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Comparative Analysis of Quality Difference of Three Locally Sourced Coarse Aggregates in Concrete Strength Performance at Selected Locations of Huda, Kola and Babban Dutse Towns of Birnin Kebbi Local Government.

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ABSTRACT

This study investigated the quality and strength variation of concrete produced using three locally sourced coarse aggregate from Birnin Kebbi local government. Samples of aggregates from Huda, kola and Babban Dutse aggregates were tested for physical properties including specific gravity, void and water absorption. Concrete cubes were casted with each aggregate specimen and tested Using rebound hammer for compressive strength at 7, 14 and 28 days. The results revealed significant variation among the aggregate samples in both the physical features and strength performance. Huda coarse aggregate revealed the best physical properties over other samples as it has the water absorption capacity of 2.06 above others with 1.75 and 1.54 absorption capacity. In terms of workability, Huda specimen indicated high level of workability with 82mm above other specimen with 42mm and 75mm workability level. The test revealed that Huda coarse aggregate has the highest compressive strength of 20.1N/mm, 23.4 N/mm and 27.5 N/mm for 7, 14 and 28 days respectively. While other samples have the compressive strength of 16.2N/mm, 17.5N/mm, 19.8N/mm and 18.6N/mm, 20.2N/mm and 23.4N/mm for 7, 14 and 28 days respectively. This indicated that Huda coarse aggregate has the highest compressive strength followed by the Babban Dutse sample and lastly the kola sample with the lowest strength and poor quality indices.It also indicated that Huda aggregate has high environmental performance and as such is the best specimen for sustainable construction. The study recommends the use of Huda coarse aggregate for critical structural applications and also suggest further investigation into the treatment or blending of lower quality aggregates to enhance performance.

Key words: Aggregate, compressive strength, concrete, variation and quality.

Introduction

Globally, concrete is considered the most fundamental and commonly used materials in concrete production, and its production on annual basis is predicted to rise to 5.5 billion tons by the year 2050. It has positive aspects like strength and durability. (Abdurrahman *e-tal*, 2024). Coarse aggregate is a fundamental component of concrete, which affects its strength, workability, and durability. The selection of suitable aggregates is critical, especially in regions where locally sourced materials are used due to economic and environmental considerations.The compressive strength of concrete depends on the water to cement ratio, degree of compaction, ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate. (Bhavya & Sanjeev, 2017).Aggregates is one of the fundamental constituents in concrete and it covers two-thirds of the totalconcretevolume.Concreteisacompositematerialwhichconsistofcement,sand,coarseaggregate and water. David et-al (2018) posited that the quality and strength of concrete is ofteninfluenced and determined by the choice of coarse aggregate used in the production. Manyproperty developers for both public and privates' projects, Due to high and progressivelyincreasing cost of construction material and transportation, many property developers and construction managers for both public and private projects, have resorted to the use of locallysourced building material. This can be achieved through the use of indigenous buildingmaterials that are available and accessible within the construction site locations. Birnin Kebbi as localgovernment and state capital has an abundant deposit of different coarse aggregate materialsobtainableatHuda, KolaandBabban Dutsetowns, whichifutilized properly can significantlyreduce the cost of construction and transportation of materials. Again, in Birnin Kebbi, manyincidencesofbuildingcollapsehaveoccurredandarestillhappeningduetothenatureand quality strength of the concrete used in the construction. This concrete failure is often influenced by the type of coarse aggregate used in production of the concrete.

As such it becomes imperative to investigate and compare concrete strength and quality difference using three different types of locally sourced coarse aggregate in Birnin Kebbi local government in order to determine among the three coarse aggregate which has more performance in terms ofquality and strength and also recommend on the type and level of construction work at which each coarse aggregate can be utilized.

Statement of Research Problem

Compressive strength of concrete is significantly affected by poor quality coarse aggregate such as porous, excessively rounded and poorly graded particles. The bond between cement paste and aggregate particles can be reduced, leading to weaker concrete with increased potential for cracking and reduced durability. Locally sourced coarse aggregates are abundant in Birnin Kebbi local government and are usedfor various construction projects which include residential commercial,industrial, specializedand many more for both public and private individual project. The three different locally sourcedcoarse aggregate obtainable at Huda, kola and Babban Dutse locations have differences in terms ofshape, gravity, density, grading, texture (roughness) and moisture. These features are essential indesigning concrete mix proportion. As at today, no single study has been conducted in BirninKebbi to determine their level of physical variation and quality difference in concrete productionand also determine their level of compliance with the building code of the minimum gradeacceptable for the concrete production. It is in view of the above that this study tends to compareand analyses the quality difference and use suitability of the three different coarse aggregatelocally sourced from Birnin Kebbi Local Government and also recommend at which constructionleveleachofthethreedifferentcoarseaggregatesmaterialscan beusedinconcreteproduction.

Aim and Objectives of the Study

Aim

Thisstudyaimed atcomparingandanalyzing thequalitydifferenceofthethree(3)differentlocallysourcedcoarseaggregateobtainableatHuda,KolaandBabban Dutseinconcretestrength.

Objectives

- To determine the physical characteristics of the three (3) different coarse aggregate sourced fromthelocalareasofHuda,Kola and Babban Dutseinthe studyarea.
- To determine the workability of the three different samples.
- To determinecompressivestrengthofthecubesproduced fromthethreedifferentcoarse aggregates inthestudyarea.
- To recommend onthetypeandlevelofconstructionand concreteproduction forwhicheachtype ofaggregateissuitableandapplicable.

Literature Review

Concrete is made up of cement, water, and fine and coarse particles mixed in a specific ratio toachieve a desired strength.The aggregate particles are held together by a paste that is createdwhen cement and water react chemically. The mixture solidifies as a mass that resembles rockand has a high compressive strength but low tension resistance.Concrete's original fluid nature gives it a great deal of versatility. It can be put into a mold andcompressed by ramming or vibratingit to trap air. The liquid solidifies after a few hours,allowingfortheremovalofthemoldor formwork. Whenusedinafoundationandtheloadtobe borneis entirely compressive.The resulting composite structure is called reinforced concrete.In heterogeneous materials like concrete, the quality of the constituent proportions in which theyare mixed determines the strength and properties of the resulting products. Knowledge of theproperties of cement, aggregates, and water is necessary to understand the behavior of concrete.In ordinary structural concrete, the aggregates occupy about 70% to 75% of the volume of thehardened mass (Olufemi& Manasseh, 2019). However, in bending, tension could develop atlowloads.

The work was prompted, according to Gambhir (2019), in his article on the assessment of coarseaggregate sizes on concrete quality, by observations made at building sites where artisans andcraftsmen were left alone in the manufacturing of concrete. Due to the difficulties of mixing, itwas found that they did notutilize enough coarse particles, eitherin terms of amountor size,even though they were not necessary for the creation of concrete. According to the research, thecreation of sufficient strength in concrete is significantly influenced by the coarse particles andtheir sizes. It was shown that when the slump test results were properly mixed, there was alwaysactual slump rather than shear or collapse type slump. When the coarse aggregate size wasincreased, the workability declinedslightly. The compressive strength increasednoticeably asthe amount of coarse particles increased. It can be deduced that when appropriate mix ratio,batching, mixing, transporting, placing, and finishing techniques are used in concrete processes,thestrengthoftheconcretecanbeimprovedbyincreasingthesizeofthecoarseaggregate.

3. 0 METHODSANDMATERIALS

3.1 Materials

Coarse Aggregate

Three (3) different samples of local coarse aggregate were obtained from three different quarries. First sample of local coarse aggregate was obtained from Huda Quarry which is reddish in colour and angular in shape. Second sample was obtained from Kola Quarry which is brown in colour and round in shape and the third sample was obtained from Babban Dutse Quarry which is white in colour and round in shape which is locally called (kankara).Laboratory sieve analysis was conducted for the removal ofimpuritiesin order toconform tothegradingrequirementBS 882:

Physical properties of the three samples of coarse aggregates

Source of Coarse Aggregate	Apparent Specific Gravity	Unit weight	Absorption Capacity	Bulk Specific Gravity	Void
Huda Coarse Aggregate	2.76	1586	2.06	2.72	38
Kola coarse aggregate	2.41	1416	1.54	2.38	37
Babban Dutse Coarse aggregate	2.53	1512	1.75	2.49	39

Source: Laboratory experiment 2025

Cement

Portland cementbrand producedfrom BUA Cement Company produced in accordance with NIS 87: Part 1 was utilized in mixing the concrete with a 41.5 N strength class. PC has a specific gravity of 3.14 and comprises 75-80% clinker, limestone and 0-7% gypsum. The setting time for cement was 162 minutes and 513 minutes for the final setting. Its early strength after three days was 20.3 MPa. This cement was known as Sokoto Cement Brand.

Fine Aggregate

Locally available fine aggregate was used in mixing the concrete. The fine aggregate sieve analysis was conducted using standard sieve size of BS 4.75mm (No. 4). This was meant for segregation between fine and coarse aggregate.

3.2 Method

Mix Proportion of Concrete

The cube concrete specimen were casted and produced using a square plastic mold size of$15cm^3 x 15cm^3 x 15cm^3$ in line with the specification (BS1881:Part108:1983). This was carried out in Building Technology Laboratory of waziri Umaru Federal Polytechnic Birnin Kebbi. The concrete were batched by weight. The quantity of each material for concrete mixed was determined using the standard and prescribed mix design of 1:2:4, water-cement ratio (w/c)of 0.6. This was meant for obtaining a target compressive strength of the concrete (BSEN12390-3). The mix ratio of 1:2:4 of the cement, coarse aggregates, sand and water were mixed together. A total of Fifty (50) cubes were produced for each sample of aggregate. This led to a total of One hundred and fifty cubes (150). The concrete specimens (cubes) were then placed in a curing medium and kept in the laboratory ambient condition, and tested in7,14, and 28 days. The cubes were removed from the curing tank, wiped off from the grit, naturally dried and weighed for determination of the ir individual masses for computation of volume and water absorption.

Slump Cone Test (Workability of concrete)

This is a test that is used to determine the worker-ability of concrete and variations in the uniformity of a mix of given nominal proportions.

Test Procedure

A metal cone or metallic mold with a bottom diameter of 20cm, top diameter of 10cm and height diameter of 30cm was used with a base plate. Steel tamping rod of 16cm diameter and60cm height was also used for compacting. The internal surface of the cone was cleaned and freed from moisture and other hardened substance. The slump cone was filled with mix concrete in three layers and each layer tampered with the tamping rod. The cone was lifted gently and the reduction in height of the unsupported concrete was measure and recorded as the slump in line with the BSEN12350-2:2019.

Testing of Hardened Specimens (compressive strength Test)

Compressive strength test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to it compressive strength. Cubes specimens produced with concrete were tested with the rebound hammer which is a non-destructive testing method of concrete which provide a convenient and rapid indication of the surface compressive strength of the concrete. The concrete surface was cleaned and smooth. The test points were marked with ruler. The rebound hammer was tested against the cleaned surface and finally the readings from the rebound hammer was taken and which shows the compressive strength of the concrete cubes.

This procedure was repeated for all concrete cubes specimen produced from the three different types of coarse aggregate.

RESULTS AND DISCUSSION

Table showing the workability of three samples of coarse aggregate

S/ N	Coarse Aggregate Type	Slump Height	Workability classification
1	Huda Coarse Aggregate	85mm	High workability
2	Kola Coarse Aggregate	42mm	Low workability
3	Babban Dutse Coarse Aggregate	70mm	Medium Workability

Laboratory experiment: 2025.

The table above indicated that *Huda coarse aggregate* (sample A) has the workability of 85mm which shows that the workability is high can be used for heavy reinforced construction. *Kola Coarse aggregate*(sample B) revealed a workability of 42mm which shows a very low workability and such is restricted to harsh mixes such as road construction. While *Babban Dutse Aggregate*(sample C) shows a workability of 74mm which indicated a medium workability and can be utilized in reinforced concrete.

Table 2: Compressive strength of concrete cubes produced from Huda, Kola and Babban Dutse Coarse Aggregate.

Curing Days	Average Density: AD (g/cm	Average Volume AV (cm)	Average weight: AW (g)	Average Load: AL (KN)	Average Compressive Strength: ACS (N/mm)
Sample A: Huda Coarse Aggregate					
7	325	3585	5921	305	20.1
14	395	3585	6243	515	23.4
28	418	3585	7645	589	27.5
Sample B: Kola Coarse Aggregate					
7	322	3585	5618	274	16.2
14	348	3585	5918	328	17.5
28	374	3585	6437	369	19.8
Sample C: Babban Dutse Coarse Aggregate					
7	324	3585	5732	284	18.6
14	371	3585	6124	378	20.2
28	396	3585	7218	398	23.4

Source*: Laboratory Test*, 2025.

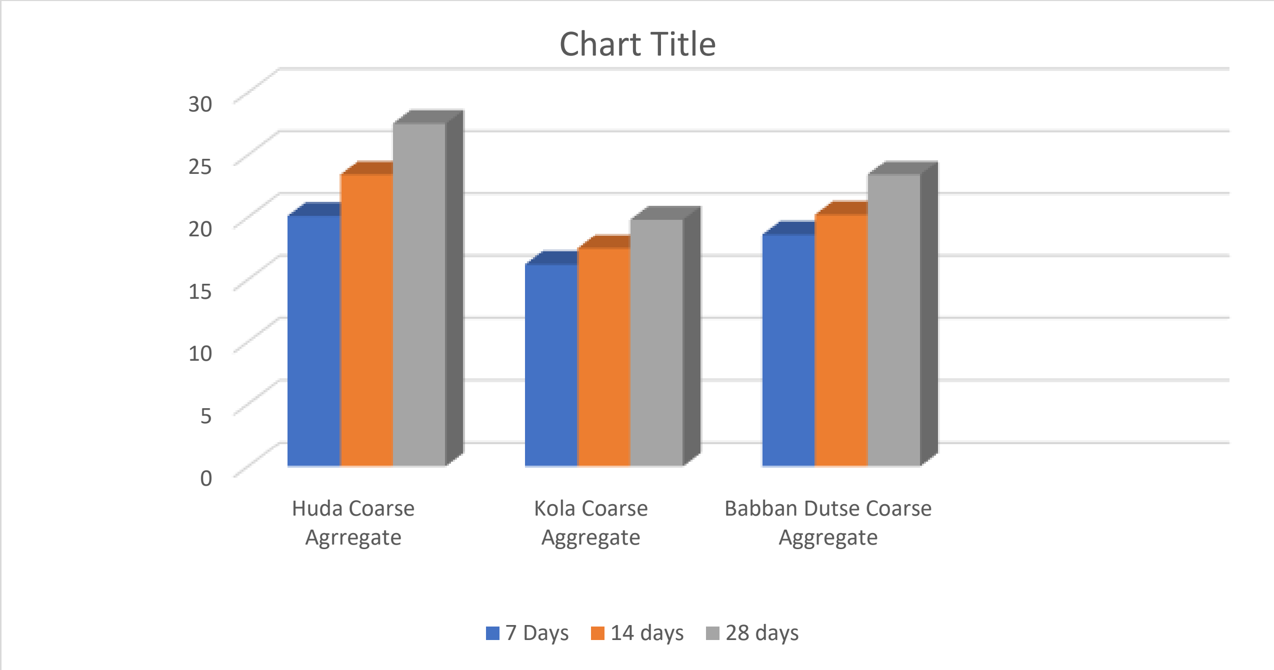

Figure 1

Figure 1 above revealed the results of rebound hammer test of cubes at 7, 14 and 28 days, respectively. The compressive strength of Huda local coarse aggregate at 7 days is higher than that of kola and Babban dutse coarse aggregates with strength values of 20.1N/m^2, 16.2N/m^2 and 18.6N/m^{2}respectively.At 14 days the reading from the rebound hammer indicated the compressive strength of 23.4N/m^2, 17.5N/m^2 and 20.2N/m^2 for Huda, Kola and Babban Dutse local coarse aggregates respectively. At 28 days, the readings shows a compressive strength of 27.5N/m2, 19.8N/m2 and 23.4N/m2 for the Huda, Kola and Babban Dutse aggregate respectively. This indicate a progressive increase in strength of the concrete at curing level. At all level of curing, Huda local coarse aggregate has the highest strength, followed by Babban Dutse and then Kola aggregate with the lowest strength.

Table 3. The sizes of the selected coarse aggregate and their applicability to concrete works.

Aggregate Property	**Aggregate size (mm) Diameter**	**Applicability to concrete construction work**
Huda coarse aggregate	12-17 mm diameter	Residential Buildings, Pavement, Precast element, Reinforced concrete with closely arranged reinforced members,
Kola coarse aggregate	23-28 mm diameter	Bridges, High rise buildings, Industrial floors etc.
Babban Dutse coarse aggregate	15-19 diameter	Mass concreting, Road basement, General concrete works where high strength is not the priority.

Source: Laboratory observation, 2025.

The table above indicates the different sizes of the coarse aggregate and also the construction levels at which they are applicable. Huda aggregate has the size of between 12-17mm diameters and is applicable to residential buildings, pavement, precast element and reinforced concrete. Kola coarse aggregate is between the sizes of 23-28 mm diameter and is applicable to concrete works for bridge, high rise building, industrial floors etc. While Babban dutse coarse aggregate is between the sizes of 15-19 mm diameters which is suitable for mass concreting, road basement and general concrete works that does not require high strength.

Table 4.0 Economic Feasibility of the Multiple aggregates of Huda, Kola and Babban Dutse

Cost Componenets	**Huda Aggregates (#)**	**Kola Aggregates (#)**	**Babban Dutse Aggregates (#)**	**Remarks**
1. Cost of fuel (per 10 ton trip)	18,000	24000	21,000	Base on distance from quarry to batching site
2. Transport cost (per trip)	25,000	30,000	28,000	Includes truck hire and drivers wage
3. Machine hiring per day for crushing	40,000	50,000	47,000	For crushing, screening and batching
4. Labour cost (daily average)	35,000	46,000	39,000	Loading packing and supervisiosn
5. Royalty tax per trip	15,000	15,000	15,000	Paid to government or local authority
6. Other missilaneous	10,000	10,000	10,000	For site levies and other local fees.
Total estimated cost per trip	**143,000**	**175,000**	**160,000**	**Summation of all listed costs**
Ranking (from cheapest to costliest)	1st	3rd	2nd	Huda coarse aggregate the most economically feasible

Source: field/market survey 2025

From the above analysis it is indicated that Huda aggregate is the most economically feasible due to its proximity and cost of transportation. While Babban Dutse is the second cheapest and Kola aggregate is the least economically feasible due its long distance and higher cost of fuel and transportation. As such, it is therefore established in terms of cost of the aggregate per trip, Huda coarse aggregate is the most economically feasible.

Table 5.0 Environmental Impact Assessment of Locally Sourced Coarse Aggregates in Kebbi State.

Parameter	**Huda Quarry**	**Kola Quarry**	**Babban Dutse Quarry**	**Environmental Impact Insight**
Aggregate Crushing Value (ACV)	24.1% (±1.9)	20.2% (±2.1)	26.3% (±2.0)	Lower ACV indicates more durable aggregates; Kola Quarry has the most durable aggregate.
Los Angeles Abrasion (LAA)	27.8% (±2.9)	25.7% (±2.7)	30.1% (±3.1)	Higher LAA implies more wear and dust; Babban Dutse may generate more environmental particulates.
Water Absorption (%)	1.48% (±0.19)	1.19% (±0.15)	1.78% (±0.21)	Higher water absorption increases cement demand and affects water resources.
Specific Gravity	2.64 (±0.03)	2.68 (±0.02)	2.60 (±0.04)	Lower values may imply less dense, less durable material; Kola Quarry provides denser aggregates.
Compressive Strength (MPa)	30.2 (±1.8)	28.1 (±1.7)	26.3 (±2.2)	Higher strength reduces material usage and construction footprint; Huda Quarry is most efficient.
Dust Generation Potential	Medium	Low	High	Inferred from abrasion and crushing values. Babban Dutse likely produces more fugitive dust.
Water Usage Impact	Moderate	Low	High	Based on absorption and potential water demand during mixing.
Ecological Disturbance Risk	Medium	Low	High	Correlated with aggregate quality, handling, and environmental degradation potential.
Suitability for Sustainable Construction	Moderate	High	Low	Overall efficiency, durability, and environmental performance considered.

Source: Field survey and laboratory analysis 2025

From the table above it is indicated that Huda demonstrates the best environmental and structural performance, making it most suitable for sustainable concrete production. Kola Quarry shows moderate quality, with acceptable durability and environmental impact. Babban Dutse Quarry poses higher environmental concerns (dust, water usage, ecological risk) and provides the lowest material strength, making it less favorable for sustainable use without treatment or blending.

Conclusion and Recommendation

The study investigated the quality and strength variation of the concrete produced using the three different locally sourced coarse aggregate from the local quarries of Huda, Kola and Babban dutse of Birnin Kebbi local government of Kebbi state. Laboratory test and experiment were conducted to determine the physical characteristics of the aggregates which includes specific gravity, unit weight, water absorption rate and void. Standard concrete cubes were cast using the various aggregates and finally tested to determine the compressive strength at 7, 14 and 28 days. The result revealed significant variation in physical properties and compressive strength among the different local aggregates. The Huda coarse aggregate showed higher strength performance and also better physical features making them the most suitable for structural concrete among the three sources. The other coarse sources from Kola and Babban Dutse indicated a relatively lower strength and poor physical features making them less suitable for structural construction if not treated adequately. This variation indicated a critical influence on the quality and strength of the concrete. As such, proper selection and assessment of the aggregate should be made prerequisite to concrete mix design more particularly in the local context.

The study therefore recommend as follows:

Stakeholders in Kebbi state construction industry should perform a regular quality assessment on locally sourced coarse aggregate before application in concrete production to ensure compliance with the standard.The design of concrete mix should be tailored to the specific physical features of locally sourced aggregate for achieving optimal performance. The relevant regulatory agencies in Kebbi state should develop and enforce standard guiding the production testing and application of locally sourced coarse aggregates. Engineers, builder, and artisans should be trained on the implication of aggregate variability and the importance of material testing for achieving safe and durable concrete structure. Finally further studies can focus on investigating the long-term durability performance (resistance to sulphate attack) of the concrete using these three locally sourced coarse aggregate of Huda, Babban Dutse and Kola.

Reference

Abdullahi, M. (2012). Effect of aggregate type on compressive strength of concrete. *International Journal of Civil and Structural Engineering,* 2(3), 782–784.

Abdullah J D K L, Ali N, Mohamed R N & Abdullahi M .M. (2018). The Effect of Quarry DustwithCementBy-ProductsonPropertiesofConcrete.*MalaysianJournalofCivilEngineering*30(3)415-428.

Adesanya, D. A., & Raheem, A. A. (2009). Development of corn cob ash blended cement. *Construction and Building Materials,* 23(1), 347–352. https://doi.org/10.1016/j.conbuildmat.2008.01.013.

Aginam, C. H., Chidolue, C. A., & Nwakire, C. (2013). Investigating the effects of coarse aggregate types on the compressive strength of concrete. *International Journal of Engineering Research and Applications*, 3(4), 1140–1144.

Alexander, M. & Mindess, S. (2013). *Aggregates in Concrete: Modern Concrete Technology*(e-library).Taylor&Francisgroup,LondonandNew York.

Alhozaimy, A. M. (2009). Effect of local aggregate on the mechanical properties of concrete. *Construction and Building Materials,* 23(2), 625–633. https://doi.org/10.1016/j.conbuildmat.2008.01.015.

Anosike, M. N., & Oyebade, A. A. (2012). Sandcrete blocks and quality management in Nigeria building industry. *Journal of Engineering, Project, and Production Management,* 2(1), 37–46.

ASTM C33/C33M-18. (2018). Standard specification for concrete aggregates. *ASTM International*.

British Standards Institution. (2008). BS EN 12620:2002+A1:2008. Aggregates for concrete. BSI

Ede, A. N., & Amadi, A. (2014). Investigation of the suitability of some selected gravel deposits for concrete production in Nigeria. *Nigerian Journal of Technology*, 33(1), 78–84. https://doi.org/10.4314/njt.v33i1.13.

Ettu, L. O., Ajoku, J. C., & Nwachukwu, K. C. (2013). Strength of ternary blended cement concrete containing palm kernel shell ash and groundnut shell ash. *The International Journal of Engineering and Science*, 2(7), 5–11.

Falade, F. (1999). The use of local aggregates for the production of concrete. *Journal of Environmental Studies*, 2(1), 1–5.

Gambhir, M. L. (2013). Concrete technology: Theory and practice (5th ed.). Tata McGraw-Hill.

Neville, A. M. (2011). Properties of concrete (5th ed.). Pearson Education Limited.

Okoli, O. G., & Ezeokonkwo, J. U. (2014). Suitability of Awka-North (Nigeria) coarse aggregates in concrete production. *International Journal of Scientific & Engineering Research*, 5(1), 1551–1554.

Olutoge, F. A. (2010). Investigations on sawdust and palm kernel shells as aggregate replacement. ARPN *Journal of Engineering and Applied Sciences*, 5(4), 7–13.

Olanitori, L. M. (2006). The effect of aggregate sizes on the strength of concrete. *Journal of Research Information in Civil Engineering*, 3(2), 59–64.

Osei, D. (2013). The use of coconut fibre in the production of structural lightweight concrete. *Journal of Materials Science and Engineering B*, 3(3), 203–207.

Oyekan, G. L., & Kamiyo, O. M. (2008). Effect of granite fines on the mechanical properties of concrete. *Nigerian Journal of Engineering Research and Development*, 7(4), 26–30.

Shetty, M. S. (2005). Concrete technology: Theory and practice. S. Chand Publishing.

Ukpata, J. O., Ephraim, M. E., & Akeke, G. A. (2012). Compressive strength of concrete using lateritic sand and quarry dust as fine aggregate. *ARPN Journal of Engineering and Applied Sciences*, 7(1), 81–92.

Udoeyo, F. F., & Dashibil, P. U. (2002). Sawdust ash as concrete material. *Journal of Materials in Civil Engineering*, 14(2), 173–176. https://doi.org/10.1061/(ASCE)0899-1561(2002)14:2(173)