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A Comparative Study of the Strength of Concrete made with River Sand and Quarry Dust as Fine Aggregate

Ihimekpen, N.I and Ugwueze, R. C

Department of Civil Engineering, Faculty of Engineering,

University of Benin, Benin city, Edo state, Nigeria.

Corresponding author: ruth.ugwueze@eng.uniben.edu.

ABSTRACT.

The cost of river sand is high due to the high cost of transportation from its natural sources. Also, the huge amount of consumption of these sources leads to environmental problems. Also, environmental transportation and other constraints make the availability and use of river sand less attractive, hence it is very necessary now to find substitutes or replacements for river sand. This study compares the strength of concrete made using River sand and Quarry dust as fine aggregate, using a mix ratio of 1:1.5:3 for both types of fine aggregate with a water ratio of 0.5 and 0.55. The result for the sieve analysis carried out showed that the aggregates fell within the upper and lower limits of grading requirement. The specific gravity of river sand used was 2.6 while that of quarry dust was determined and the results obtained was 2.54. The slump obtained from specimens with different W/C of 0.5 and 0.55 ranged from 51 – 75mm. The concrete produced from 100% quarry dust as fine aggregate with a water-cement ratio of 0.5 produced a maximum compressive strength of 35.27 N/mm^3 at the highest curing age in days, while sand as fine aggregate produced the compressive strength of 34.17 N/mm^3 . The result showed that the concrete made with Quarry dust had a slightly higher compressive strength than the concrete made with River sand. The study concludes that quarry dust can be a suitable replacement for River sand in concrete construction, as it not only helps to conserve natural resources but also result in a stronger concrete.

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Keywords: Concrete, cement, strength, quarry dust and river sand.

1. Introduction

Concrete is a composite material that is produced by mixing water, cement or another binding agent, and aggregates (both fine and coarse aggregate) and is frequently used in construction

(Barritt, 1984, ASTM 2015). The most often used fine aggregate in the creation of concrete is river sand, commonly referred to as concrete sand. However, due to the material's excessive use, our environment is the most severely harmed, and the cost of river sand has increased recently (Sukesh at el 2013). Apart from river sand, sea sand, pit sand, manufactured sand, crushed gravel (quarry sand) and crushed stones there are many other types of fine aggregates which are being used in the construction industry today, and many more suitable alternatives are at their level of research and development in laboratories around the world. To some extend these alternatives are being used, to partially or completely replace river sand. Developing countries has taken a major responsibility of constructing the infrastructure, to meet this requirement of globalization in the construction of building as well as other structures concrete plays an important role and a large quality of it is being used. River sand, which is highly expensive and also scares, is one of the main components used in the preparing of conventional concrete. The accessibility of river sand as a fine aggregate at low-cost option is not possible, therefore there is need to search for an alternating material.

Quarry dust is a waste material that is generated from stone crushing industries which is concreted material in the form of dust. It is dumped as useless material causing air pollution. Recycling such waste by incorporating them into building materials is a practical solution for pollution problem and can become an alternative building material, the use of waste to make concrete is a new technique to handle waste materials from industries. The need for natural sand, or river sand, is being replaced by alternative materials in the developing world's building sectors in order to lessen environmental impact and waste management costs, increase concrete quality, and lower production costs. (Lohan et al 2012). Concrete quality is assessed using the criterion of compressive strength (Troxel et al 1968, M.S Shetty 2008, K.E Kurtis 2018, ACI 2019). knowing fully well that the strength of concrete is majorly derived from the aggregates, and as such it becomes necessary that for a concrete to be used, its compressive strength has to be determined. So here comparison is made between the compressive strength of concrete made with river sand and that made with quarry dust as fine aggregate in the production of concrete

2. Materials and Methods.

River sand

River sand obtained from Okhuaihe river, Edo state, Nigeria was used as fine aggregate for this experimental work and the River sand Sample was classified as uniformly graded fine sand.

Quarry dust

The quarry dust used in this work was obtained from the abundant deposits at A quarry site in Uhunwode Local Government Area of Edo state, Nigeria. Quarry dust is a fine rock particle, grey in colour.

Coarse Aggregate

Gravel was used as coarse aggregate for this experimental work.

Water
Water used in the experiment was clean tap water free from impurities capable of undermining the chemical reaction of cement with the water. Density and PH value of water were 1000kg/m3 and 6.9 respectively

Cement
Limestone Portland cement purchased at the building material market in Edo state from local distributors. The cement was well protected from dampness and it had a mass of 50kg, and grade 42.5N.

Sieve analysis
Sieve analysis of the fine aggregates were carried out and the results displayed in table 1 below.

Table 1: Sieve Analysis Result

Approx. Imperial Equiv (inches)	British Standard Sieve size(mm)	Retained (gm)	Passing (gm)	Passing (%)
$^1/_8$	3.35		100	100
7	2.36	5.00	95.00	95.00
10	2	14.00	81.00	81.00
14	1.18	16.00	65.00	65.00
25	0.6	21.00	44.0	44.00
36	0.425	38.7	20.00	20.00
52	0.3	0.70	5.30	5.30
72	0.212	3.30	2.00	2.00
100	0.15	1.00	1.00	1.00

This conforms to grading zone III.

Specific Gravity Test

Specific gravity test was carried out on the grit sample and is expressed in the table 2 below.

Table 2: Specific Gravity test

BOTTLE/ TEST NUMBER	1	2
Weight of bottle only (g)…. M1	22.50	17.70
Weight of Bottle and dry Sample (g)…M2	56.60	56.80
Weight of Bottle, Sample and water (g)….. M3	95.90	92.40
Weight of Bottle and Water (g)…… M4	75.20	68.70
$G_S = \frac{M2-M1}{(M4-M1)-(M3-M2)}$	2.54	2.54
Average G_s =	2.54.	

Mix Design, Casting and Curing

Mix design involves the calculation of various materials needed to produce a given volume of concrete. In this study, 3 cubes of dimensions 100mm x 100mm x 100mm were used in other to produce a high-quality concrete. A consideration of the design is therefore necessary in order to come up with the appropriate mix in accordance with BS 1881 part 125:1986, BS 8500-2: 2006 and BS EN 206-2013. The concrete was produced in two different batches;

- Batch 1 100% river sand as fine aggregate
- Batch 2 100% quarry dust as fine aggregate

The concrete cubes were made in standard Moulds at a mix design ratio of 1:1.5:3 and w/c of 0.5 and 0.55 The slump of the wet concrete was measured maintaining the specifications of the BS 1881: Part 102 (1983), AASHTOTIM (2018) and ASTM C143/C143M (2020). For each type

of fine aggregates cubes (100x100mm) were cast also in accordance to BS 1881: Part 108 (1983), AASHTO T23 (2017) and ASTM C31/C31M (2019). After one day of casting, the concrete cubes were removed from the mould and were transferred to a water tank for curing until the specimens are ready for compression test

Figure 1: Quarry dust sample

Figure 2: Concrete in cubes moulds

Figure 3: Concrete Mix Sample.

Figure 4: cubes in Curing Tank.

Compressive Test Testing

The concrete cubes were cured and compression test carried out at 7, 14, and 28 days. Three cubes were tested for each water cement ratio and the average taken as the compressive strength of the concrete**.**

3. Result and Discussion

Properties Of Aggregates

The result for the sieve analysis carried out showed that the aggregates fell within the upper and lower limits of grading envelope indicating that it is very suitable for construction works.

Specific Gravity

The specific gravity of river sand was obtained as 2.6, while that of grit was determined as shown in table 2. The results obtained from two outcomes were 2.54 and 2.54, and the average found was 2.54. This was taken as the specific gravity for grit and it falls within the standard range for fine aggregates.

Slump and Workability

The results of the slump test of the wet concrete specimens were also obtained. The slump obtained from different W/C of 0.5, and 0.55 ranged from 55 – 75mm. The slump at a w/c of 0.55 was relatively higher than that of other 0.5 indicating the concrete produced better workability at increased absorption and w/c. At lower water-cement ratio more paste will be required to make the mix cohesive and produce better workability.

Compressive Strength.

The result for the compression test on the concrete is shown in Table 3, for the concrete specimens considered. It was generally observed that the compressive strength increases with age of curing. The highest strength was obtained for each w/c at 28days of curing. At curing age of 14days the compressive strength of concrete made with both quarry dust and river sand was having close values of compressive strength. At the w/c of 0.5 there is an increase in compressive strength of concrete made with River sand with corresponding decrease in compressive strength of concrete made with quarry dust content. This may be due to the high-water absorption property of quarry dust which left insufficient water in the mix for the complete hydration of cement. The quantity of coarse aggregate affected the strength of the concretes, the more the coarse aggregate in the mix, the less the strength in the quarry dust concrete as compared to river sand concrete. The reason for this is that as aggregate quantity increases, the quantity of fine aggregate in the concrete decreases, thereby reducing the aggregate surface area to absorb water, with consequence of increasing the free water content in the concrete. The highest compressive strength is 32.33N/mm^2 obtained for concrete containing quarry dust while the lowest strength is 21.67 N/mm^2 , obtained with the same concrete made of quarry dust. This is due to the difference water cement ratio and the curing days So quarry dust can effectively be used to replace river sand and reduce the negative impact this causes our environments due to constant plunging of our rivers and coastal areas in the name of extracting river sand for construction purpose

The variation of compressive strength (N/mm^2) with age (days) using a w/c of 0.5 and 0.55 compares well with the previous works of Udeoyo *et al* 2006, Illangovana et al 2008 and Efe. E.I and Salu M.A 2010. The strength of quarry dust was a bit low for the same water/cement ratio probably because of excessive water in the concrete which exceeds the required amount of the hydration of cement since quarry dust does not have much water absorption capacity. This agrees with work of Khamput. P (2006), Al-Mukhtar, M.A and Al-Jbril K.A (2010) and Raj, G.N and Sivakumar M. (2010). who gave a lower water/cement of 0.5 as optimum for concrete using quarry dust as fine aggregate. The result of Illangovana *et al* 2008 for quarry dust also compares closely with others.

The strength characteristics of quarry dust is almost same as that of the river sand, the specific gravity and sieve analysis result shows that quarry dust can be as alternatives to river sand as fine aggregate. The specific gravity of all the crushed samples lies in between 2 to 2.7 which fulfill the river sand requirement

Table 3: Compressive Strength Result of Concrete made with River sand.

Curing Time(days)	W/C	Compressive strength(N/mm^2)
7	0.5	28.00
	0.55	26.08
14	0.5	31.67
	0.55	27.67
28	0.5	34.17
	0.55	28.17

Table 4: Compressive Strength Result of Concrete made with Quarry Dust**.**

Curing Time(days)	W/C	Compressive strength(N/mm^2)
7	0.5	21.67
	0.55	25.5
14	0.5	32.33
	0.55	27.00
28	0.5	35.27
	0.55	29.00

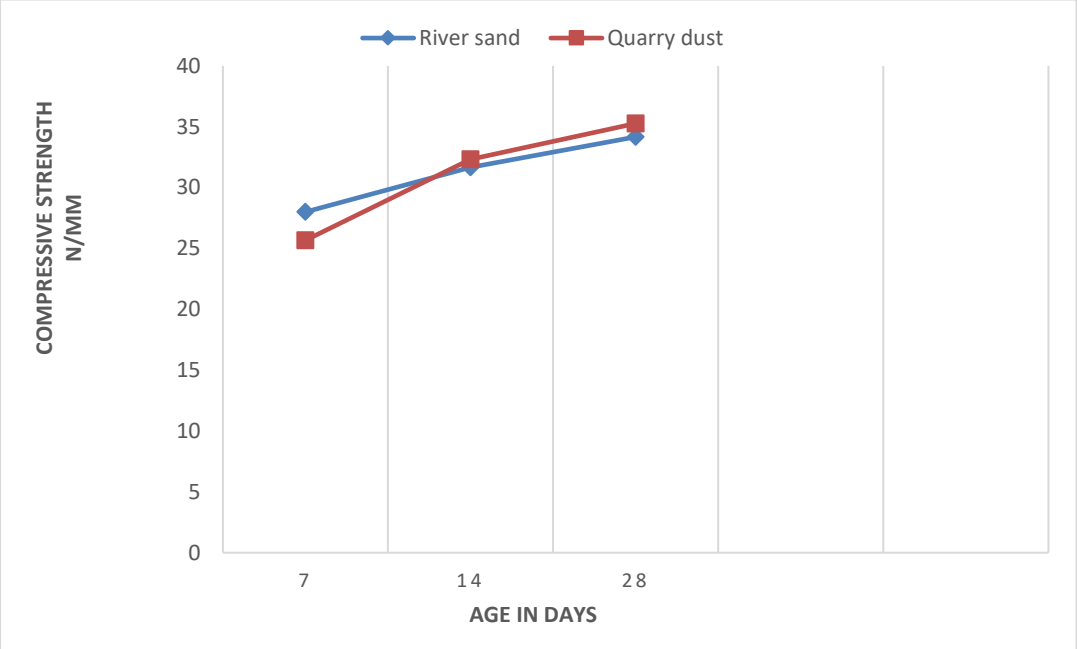

Figure 4: Effect of compressive strength of concrete against curing time with water/cement ratio of 0.5

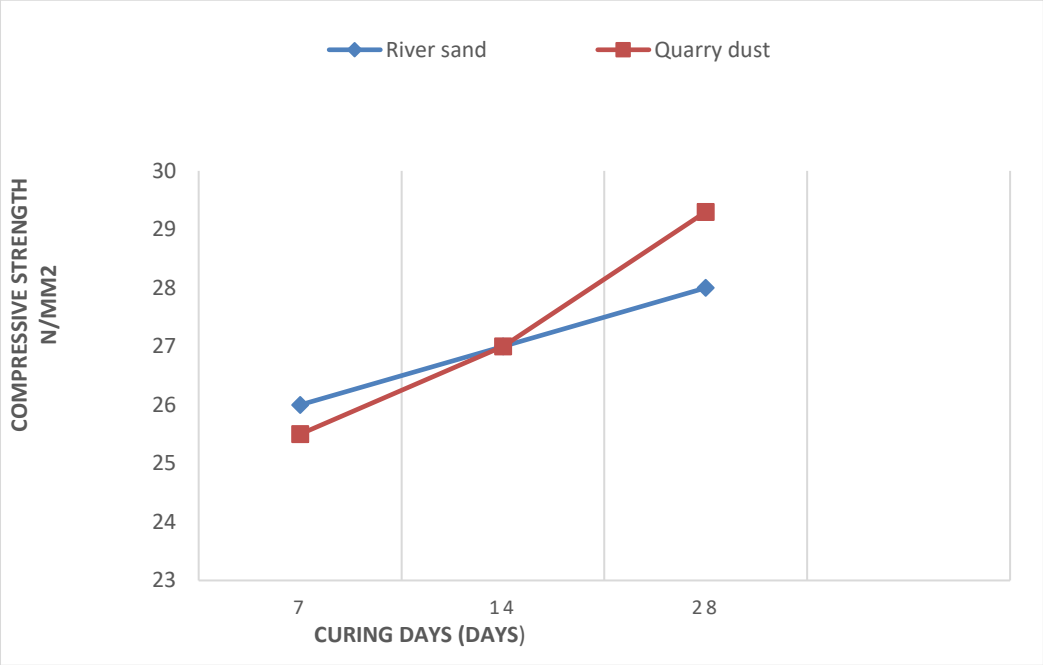

Figure 5: Effect of compressive strength of -concrete against curing time with water/cement ratio of 0.55

4 Conclusion

The following conclusion can be drawn based on the results and discussion of the study conducted:

1. Maximum compressive strength for concrete samples was obtained at the longest curing age of 28 days.

2. Highest compressive strength was obtained from concrete sample made with quarry dust as fine aggregate.
3. The more the water content in the mix, the less the compressive strength of concrete.

4. quarry dust can effectively be used to replace river sand and reduce the negative impact this causes in our environments due to constant plunging of our rivers and coastal areas in the name of extracting river sand for construction purposes.

Recommendations

Based on the result of the study carried out, the following are hereby recommended

1. The quarry dust can be widely used in construction industry

2. quarry dust can be used as fine aggregate in concrete for paving block of good permeability capacity and high-grade concrete production

3. quarry dust gives better workability and strength when it is mixed with the ingredients like fly ash in concrete, further studies and investigations should be carried out on this area**.**

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