COMPARATIVE ANALYSIS OF CONCRETE STRENGTH UTILIZING QUARRY-CRUSHED AND LOCALLY SOURCED COARSE AGGREGATES

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ABSTRACT

Concrete is the global construction industry's most critical and consumed construction material. The use of two types of coarse aggregates, Crushed granite and local coarse aggregate, is examined in this study. Compressive strength is the most vital property of concrete. This research utilized two coarse aggregates: crushed granite and local coarse aggregate. Sharp sand is the fine aggregate. An initial laboratory examination was conducted to establish the appropriateness of utilizing the aggregates for construction purposes. Slump tests were investigated. Mix ratio (1:2:4) was used for this work, and mix structures were analyzed using the absolute weight technique. A total of 18 cubes (150×150×150mm) were cast to permit the compressive strength to be observed at 7, 14 and 28 days. Test results revealed that concrete produced from local gravel has better workability than crushed granite. Concrete produced from granite aggregate produced higher compressive strength at all periods. Compressive strength patterns were suggested as a result of age at curing.

Keywords: Coarse aggregate, compressive strength, concrete, gravel aggregate,

1.0 INTRODUCTION

Concrete is described as artificial materials of Cement, sand, coarse aggregate and Water mixed in a definite proportion. The Cement in concrete acts as a binder that sets and hardens other concrete components together, while the aggregates are employed for adequate bonding (Raza et al. 2019). Solomon *et al.* (2017) have demonstrated that the quality of concrete is affected by the choice of coarse aggregate used in its production. Aggregates account for about 60- 75% of the total concrete mix volume and 70-85% of weight, with coarse aggregate contributing to about 45-55% of the total mass (Bamigboye et al. 2016). Aggregate is regarded as an inert material, but it is essential in determining concrete's thermal, elastic, and structural integrity. Concrete's workability, strength, durability, and economy are all influenced by aggregate qualities. (Neville, A., & Brooks, J. 2010). The significance of aggregate, as noted by Alexander and Mindess (2013), includes not only being filler material but also having essential physiognomies in improving the workability of fresh concrete.

Additionally, the properties of hardened concrete, such as volume stability, unit weight resistance to destructive environments, strength, and thermal properties, play significant roles in coarse aggregate production in Portland cement concrete. Thus, the choice of aggregate in concrete production can significantly affect the performance of concrete. The aggregate type by source significantly influences concrete's overall performance and strength in fresh and hardened stages (Hassan, 2011).

The coarse aggregate used in concrete mixing significantly affects the compressive strength of fresh and hardened concrete. Because coarse aggregates account for most of the volume in concrete, their overall properties impact the properties of concrete produced with various nominal mixes. The source, size, form, unit weight, texture, and other coarse aggregate characteristics determine their properties. The source from which coarse aggregates were collected significantly impacts their geological, mineralogical, physical, and mechanical properties. The strength, workability, and durability of concrete are all affected by variations in aggregate properties (either mechanical or physical). (Alexander MG, Davis DE.,1989). Olajumoke and Lasisi (2014) evaluated the strength of concrete made with dug-up gravel available in the Ile-Ife area of southwest Nigeria. The study showed a significant increase in compressive strength when the gravel was washed. In determining the compressive strength of washed and unwashed gravel at different mix ratios, Ode and Eluozo (2016) found that impurities on gravel impact the compressive strength of concrete prepared with unwashed gravel. They inferred that there is a positive relationship between the strength, stiffness and fracture energy of concrete and the type of coarse aggregates. Bamibgoye et al. (2016) undertook particle size distribution analysis, slump test and compressive strength on hardened concrete in exploiting the economics of gravel as a substitute for granite in concrete production. They found that a higher gravel composition significantly improves concrete's consistency property while more significant proportions of granite significantly enhance compressive strength. Also, Sulymon et al. (2017) reported that gravel sources greatly influence concrete's compressive, flexural and split-tensile strength.

This research aims to compare concrete strength using quarry-crushed and locally sourced coarse aggregate in Sokoto State.

1.1 Objectives

- i- To produce concrete samples
- ii- To determine the mechanical properties (compressive strength) of the concrete produced.
- iii- To compare the strength of the concrete produced.

2.0 LITERATURE REVIEW

2.1 Concrete

Concrete is an artificial material that has been used extensively and globally for a long time. Concrete is a coarse aggregate composite combined with Cement and Water's hydraulic paste (Salau et al., 2011). The quality of sand used in concrete preparation plays a paramount role in developing the resultant concrete's physical and strength properties. Water, Cement, fine aggregates, coarse aggregates and any admixtures used should be free from harmful impurities that negatively impact the properties of hardened concrete. Sand is one of the average natural fine aggregates used in concrete production (Sandanayake et al., 2020). Aggregates are inner granular materials such as sand, gravel, or crushed stone that, along with Water and Portland cement, are essential ingredients in concrete (Mark et al., 2010). Even though aggregate is a filler material, it is precious in producing concrete properties such as durability, workability, tensile strength and compressive strength. The type and properties of fine and coarse aggregate significantly affect the hardened concrete performance because it consists of a large percentage of concrete volume (Zhang, 2011). Good quality concrete is a homogeneous mixture of cement, coarse and fine aggregate, and Water, which consolidate into a rigid mass due to chemical action between the Cement and Water. Each of the four constituents has a specific function; the fine aggregate fills up the voids between the paste and the coarse aggregate. The Cement, in conjunction with Water, acts as a binder. The cement paste and fines aid the mobility of the mixture and, nowadays, are increased using admixtures.

2.2 Aggregates

The aggregates usually used for concrete production are natural deposits of sand and gravel; where available, in some localities, the deposits are hard to obtain, and large rocks must be crushed to form aggregate. Because of their shape, crushed aggregates usually cost a lot to produce and require more cement paste. More care must be taken when handling crushed aggregates to ensure a good mixture and proper dispersion of the size through the finished concrete. Artificial aggregates, such as blast furnace slag or specially burned clay, are sometimes used.

2.3 Fine Aggregate

These are materials that would pass through the No.4 sieve and will, for the most part, be retained on a No. 200 sieve. The fine aggregate should have a rounded shape for increased workability and economy, as reflected by less Cement. The purpose of the fine aggregate is to fill voids in the coarse aggregate and to act as a workability agent (Aluko, 2020).

2.4 Coarse Aggregate

Coarse aggregate is a material that will be retained on the international system of sieve 4.75mm with fine aggregate for increased workability and economy, as reflected by the use of less Cement. Coarse aggregate should have a rounded shape even though the definition limits the size for which other considerations must be accounted. When properly proportioned and mixed with Cement, these aggregates yield an almost voidless stone that is strong and durable (Aluko, 2020).

2.5 Curing of concrete

Since many of the properties of aerated concrete depend upon the successful curing process, outlined below are some methods by which its strength can be increased. This is the easiest and most popular method of curing. It is a slow but acceptable system that enables a turnaround of molds every 24 hours on average, depending on the ambient temperature. When precast erected concrete panels and slabs are made under factory conditions to obtain a relatively fast turnaround of molds, it may be economical to induce an early strength into the concrete by applying heat from steam to the underside of the molds. This causes a rise in temperature in the concrete and a resulting increase in strength (Aluko, 2020).

2.6 Compressive strength of concrete

The compressive strength of concretes constitutes one of its most significant and valuable properties and is the most easily determined. The compressive strength of concrete is taken as the maximum compressive load it can carry per unit area. Concrete strength of up to 80N/mm2 can be achieved by selective use of the type of Cement, mix proportions, method of compaction and curing conditions. Since compressive strength constitutes an essential and valuable property, it is used as a measure of the overall quality of the concrete and, thus, as an indication of other properties relating to the determination of durability (Akinsola *et al.*, (2012).

3.0 MATERIALS AND METHOD

3.1 Materials

a. Cement

The Cement was purchased from the cement stores at Arkilla at the back of Umaru Ali Shinkafi Polytechnic, Sokoto. The Cement used in this research is an ordinary Portland cement brand produced by Sokoto Cement (Nig).

b. Water

Water from the Department of Building Laboratory of Umaru Ali Shinkafi Polytechnic, Sokoto, produced the concrete mixture for this study.

c. Fine Aggregate

The fine aggregate was sieved through a BS 4.75mm sieve to remove some of the coarse aggregates.

d. Coarse Aggregates

Crushed granite and local coarse aggregate were used in this research. It was obtained from a local dealer at Arkilla at the back of Umaru Ali Shinkafi Polytechnic, Sokoto. It was cleaned and sieved to ensure they were dirt-free and conform to the coarse aggregate requirement, BS 12620 (2002). They are mostly used in the production of normal dense concrete.

Local coarse aggregate

Quarry-crushed aggregate

3.2 Method

a. Concrete Mix Proportion

The concrete samples were batched, mixed, and cast using a square mold size of 15x15x15cm in the Department of Building Technology laboratory, Umaru Ali Shinkafi Polytechnic Sokoto, Sokoto State. The Absolute Volume batching method produced concrete of a nominal mix of 1:2:4 using a w/c ratio of 0.60. A total no. of 2 experiments was prepared with mix proportions by weight, mix ratios of 1:2:4 and a water-cement ratio of 0.6 were adopted. Nine (9) cubes were produced for each experiment in triplicates and crushed at 7, 14, and 28 curing periods, respectively, making it a total of 18 (cubes).

b. Workability of Concrete (Slump Test)

The slump test measures the concrete's workability. It was conducted by 8500-2 (2002).

c. Compressive Strength Test

The compressive strength test of the hardened concrete was determined using the compressive testing machine at the Department of Civil Engineering Concrete Laboratory, Umaru Ali Shinkafi Polytechnic Sokoto, Sokoto State.

4.0 RESULTS AND DISCUSSION

Table 1: Compressive strength of concrete samples

	Samples	7days	14days	28days
1	Crushed granite	12.5	27.2	29.5
3	**Local coarse aggregate**	10.05	20.41	25.75

Source: Experimental work (2024)

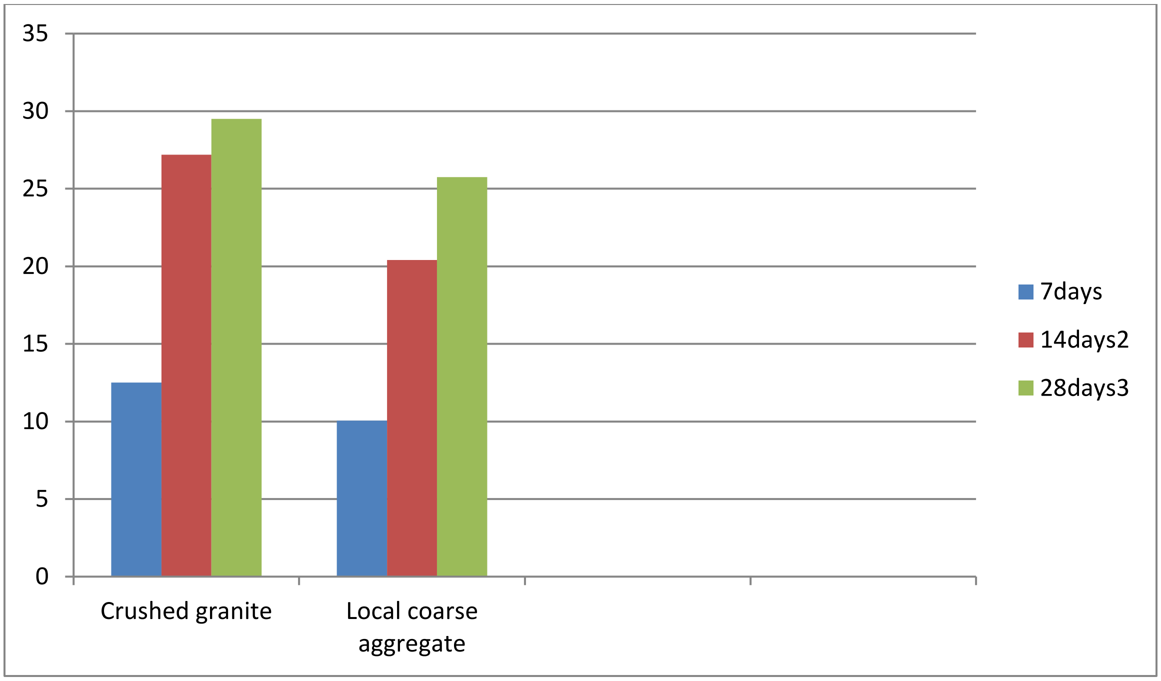

Figure 1

Table 1 and Figure 1 display the results of cube crushing at 7, 14 and 28 days, respectively. The compressive strength of granite at the 7 days is higher than that of the local gravel, with a considerable difference of 2 N/m^2. The 14-day granite compressive strength surpassed that of local gravel with a significant fringe of 6.8N/m^2. At 28 days, the compressive strength difference of 3.8 N/m^2. These results can be compared to work carried out by (Aginam et al. 2013; Olajumoke and Lasisi, 2014 Ode and Oluozo, 2016). Their results indicate an average of 15.93N/mm2 compressive strength for concrete made with unwashed gravel across southern regions in Nigeria. There was an increase in strength at growing curing ages, and in all instances, the compressive strength of the unwashed gravel was the minimum. The difference in strength growth could be due to the presence of silt, clay and humus materials, which are constraints to improvement of mortar and concrete strength (Joshua and Lawal, 2011; Olusola and Joshua et al., 2014). Based on the findings of this study, local gravel will be specified for use in structural members, while granite is more suitable for any structural work.

5. CONCLUSIONS

This research mainly aimed to compare crushed granite and locally sourced coarse aggregates to restrict their use in various applications. The following conclusions were drawn from this study:

- It was observed that concrete prepared with crushed granite achieved better compressive strength than those made with local gravels. This study validates the previous studies (Aginam et al., 2013; Olajumoke and Lasisi, 2014; and Ode).

• The findings in the current study may be of practical importance to stakeholders in the construction industry (i.e., contractors, clients, government, policymakers, and so on), who could adequately adjust their implementation and development plans based on the results of the study

6.0 RECOMMENDATIONS

- Notwithstanding the limitations of compressive strength differences due to compaction variation, the study suggests that gravel obtained with impurities should be sieved and washed before use in concrete production.
    - The utilization of granite is strongly advised in higher-strength concrete applications like high-rise buildings where strength compromise cannot be accommodated. Even if gravel is to be used in high-height applications, it should be sieved and the course content washed before use.
- However, unwashed gravels can be used for concrete production blinding and mass concrete works. Evaluation of the aggregates for strength capabilities is crucial to the sustainable growth of the construction industry and the economy in general.
- Further studies should investigate how to improve the utilization of gravel for higher-strength applications

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Appendix

Plate 5: Curing