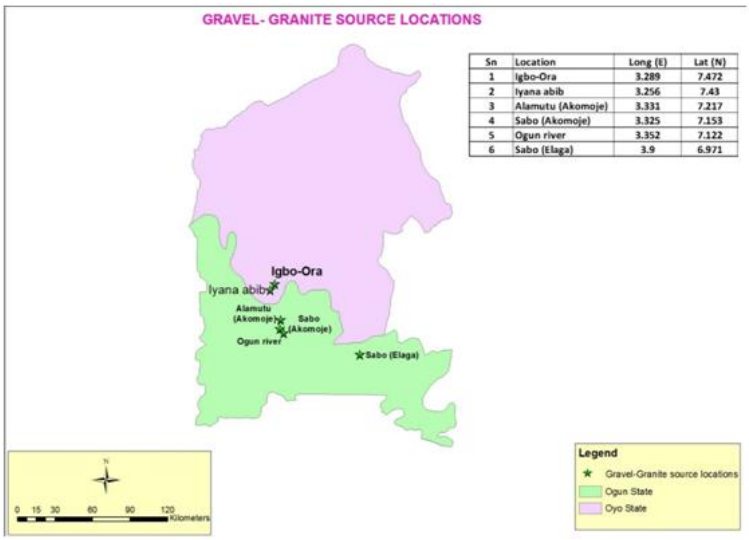

Figure 2 Sharp sand, gravel and granite locations

3. RESULTS AND DISCUSSION

3.1. Sieve Analysis

Sieve analysis was carried out on fine aggregate as shown in Figure. 2 which shows the graphical representation of the results. From the curve it can be deduced that the sample is uniformly graded having a greater percentage of the particles falling within the sand fraction with only a small percentage in the fine section of the gravel fraction. The uniformity coefficient, CU= D60/D10 =0.52/0.16 =3.25, which implies that the sand is uniformly graded. Since $3 \leq CU \leq 5$. The results of the coarse aggregate grading test of samples A, B, C and D were presented in Figures 3, 4,5 and 6 respectively. From the curve of Figures 4 and 5, it can be deduced that sample B and C are uniformly graded having a portion of the curve almost vertical. It has a larger percentage of the particles falling with the fine and medium section of the gravel fraction with only a small percentage falling into coarse sand section of the sand fraction. From Figure. 6, it shows that sample D was poorly graded. It has majority of the particles falling in the medium and fine section of the gravel fraction but are not evenly distributed. It also has a relative percentage of the particles in the coarse section of the sand fraction which indicated that a higher percentage of sand is present.

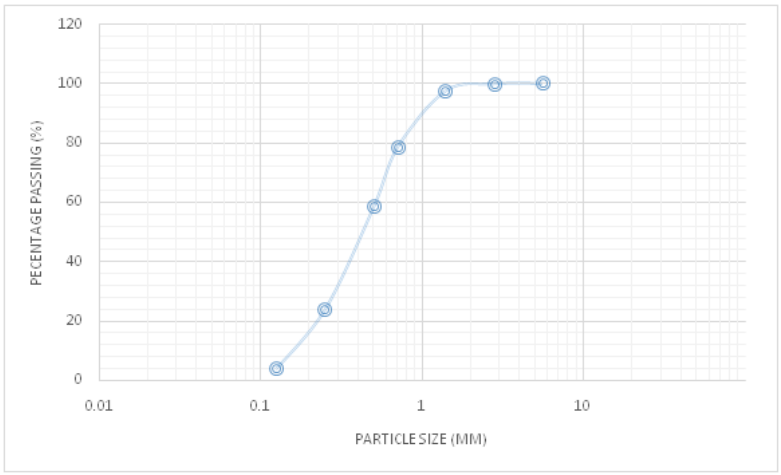

Figure 2 Particle size distribution for Sharp Sand

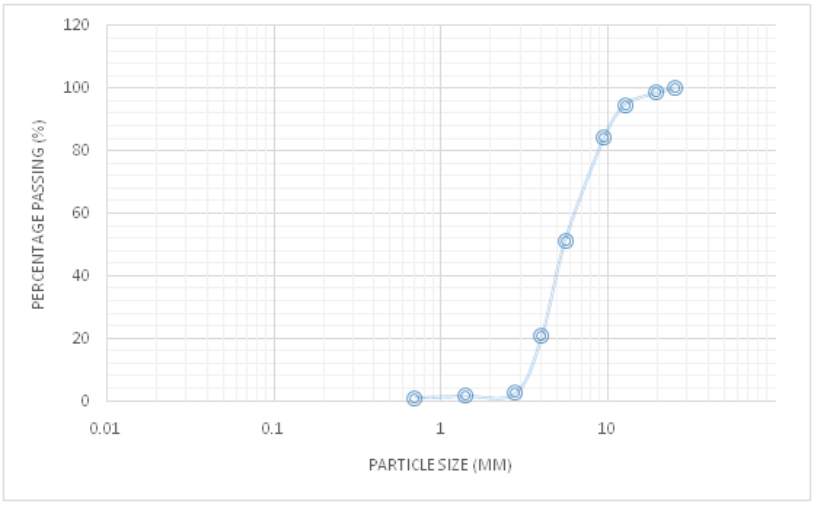

Figure 2 Particle size distribution for Sample A (Sabo)

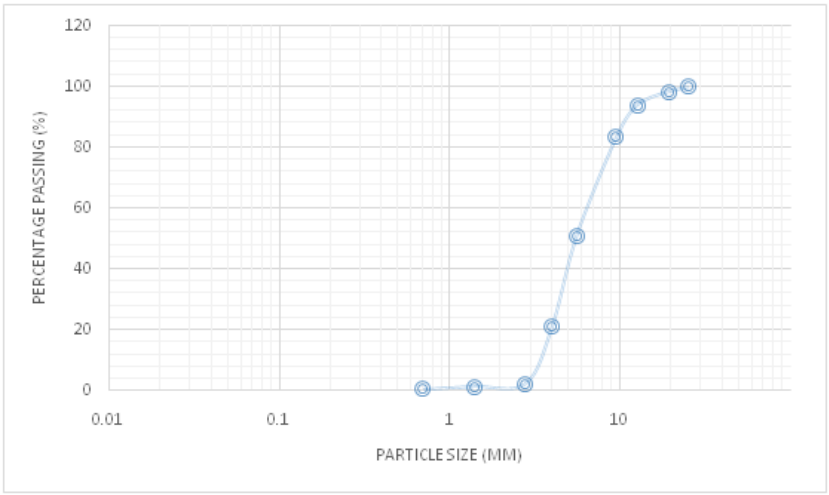

Figure 3 Particle size distribution for Sample B (Alamutu)

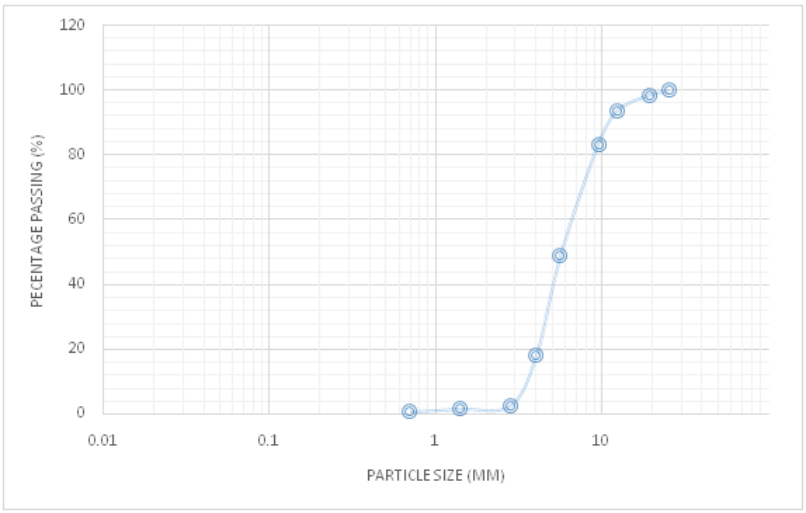

Figure 4 Particle size distribution for Sample C (Igbo-Ora)

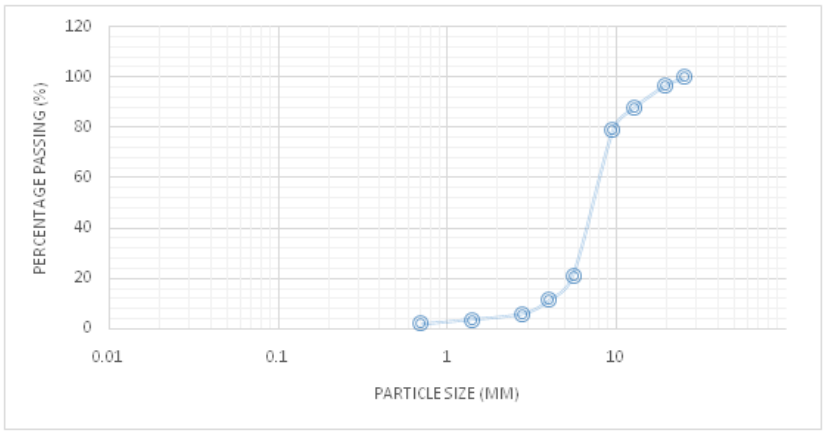

Figure 5 Particle size distribution for Sample D (Iyana-Abib)

3.2. SLUMP TEST

The results obtained for 1:2:4 and 1:3:6 slump test are shown in Figure 7 and 8 respectively. From the results the slump test for the various concrete mix ranges between 25 mm and 30 mm which indicates that a true slump was observed for each concrete sample.

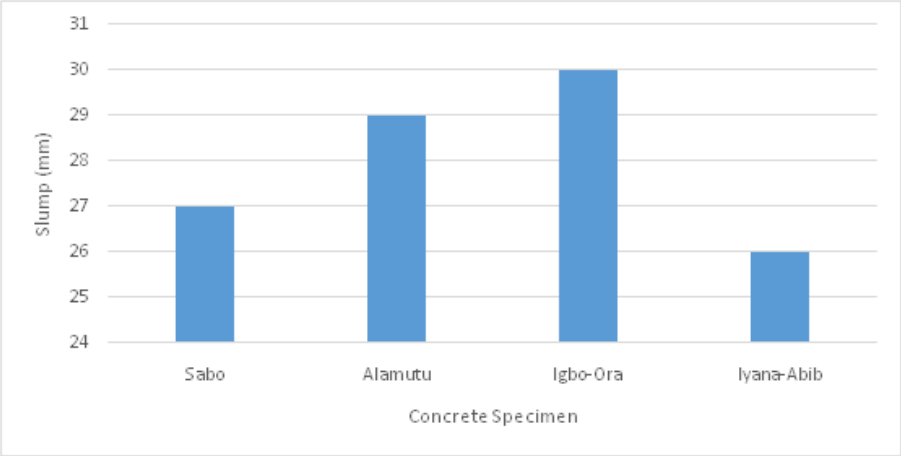

Figure 71:2:4 Slump

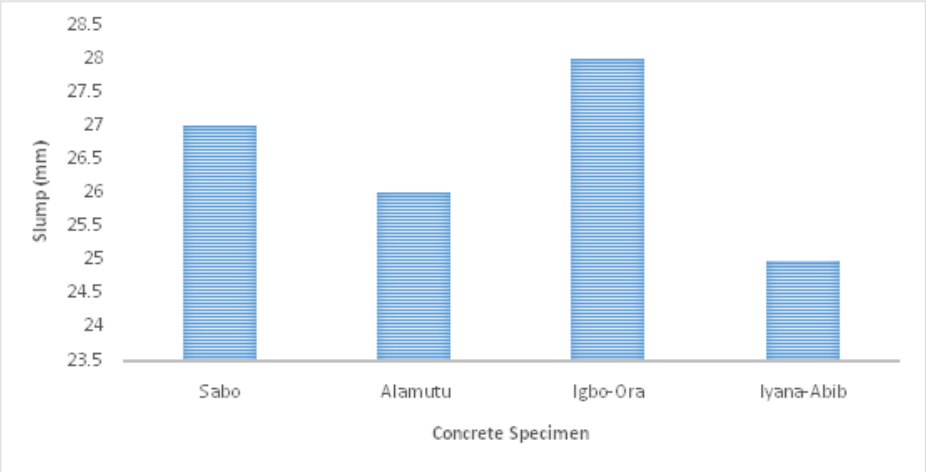

Figure 8 1:3:6 Slump

3.3. Compression Test Results

Figure 9 and 10 show the compressive strength results obtained from different concrete sample using 1:2:4 and 1:3:6 mix ratios respectively. From Figure 9 specimen D displayed the lowest compressive strength of 10.7 N/mm^2 on 28days. It was observed that sample D is poorly graded with significant percentage of sand in gravel and this contributed to comparably lower strength, because much of the coarse aggregate is being replaced by fines particle which in essence alternate the mix ratio, there by resulting into lower coarse aggregate content and higher fine aggregate content. While specimen C with uniformly graded coarse aggregate displayed highest strength of 25.3 N/mm^2 at 28days follow by specimen B with compressive strength 23.7 N/mm^2 at 28days.The two sample C and B satisfied the minimum requirement of 20 N/mm^2 of [19] and [20]. Also in line with [21] and [14] which obtained 26 N/mm^2 and 29.7 N/mm^2 at 28days respectively. From Figure 10, similar trend was observed where Specimen D produced the lowest compressive strength of 9.00 N/mm^2 at 28days whereas specimen C produced the highest compressive strength of 20.50 N/mm^2 follow by B with 19.50 N/mm^2 and A with 15.40 N/mm^2. Specimen C, B and A satisfied the 1:3:6 minimum compressive strength of 15 N/mm^2 at 28day of [19].

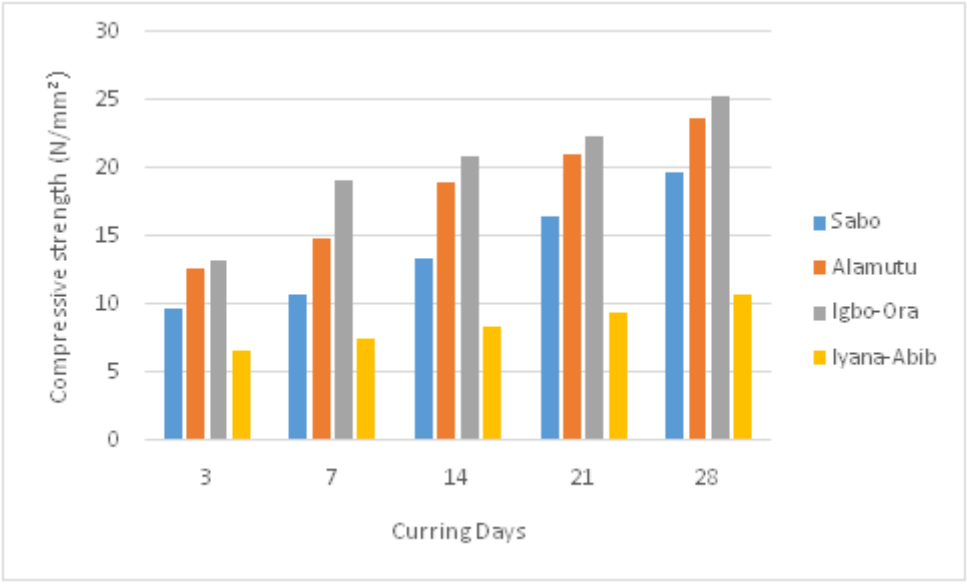

Figure 9 Compressive strength for 1:2:4 mix ratio

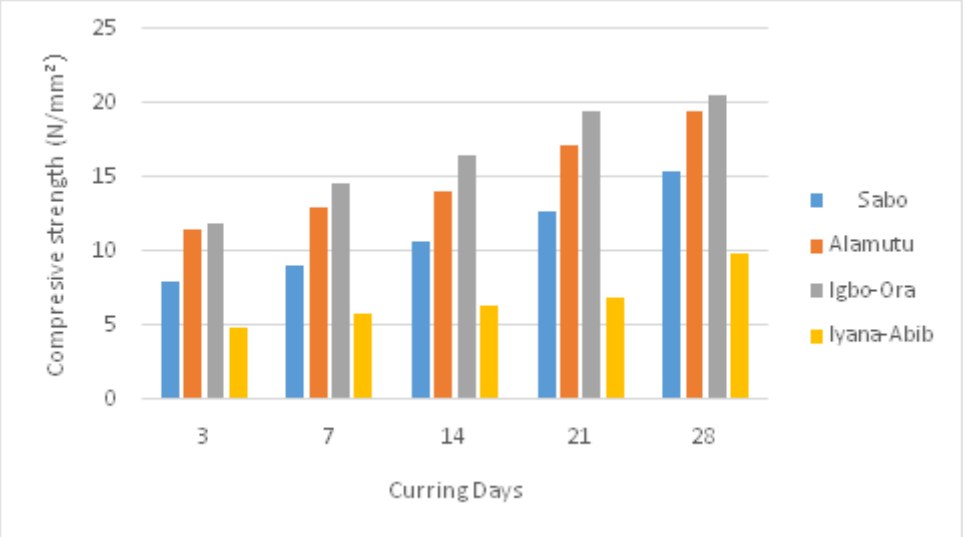

Figure 10 Compressive strength for 1:3:6 mix ratio

4. CONCLUSION

Based on the results of the experiment and discussion of the results, the following conclusions were drawn:

- The strength of concrete increases with ages
- The strength of concrete reduces with increasing amount of silt and sand in gravel.
- The concrete produced with gravel from Igbo-Ora is better in strength than the others and therefore recommended for concrete production.
- The low strength exhibited by the concrete with gravel from (Alamutu) site was attributed to the relative percentage of sand particle present in the aggregate.

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