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Comparison of M20 Concrete Strength Characteristics Using Different Locally Accessible Fine Aggregates

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ABSTRACT
The affordability of building materials is critical in all types of construction. Bricks, cement, rod, and sand account for a sizable portion of total construction materials. The cost of building materials is not the only factor pushing up prices. The cost of blocks work and concrete contributes significantly to the overall cost of construction. The block work and concrete materials are primarily made of fine aggregates. Concrete is a composite material used to construct structures, and as such, it is critical that the materials used to make the concrete are of high quality and meet standards. The purpose of this study was to determine the strength of concrete produced from four locally available geotechnical fine aggregate in Usen town, Ovia South West LGA of Edo State, as a precursor to such materials being used as an alternative to river sharp sand in construction to reduce construction costs.
Keywords*: Aggregates, Characteristics Strength of Concrete, M20 concrete, Construction*

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I. INTRODUCTION

In Nigeria, widespread and severe poverty is a reality. It is a reality that depicts a lack of food, clothes, education and other basic amenities. Severely poor people lack the most basic necessities of life to a degree that it can be wondered how they manage to survive (Ucha, 2010).Poverty and homelessness are inextricably linked. When individuals or families are unable to generate enough income to pay for necessities such as housing, food, childcare, health care, and education, necessities with a high cost burden may be neglected. Although the cost of living and housing have risen, wages have not kept pace, and eviction is becoming more common as a result of an inability to pay rent or mortgage payments (IGH, 2017). According to Homeless Hub (2021), it has been conclusively proven that poverty and homelessness are closely related, with a loss of income serving as a significant contributing factor to homelessness.

In Nigeria, the cost of constructing a home is constantly rising due to so many factors. Whether you wanted to build a simple boys' quarters apartment, a duplex, or a bungalow with three bedrooms etc.

Building a house in Nigeria is not as difficult as a lot of people make it seem especially of you know what you want and what to do about it. There are different housing options to choose from, depending on your budget and other factors (Maramani.com, 2022).

According to Ikenna (2022), the cost of building a house is affected by a number of factors ranging from:

- Location of the property.
- Cost of obtaining necessary permits and ownership documentation
- Nature of the site
- Cost of building materials.
- Quality of building materials.
- Charges of professionals as it varies.

According to building industry researchers, building materials account for between 50 and 60 percent of the total construction input. The high price of these products, which is believed to have slowed the growth of the building and construction sector in Nigeria, must therefore be urgently addressed. The largest single input in housing construction is building materials. While Arayela (2005) asserted that the cost of building materials makes up about 65 percent of the construction cost, Adedeji (2010) found that about sixty (60) percent of the total housing expenditure is spent on the purchase of building materials.

One of such building materials is the concrete. According to Rahman (2019), quality of the concrete plays an important role in the construction field as the concrete is the excessive element in any construction. The strength parameters such as durability, load bearing strength and resistance to environmental factors such as wind, snow and water depends on the quality of concrete. So the quality of concrete is to be taken as an important factor in the construction of any building or other structure. Generally, the quality of concrete is checked in the different stages of the concreting process.

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service conditions. Concrete mix can be designed or proportioned to obtain the required engineering and durability properties as required by the design engineer (Paul, 2016).

PROBLEM STATEMENT/JUSTIFICATION

Building materials play an integral role in the development of the construction industry because they are the materials used to construct buildings; construction projects would be fraught if building materials were not used (Akanni, Oke&Omotilewa, 2014).

The continued reliance on imported building materials has exacerbated Nigeria's already precarious balance of payments situation and fueled inflation in the industry, which has led to cost overruns on public and private building projects. Additionally, it prevents private initiatives to produce shelter and makes it impossible to provide shelter for the nation's low-income households.

The cost construction of is quite high. Considering the poverty level in the country and its attendant house deficiency it is important to investigate into the use of other locally available fine aggregate to address this high cost.

This research is targeted at investigating the strength of concrete produced from the local geotechnical fine aggregates with a view of identifying alternative(s) to lower the cost of construction materials.

OBJECTIVES(S) OF THE STUDY

The followings are the objectives of the study:

a) To investigate and determine different geotechnical fine aggregate material present in Usen community (at least)

b) To compute performance analysis for each of the materials as regards concrete strength

c) To compare the performance of these materials

d) Report the results of the comparative studies and analysis

II. LITERATURE REVIEW

As the foundation for building development in any country, the building and construction sector is extremely important for the social and economic development of that country. One of the essential components that makes this sector functional is the cost of acquiring the building materials (Ademola, 2014; Gbadebo, 2014; Agulaka, 2003).It is common knowledge that the cost of building materials and components accounts for between 60 and 70 percent of the cost of buildings. This inevitably implies that expensive building materials will result in expensive construction costs. On the other hand, the obvious remedy for Nigeria's high cost of housing construction is the availability on a sustainable basis of relatively inexpensive, locally produced, and tried and true building materials and technologies.

The delivery of housing has been significantly slowed down by the high cost of building materials, but this issue can be rationally minimized by using non-conventional building materials or some locally available materials.

Construction materials are things that are used in building. Buildings have been made from a variety of naturally occurring materials, including clay, mud, rocks, sand, wood, thatch etc. In addition to naturally occurring materials, a variety of man-made products, some more synthetic than others, are in use. One of the most versatile of these building materials is the concrete.

Concrete is the most widely used man-made material on the planet, second only to water in terms of usage (Jackson, 1981). It is one of the most important building materials because it is relatively inexpensive, simple to manufacture, provides continuity and solidity, and binds quickly with other materials. It is composed in the proper proportions of cement, fine aggregate (sand), coarse aggregate (crushed or uncrushed stones), and water. The raw materials used to make the concrete are crucial to its quality (Nwafor&Eme, 2016).

Concrete is a mixture of particles that are tightly bound together and an engineering material that mimics the characteristics of rock. It is merely a mixture of aggregates, typically made up of crushed rock or natural sand and gravel. A hydraulic binder, such as Portland Cement, is used to bind them together, and water is used to activate the binder to create a dense, semi-homogeneous mass.According to the America Concrete Institute, cement, fine aggregate, coarse aggregate, water, chemical admixtures, and mineral admixtures are the main components of the concrete mix. Reinforcing bars, wire mesh, and other reinforcing fibres may also be present in concrete used in construction. The strength of the concrete is influenced by the type of ingredients used, their amounts, and how they are combined.

The compressive strength of concrete is determined by its batching for every batch in order to maintain the desired quality of concrete during casting. Concrete specimens are a cast and tested under the action of compressive loads to determine the strength of concrete.

The capacity of concrete is reported in psi – pounds per sq. inch in US units and in MPa – mega pascals in SI units. For normal field applications, the concrete strength can vary from 10Mpa to 60 Mpa. For certain applications and structures, concrete mixes can be designed to obtain very high compressive strength capacity in the range of 500Mpa, usually referred as Ultra High Strength Concrete or Powder Reactive Concrete.The compressive strength of concrete is given in terms of the characteristic compressive strength of 150 mm size cubes tested at 28 days. The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall.Average 28 days' compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used shall not be less than 90% of average of strength of three similar concrete cubes prepared with distilled water (Rahman, 2019; Paul, 2016; Afsar, 2012).

There are different grades of concrete but for this research an M20 grade concrete is what we are zeroing on. IS 456-2000 has specified the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In the following construction video tutorial, brief explanation is given on M20 grade of concrete. In M20, M denotes Mix and 20 refers to the characteristic strength (fck) of that mix i.e. 20Mpa. Cement, sand and aggregates are used for mixing in the ratio of 1 : 1.5 : 3. M20 signifies mixture of cement, sand and aggregate which are prepared in such a manner that a cement concrete cube of size 15 cm x 15 cm x 15 cm is formed with characteristic strength (fck) of 20mpa while examining it after being cured for 28 days.The characteristic strength (fck) signifies the strength under which not over 5% of test results are predictable to fail.

The concrete compressive strength for normal construction work varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and more in commercial and industrial structures. The strength of concrete depends on factors such as water-cement ratio, the strength of cement use, quality of concrete materials, quality control during the production of concrete, etc. (Mahajan, 2022). The M20 strength is 20MPa.

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III. METHODOLOGY

- **Objective**:Determination of compressive strength of concrete.
- **Apparatus**: The Schmidt rebound hammer or rebound hammer
- **Number of Specimens**:At least four specimens for each fine aggregates. Preferably from different batches made up of fine aggregate from different sources within and around Usen community, shall be made for testing at each selected age.
- **Materials**: The materials and methods adopted in this research work were as follows;

a) Cement: Ordinary Portland cement

b) Fine Aggregate: Four different types of fine aggregate including river sharp sand (sample 1), erosion sand (sample 2), top soil (sample 3), laterite (sample 4).

c) Coarse Aggregate: 20mm crushed granite.

d) Water: Portable drinkable water obtained from borehole within the polytechnic.

- The test samples were batched and prepared and concrete was tested for 7, 14, 21, 28days.
- Four (4) samples reading for a particular batch (mix) were taken and the averages estimated.
- 16 samples each were produced and the total of 64 cubes.

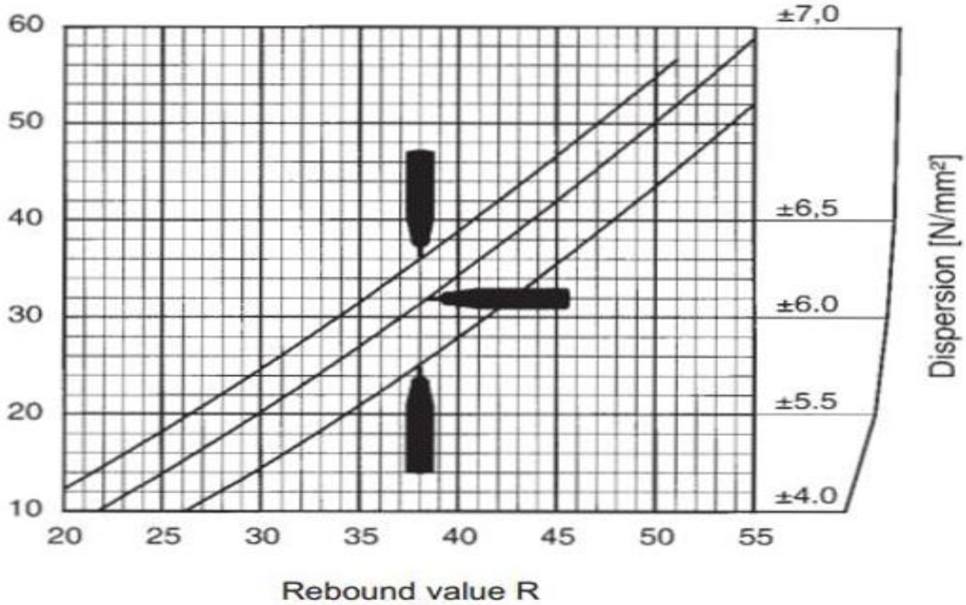

Figure 1: Rebound number and Characteristics strength graph

Table 1: Rebound Number for 7 days

Samples	1st	2nd	3rd	4th	Average
1	18	20	18	21	19.25
2	17	18	18	19	18
3	16	15	14	15	15
4	17	16	16	16	16.25

Sample 1: River sharp sand

Table 2: Rebound Number for 14 days

Samples	1st	2nd	3rd	4th	Average
1	25	23	23	22	23.25
2	22	22	23	19	21.5
3	16	16	17	18	16.75
4	20	19	20	21	20

Sample 2: erosion sand

Table 3: Rebound Number for 21 days

Samples	1st	2nd	3rd	4th	Average
1	26	26	27	28	26.75
2	23	21	22	24	22.5

Sample 3: topsoil

3	18	19	21	20	19.5
4	19	20	22	22	20.75

Table 4: Rebound Number for 28 days

Samples	1st	2nd	3rd	4th	Average
1	29	27	28	28	28
2	25	26	28	27	26.5
3	19	18	21	20	19.5
4	22	24	24	25	23.75

Sample 4: laterite

The tables 1-4 presents the rebound numbers for each concrete sample for days 7, 14, 21 and 28.
The compressive strength test was done at 7, 14 and 28 days to assess strength development of concrete. All samples indicated a progressive strength gain with curing age with Sample 1 developing the highest initial strength and 3 recording the lowest. At 7 days curing, none of the samples attained any early strength of 20N/mm2 of the characteristic strength. At this stage all the rebound number were less than 20. At 14 days of curing, all the samples with the exception of sample 3 got a rebound number of 20 and above. With this rebound number the strength can be deduced from figure 1 (mass curve for converting rebound number to characteristics strength of concrete).At 21 days of curing it is observed that all the sample at this stage had rebound numbers of 20 and above. The same for 28 days of curing.

At 21 days of curing the only M20 sample that attained the characteristic strength of 20N/mm2 was sample 1 with 20N/mm^2.
At 28 days of curing the final characteristics strength all of the samples investigated were sample 1, 23.5N/mm^2; sample 2,20N/mm^2; sample 3, 12.2N/mm^2 and sample 4, 16.5N/mm^2.

Table 5: characteristics strength of concrete

Days	Average Rebound Number	Characteristics Strength of Concrete (N/mm^2)
7 days	19.25	12.0*
	18	11.3*
	15	9.4*
	16.25	10.2*
14 days	23.25	16.0
	21.5	14.0
	16.75	10.5*
	20	12.5
21 days	26.75	20.0
	22.5	15.0
	19.5	12.2*

	20.75	13.0
28 days	28	23.5
	26.5	20.0
	19.5	12.2*
	23.75	16.5

- Interpolated values for characteristics strength of concrete

Table 6: percentage characteristics strength of the samples

Days	Average Rebound Number	Characteristics Strength of Concrete (N/mm^2)	% Characteristics strength of concrete
7 days	19.25	12.0	60
	18	11.3	56
	15	9.4	47
	16.25	10.2	51
14 days	23.25	16.0	80
	21.5	14.0	70
	16.75	10.5	52
	20	12.5	63
21 days	26.75	20.0	100
	22.5	15.0	75
	19.5	12.2	61
	20.75	13.0	65
28 days	28	23.5	118
	26.5	20.0	100
	19.5	12.2	61
	23.75	16.5	83

Further analysis based on the percentage characteristics strength of the total expected strength is as follows from table 6.

At 7-day curing for the samples the percentage of characteristics strength were sample 1, sample 2, sample 3 and sample 4; 60 %, 56%, 47% and 51%.

At 14-day curing for the samples the percentage of characteristics strength were sample 1, sample 2, sample 3 and sample 4; 80%, 70%, 52% and 63%.

At 21-day curing for the samples the percentage of characteristics strength were sample 1, sample 2, sample 3 and sample 4; 100%, 75%, 61% and 65%

At 28-day curing for the samples the percentage of characteristics strength were sample 1, sample 2, sample 3 and sample 4; 118%, 100%, 61% and 83%.

IV. Conclusion

Building materials account for between 50 and 60 percent of total construction input, according to building industry researchers. The high cost of these products, which is thought to have slowed the growth of Nigeria's building and construction sector, must therefore be addressed immediately. Building materials are the most expensive single input in housing construction.

From this study it can be concluded that sample 2 can be used as a replacement for sample 1 as building materials (fine aggregate) in the bid to lower construction cost.

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