Properties and effects of dormant aggregates on concrete strength

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Abstract. Aggregates used for concrete are sometimes abandoned on sites for extended periods of time. These aggregates are left dormant and exposed to harsh weather conditions before utilization. This study investigates the effect of aggregate dormancy of both fine aggregate (river sand) and coarse aggregate (gravel) on quality of concrete produced and its strength. Data for the study was collected over a 3 years dormant period of the aggregates, to determine the efficiency of the aggregates and its quality on concrete production and its strength. Experimental procedures such as; silt content, water absorption, specific gravity, sieve analysis, and the compressive strength test were conducted on the dormant aggregates to analyse its quality and strength of concrete produced through it. The analysis of the performed experiment on the dormant aggregates was presented through tables and figures. The finding of the study shows that that the strength of the concrete increases yearly due to reduction of silt content, high specific gravity, and an increase in the water absorption of the dormant aggregates. Base on the finding of this study, it is concluded that the dormancy of aggregates (river sand and gravel) have no effect on the concrete quality and its strength.

Keywords: aggregate; aggregate dormancy; silt content; water absorption; specific gravity; compressive strength.

1. Introduction

Aggregate dormancy is a dormant period of aggregates before utilization for concrete production [1]. In construction work generally, aggregate material required for concrete production was usually left in a state of inactiveness through its non-utilization and exposure to different atmospheric conditions. The dormancy of these aggregates could compromise the quality and strength of concrete to be produced using the dormant material. Abdullahi [2] in his work noted that aggregates of different types are used in the production of concrete. To attain good quality and strength, concrete needs a standard mix designed, good planning, established by professional institutions [3], [4]. Ojerinde [5] opined that provision of quality material for residential building need to meet some standard requirement in terms of mechanical and durability properties. Concrete as an artificial conglomerate is made of a bonded material such as cement, water, and aggregates with a restrained amount of entrained air [6]. Aggregates and water constitute concrete major component [7]. In the world all over, concrete is considered because of its material constituent sustainability, economic values, and strength [8]. The natural abandonment and availability of its major constituent materials required in its production influence its usage [9]. The study of [10] in assessing the quality of good concrete show
that density, permeability, shrinkage, fresh concrete segregation, grain sizes, shape, and toughness were characteristic that determines hardened concrete durability. Bamigboye [11] opined that aggregates account for between 60 -75% of the total volume of the concrete mixture. Conversely, Ajao [12], stated that concrete quality showed in the texture of aggregates together with its compressive strength values. The finding of [13], revealed that water/cement ration in concrete production depends on the aggregate type which is useful in achieving good strength and stiffness of concrete. Olajumoke [14] in their finding as corroborated by the study of [15], [16], show that the choice and quality of aggregates used in concrete production have a reasonable effect on the strength of concrete. Conversely, the study of [3] showed that the compressive strength of normal concrete is affected by aggregate types. The study further shows that concrete produced with quality aggregates will attain good compressive strength values. In a research work carried out by [17], gravel was used as coarse aggregate to produce normal and high-performance concrete, the result shows that it strength gave a similar compressive strength with basalt coarse aggregate material. The ready availability of aggregate required for concrete and its influence which is characterized by its quality and strength makes concrete an important method of production. It is a rewarding research goal to evaluate the properties and effects of dormant aggregates (river sand and gravel) on concrete quality and its strength.

2. Materials and Method

Ordinary Portland cement (Dangote brand) of 42.5R grade, Type 1 was obtained and used for this research work in accordance with [18]. Aggregates (river sand and gravel) were obtained in conformity with [19], from Ijoko aggregate dump site in Ogun State, Nigeria. The aggregates were collected over a three years dormant period. Best methods for mixing, curing, and strength testing parameter for concrete was strictly followed and they were all in compliance with [20]. The concrete was mixed using clean water, good for consumption devoid of impurities as stated in [21]. The research made use of the following equipment, apparatus, and tools: compressive strength testing machine, sieve shaker with different sieve sizes, digital oven, digital weighing balance, moisture content can with led, conical measuring cylinder, wheelbarrow, hand trowel, steel shovel e.t.c. Concrete produced using the dormant aggregates was cured by immersing the cubes inside curing tanks for 28days. The concrete cube was open dried for 24hours before its compressive strength was tested at different stages in accordance with [22], [23]. To have a good basis for the results, several tests such as Grain size distribution, Specific gravity, silt content, and water absorptions were conducted on the dormant aggregate samples to determine its quality and suitability, which were in conformity with the stipulated standards as stated by [24]. The safety procedure for the research was in line with the finding of [25].

3. Result and discussion

3.1 Grains size Analysis of fine aggregate (river sand) base on dormant period

The sieve analysis was carried out in accordance with [26]. From the result in Figure 1, it can be deduced that the Coefficient of Uniformity (CU) for 2016, 2017 and 2018 for fine aggregate sampled are 4.29, 4.37, and 4.47, while the coefficient of curvature (CC) are 1.39, 1.44, and 1.52 respectively. Based on the Unified Soil Classification (USC) the dormant fine aggregate could be adjudged as a uniformly graded soil based on the result of the analysis's which shows that CU > 4 and CC is between1-3, for all the samples. This is due to the effect of dormant age of the fine aggregate and its exposure to weathering condition over the years which reduces the silt particle content of the aggregate. The result buttressed the find of [1], [2].
3.2 Grains size Analysis of coarse aggregate (gravel) base on dormant period

The sieve analysis was carried out in accordance with [26]. The result from Figure 2, shows that the Coefficient of Uniformity (CU) for 2016, 2017 and 2018 coarse aggregate sampled falls within 2.1 while the coefficient of curvature (CC) falls within 1.24. Base on the Unified Soil Classification (USC) the soil could be classified as a poorly graded soil because CU < 4 but the aggregate can be said to be uniformly graded because CC is between 1-3. This is due to the exposure of the dormant coarse aggregate materials to weathering condition within the study years. Thereby, reducing the finer particles and making the gravel to be coarser. This result is similar to the findings of [27], [28].
3.3 Analysis of Silt content for fine aggregate (river sand) base on the dormant period

Result from Figure 3 shows the average silt content for the dormant fine aggregate within the years of study. The result shows that the silt content of the aggregates reduces from 7.3% (2016), 6.0% (2017) to 3.0% (2018). This reduction is due to the dormant period of the fine aggregate, and it provides more paste as lubrication for aggregates during concrete mixing. This study is similar to the result of [5].

![Figure 3: Analysis of silt content for the dormant fine aggregate](image)

3.4 Specific Gravity

Result from Figure 4, analyzed the specific gravity for the dormant aggregates within the years of study. The result shows that the fine aggregate specific gravity increases with time from 2.56 (2016), 2.63 (2017), to 2.7 (2018), while the dormant coarse aggregate specific gravity values reduce from 3.33 (2016), 3.22 (2017), to 3.00 (2018). This further buttressed the result of [27].

![Figure 4: Analysis of specific Gravity for the dormant fine and coarse aggregate](image)

The result from Figure 5, shows that water absorption for dormant fine aggregate increases from 1.87% (2016), 1.98% (2017), to 2.09% (2018), while water absorption for dormant coarse aggregate increase marginal from 0.56% (2016), 0.57% (2017), to 0.6% (2108). This further buttressed the result of [28].
Figure 5: Analysis of water Absorption for the dormant fine and coarse aggregate

3.5 Compressive strength
The compressive strength result for the three samples are shown in Figure 5, and it showed differences in the strength parameters of the samples used. With the average compress strengths of 20.24N/mm² (2016), 22.92 N/mm² (2017), and 24.48N/mm² (2018) gotten from the produced concrete using the dormant aggregates within the study years. Thereby, the concrete sample produced with dormant aggregates material (river sand and gravel) in the year 2018 (24.48N/mm²) as the highest average compressive strength. This result is in agreement with the finding of [1], [2] and [29].

Figure 6: compressive analysis of concrete sampled
4. Conclusion
This study examined the effect of aggregate dormancy of both fine aggregate (rivers sand) and coarse aggregate (gravel) on quality of concrete produced and its strength. The study showed that the dormant aggregates, based on dormancy period of the aggregate become coarser through marginal reduction of silt particles and high specific gravity over the years, which is due to weight and porosity of the coarse aggregate (gravel). The study further showed that the dormant aggregates absorbed more water over the years, which is attributed to the settlement of finer particles within the dormant aggregates due to its exposure to different atmospheric conditions within the dormant period. From the study, concrete with the dormant aggregates, showed average compressive strength between 20.24 N/mm² (2016), 22.92 N/mm² (2017), and 24.48 N/mm² (2018). This shows that the strength of the concrete increases yearly due to reduction of silt content, high specific gravity, and an increase in the water absorption of the dormant aggregates. Base on the findings of this study, it is concluded that the dormancy of aggregates (river sand and gravel) have no effect on the concrete quality and its strength.

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