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Case study

Performance evaluation of concrete made with sands from selected locations in Osun State, Nigeria

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ABSTRACT

It is common practice among most local contractors in Nigeria to produce concrete with any available sand, disregarding its attendant effect on concrete performance. Sands obtained from popular quarries in Osun State, Nigeria were investigated to determine their suitability for concrete production. The sands were labelled A, B, C, D and E. Physical and chemical properties as well as grading characteristics of the sand samples were determined using standard procedures. Impurities in the sands were equally evaluated. Strength and water demand of the concrete produced from these sands were also examined. The results showed that all the sands contained high silica with traces of alumina in almost the same quantity except Sand E that had relatively low silica but higher alumina. Particle size distribution of the sands indicated that Sand A had more fine particles with fineness modulus of 1.95 while sand D was coarser (2.79) and other sands (B, C and E) were within the range of 2.7 and 2.6. The specific gravities of the sands fell in the range of 2.5–2.7 except Sand A, which was 2.2. The strength of the concrete made from each of the sands equally differed significantly, with Sand E having the highest strength (23.5 N/mm^2). Water absorption results indicated that Sands A and C may pose durability challenges due to higher water absorption compared to other sands. The study concluded that the selected sands had influence on the performance of concrete and it was recommended that all except Sand A, could be used for specific construction application.

1. Introduction

Construction aggregate, or simply 'aggregate', is a broad category of particulate materials used in construction which includes sand, gravel, crushed stone, granite, slag, recycled and geosynthetic aggregates.

Aggregates constitute approximately 80 percent of the total volume of concrete; hence aggregate characteristics significantly affect the performance of fresh and hardened concrete as well as have an impact on the cost effectiveness of concrete [1]. Aggregate is the most inexpensive component of Portland cement concrete after water. Conversely, cement is the most expensive component and, typically, is responsible for about 42 percent of the total cost of materials [2]. If aggregate of minimal voids are used, the amount of paste required for filling these voids will also be minimized enhancing workability and strength. Consequently, optimal mixture proportioning will produce good-quality concrete with a minimum amount of cement. Within prescribed limits, the less the paste at a constant water-cement ratio, the more durable the concrete.

Studies carried out by [3] showed that incidents of building collapse in Nigeria are traceable to the use of substandard building materials such as poor aggregates. The common practice, especially among local contractors in Nigeria like any other developing

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countries, is to select any available sand, mindless of its properties, for concrete production. Many of them do not have the wherewithal to carry out quality control on sand before use. Thus, the sand used as fine aggregate in concrete production may not be well graded and may contain excessive fines (silt and clay) as well as organic impurities that reduce the strength of hardened concrete made from them.

Researchers have shown that aggregates could no longer be viewed as inert ingredients of concrete as their indispensable role in concrete performance has now been recognized. For instance [4], noted that physical, chemical as well as thermal properties of aggregates greatly influence the properties of concrete. Similar reports have shown that natural aggregates containing organic impurities interfere with the hydration process, which subsequently impairs strength development. Furthermore, aggregate hardness provides wear resistance to the concrete mass while its strength provides better dimensional stability for concrete. Without aggregates, large castings of neat cement paste would essentially lead to self-destruction upon drying. The best grading for concrete is a highly debated issue [5].

In general, there is agreement that well-graded aggregate greatly contributes to the overall quality of concrete. These mixtures produce denser concrete with a higher degree of aggregate packing resulting in a less permeable product. Excessive coarse aggregate, on the other hand, can produce concrete with poor abrasion resistance while excessive sand can produce mixtures requiring increased water for effective pumping and finishing. Simultaneously, though, insufficient fine material can produce mixtures that lack cohesion and segregate readily [6]. In the same vein, particle size distribution of fine aggregate plays a very important role on workability, segregation, and pumpability of fresh concrete. Many authors claim that uniformly distributed mixtures produce better workability than gap-graded mixtures, although higher slumps could be achieved with gap-graded mixtures. Some properties of hardened concrete are also affected by grading [5].

In the work of [7], sands sourced from eight supply points in Nairobi City County and its environs were investigated to determine the qualities of sands and their effects on the bond strength of concrete. Their results indicated that the bond strength between concrete and reinforcing bars decreased with increase in silt and clay content as well as the presence of organic impurities. Despite the fact that aggregates are available naturally, sourcing them is still a major challenge taking into consideration of their environmental impact. Most aggregates are quarried from the ground or rock, while larger proportion of fine aggregates is obtained from water bodies. In the cause of quarrying or blasting rocks, environmental damages occur such as noise pollution, habitat of many organism are destroyed while most fertile land are rendered useless [8]. Worst still, the areas where such quarrying of rocks occur are exposed to earth trembling and uncontrollable erosion. The import of this trend is that the practice is not sustainable, since the quarried rock could not be rejuvenated. Thus, aggregates are sourced indiscriminately.

Presently, there is dearth of information regarding the quality of fine aggregates commonly used in Osun State for construction purposes. Neither the local contractors have the wherewithal to investigate the quality of sand used nor could the client afford additional cost of investigation. Thus, they result to indiscriminate use of sand in concrete. The attendant effect is that poor concrete is produced, which is dangerous to the inhabitant of the building built with it. This study, therefore, investigated sands selected from five supply points in Osun State, Nigeria. This is with a view to evaluating their effect on concrete produced from them. The results would seem to serve as guide to local contractors that source their sands from these locations as well as provide information as to their suitability for concrete production or otherwise. This will further add to the existing knowledge of impact of sand quality of concrete properties.

2. Materials and methods

2.1. Materials

Ordinary Portland cement of grade 32.5 was used as binder. Coarse aggregate used was granite of maximum nominal size of 12.5 mm. Potable water was used for mixing the concrete, while sand samples were collected from five main supply points in Osun State, Nigeria. Sand from *Alakowe Opa* was named Sand A while those from Erosion Deposit Pit and *Eleweran* were sands B and C, respectively. These supply points are within *Ile-Ife*. Similarly, Sands D and E were those obtained from *Coker Village* and *Okinni*, in *Osogbo*, the State capital. Fig. 1 shows the locations where the sands were collected.

The choice of Ile-Ife and Osogbo were deliberate. Osogbo is the State capital, while Ile-Ife hosts the only Federal university in the State. It is expected that construction works will be more in the two cities compared to other locations in the State. Fig. 2 shows the appearance of the sand collected from each supply point.

2.2. Chemical, physical and grading properties of the sand samples

Oxides present in each of the sands were determined, using XRF technique. The test was conducted at the chemical laboratory of Lafarge Cement, Ewekoro, Nigeria. Specific gravity and moisture content tests were carried out in accordance to [9], respectively. Grading analysis and fineness modulus for each sand sample were equally determined following the procedure specified in [10].

2.3. Determination of impurities in the sand specimens

In determining organic impurities in each of the sand samples, a glass bottle was filled with sand sample to about 130 ml and sodium hydroxide solution was added up to 200 ml level. The bottle was covered and shook vigorously. Then, the bottle was allowed to stand and the colour of the filtrate was observed after 24 h.