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European Journal of Advances in Engineering and Technology, 2018, 5(6): 391-395

Research Article ISSN: 2394 - 658X

Effect of Partial Replacement of Sand with Quarry Dust on the Properties of Concrete

Ibrahim Yahaya[1], Mustafa Aminu[2] and Samaila Saleh[3*]

[1 & 2]HND Student, Department of Civil Engineering, Hassan Usman Katsina Polytechnic, Katsina Nigeria
[3]Lecturer, Department of Civil Engineering, Hassan Usman Katsina Polytechnic, Katsina Nigeria
Emails: ibrahimyahaya023@gmail.com, musteeyelladan@gmail.com, samailasaleh2003@yahoo.com
**Corresponding email: samailasaleh2003@yahoo.com*

ABSTRACT

The continuous increase in the cost of river sand and the fear of environmental and ecological distortionobligethe need to find materials that can replace river sand in the production of concrete. The purpose of this research is to study the properties of the fresh and hardened concrete made using quarry dust as fine aggregate to replace some portion of sand. In this research, the mixing proportion of Cement: Fine aggregate: Stone (gravel) is equal to 1:2:4 by weight and Water/Cement (W/C) ratio equal to 0.60. The result of compressive strength at 28 days using quarry dust to replace sand 0%, 5%, 10%, 15%, 20% and 25% (15.49, 12.5, 16.82,16.40, 20.00, and 17.76) N/mm^2 respectively. The compressive strength of normal concrete is 15.49 N/mm^2 and 20N/mm^2 for 20 % replacement is nearly above as all concretes mixed with quarry dust. The experimental results suggest that the concrete mixed with quarry dust could be used in the general concrete project since there is an increase in a certain percentage replacement in the strength of the concrete.

Key words: Sand, Quarry Dust, Properties of Concrete

INTRODUCTION

Concrete is the one of the critical construction material used in the world of all engineering works including the infrastructural development proving that it is a cheap material and it is constituents are widely available. Due to widespread usage and fast infrastructural development in all over the world, there is a shortage of natural aggregate, such as fine aggregate and coarse aggregate. To prevent this fine aggregate and coarse aggregate can be replaced with west materials. Concrete is a mixture of water, cement orbinder and aggregate (fine and coarse aggregate) and is a commonly used material for construction. River-sand has been the most popular used fine aggregate in the production of concrete; our environment is worst hit also the price of river sand has soared in recent time. The decrease in the sources of natural sand and the need for minimising the production cost of concrete has causedthe need to identify substitute material to sand asa fine aggregate in the production of concretes. In such a situation the dust can be a fiscal alternative to the river sand [1].

Sukesh *et al* [2], the construction industry in developing worthd is looking for alternative materials that can replace the demand for natural sand, thereby reducing the burden on the environmental,cost saving, waste management, as well as enhancing the quality of concrete.

The quality of concrete is determined base on its compressive strength Lohan *et al* [3].

Quarry dust is a fiscal alternative to the river-sandmainlydue to the additional cost of transportation from natural sources,andlarge-scale depletion of these sources create a problem. Sand mining of either side of the river upstream and in-stream is one the course of environmental degradation and also a threat of biodiversity. Over alarming rate of un-restricted sand mining cause damagesto the ecosystem of the natural habitat of organism living on the river bed, it affects fish breathing, migration, increases saline water in the rivers and spellsa disaster for the conservation of many bird species. Extraction of alluvial material from within or near a stream bed has a direct impact on the concrete material.

Quarry dust, is a product of the crushing process during mining activities of granite. It can increase the strength of concrete, however, reduce the workability of concrete. Its specific gravity depends on the nature of the rock from which it was made. Shrinkage and water absorption is more in quarry dust when compared to that of the natural river sand [4].

2. MATERIALS

2.1. Coarse Aggregate

In this paper, crushed granite chippings of size 19mm to 20mm nominal size obtained from Azuba commercial quarry dust seller in Katsina was used. It was ensured that before use, the aggregates were passed through sets of sieves to screen the particle sizes. The portion passing through sieve 20mm and retained on sieve 5mm was used. Approximately four bags of 50 Kg/bag were purchased so as to cover for the entire experiment.

2.2. Fine Aggregate

Natural sand (having smooth and more rounded particles) used was used. It was air-dried in the Civil Engineering laboratory before use to reduce excess moisture. Natural sand produces conventional concretes that are more workable than those of manufactured sand. For use in this concrete production, it was ensured that the sand was clean, sound and well-graded according to requirements set by ASTMC 144, standard specification of aggregates for conventional concrete.

2.2. Cement

Dangote Ordinary commercial Portland cement grade 42.5R was used being the most widely recommended material of its kind. It acts like a hydraulic binder that sets and hardens by chemical interaction with water conforming to BS12 code specification. Typical example of this employed is the Dangote cement. It was purchased and taken to the laboratory in two sealed 50kg bags. The cement was protected from dampness to avoid lumps.

2.4. Water

Portable tap water supplied by Hassan Usman Katsina Polytechnic Civil Engineering laboratory was used throughout the experiment especially for mixing and curing. Water is essential in starting the reaction between cement and other constituent materials. The binding property of cement cannot take effect without water. It was obtained directly from the tap in the water laboratory and it is confirmed fit for drinking.

2.5. Quarry Dust

The quarry dust is mainly composed of particles with a diameter range of between 0.05mm and 5.00mm. Specifically, the quarry dust particles employed here have a physical identity of being rough, sharp and angular in which case is providing additional strength due to better interlocking. Based on ASTMC 128-88, the specific gravity of quarry dust is 2.65, and it is categorised as fine aggregate [5-7].

3. METHODS

3.1. Sieve Analysis

Sieve analysis is commonly known as particles distribution test. In general, it has been used for decades to monitor material quality based on particle size distribution. For coarse material sizes that range down to (150µm), sieve analysis and particle size distribution are accurate and consistent.

3.2. Compaction Factor Test

This is usually in situ test used to determine the consistency or self-compaction of the green concrete as is conducted by the site supervisor. In recent times, this test is commonly replaced by slump test to determine the workability of concrete. This test is carried out for compacted (where concrete is filled in three layers and tampered one after the other) and uncompacted concrete.

$$\text{Compacting factor} = \frac{\text{wt of partially compacted concre te}}{\text{wt of fully compacted concrete}} \quad (1)$$

3.3. Slump Test

The slump test is a measure of workability of fresh concrete. Workability is the ability of a fresh (plastic) concrete mix to fill the form/mould correctly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on the water/cement ratio, aggregate grading and shape and age (level of hydration) of a concrete mix. The slump test is useful in the determination of variations in the uniformity of concrete mix. Raising the water content and adding chemical admixtures will increase concrete's workability while excess water will lead to bleeding and segregation.

3.3. Concrete Mix Design

Concrete mix design is a recipe used to make Portland cement concrete. Mix design usually is based upon volumetric measurements, but concrete is usually mixed (at least in a commercial setting) according to the weight of materials. Therefore, a mix design most commonly gives direction or clue for making the concrete mix based upon weight. A straightforward method for mixing concrete is the 1: 2:3 proportions; but for the sake of this study, the suggested mix ratio used is 1: 2: 4. This type of concrete will consume one part of cement, two parts of fine aggregates (sand and quarry dust) and four parts of coarse aggregates (gravel). A considerable amount of water is often added to the mixture (0.6 multiple of cement by weight for this study) to bring the concrete to the desired consistency.

3.5. Batching process

The process of preparing and producing concrete by placing its constituent one after the other as far design proportion. This operation goes in line with the concrete mix design procedure which allows one to determine the actual proportion by weight and volume of all the ingredients available in producing the concrete. This study uses a mixing ratio of 1:2:4 and Water/Cement ratio of 0.60.

3.6. Casting of Concrete Cubes

Concrete mixing, slump test and compaction factor tests precede casting of concrete cubes. The process whereby a freshly prepared concrete of specified mix proportion is being placed in layers into cube moulds and compacted until it fills the form of the cube completely.

3.7. Curing of Concrete Cubes

Considering that the cement requires time to hydrate before it acquires strength and hardness; the Concrete curing can only start after achieving the initial setting. Curing is the process of keeping or storing concrete under a suitable specific environmental condition until hydration is relatively complete. The environment promotes hydration after removing the moulds in a process called 'Striking'. The concrete should have formed, hardened and set within of 24 hours of casting before striking and thenplaced in the curing tanks for a different length of time known as curing ages after which they remove for crushing.

3.8. Comprehensive Strength Test (Crushing Test)

Curing is succeeded by crushing of the concrete for different curing ages with the first being after 7days. Crushing is an operation performed on concrete cubes by way of applying a compressive force on them gradually until the cubes start breaking after having attained its supposed maximum strength limit. For every sevendays' interval, within 28days duration, the rest of the cubes are crushed all in the crushing machine. The nominal ultimate compressive strength is usually obtained as the 28day compressive strength in Mega-Pascal (Mpa) or Pounds per square inch (Psi).

4. RESULT AND DISCUSSIONS

4.1. Compaction Factor

Table 1 shows the values obtained for compaction factor in this study. It is between 1.0 to 1.1 for all the ranges of replacement quarry dust replacement of 0% to 25 %. These values fall within an acceptable range meaning that the concrete has acceptable workability and can be placed in the formwork or mould.

Table 1: Effect of Quarry Dust on Compressive Factor

Trials	**Compaction factor for different percentage of quarry dust**					
	0 % quarry dust	**5 % quarry dust**	**10 % quarry dust**	**15 % quarry dust**	**20 % quarry dust**	**25 % quarry dust**
1	1.0	1.1	1.1	1.0	1.1	1.0
2	1.1	1.0	1.1	1.0	1.0	1.1
3	1.0	1.1	1.0	1.1	1.1	1.1

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4.2. Slump Test

Table 2 shows slump height obtained for this research. The average slump values were 131mm, 135mm, 141mm, 140mm, 143mm and 141mm respectively for 0%, 5%, 10%, 15%, 20% and 25% quarry dust replacing sand.The slump type associated with all the tests performed for the various percentage replacements is the Shear Slump. The Slump is affected by the water/cement ratio and based on these values; the concrete is workable as there was no total collapse of the slump.

Table 2: Effect of Quarry dust on Slump of fresh concrete

Trials	**Mix ratio**	**0 % of quarry dust**	**5 % of quarry dust**	**10 % of quarry dust**	**15 % of quarry dust**	**20 % of quarry dust**	**25 % of quarry dust**
		Slump (mm)	**Slump (mm)**	**Slump (mm)**	**Slump (mm)**	**Slump (mm)**	**Slump (mm)**
1	1:2:4	130	140	145	140	140	145
2		125	130	142	145	145	140
3		140	135	138	135	145	138
Average slump		**131**	**135**	**141**	**140**	**143**	**141**

4.3. Compressive Strength

The letter A, B, C, D, E and F were used to denote 100% sand and 0% quarry dust, 95% sand and 5% quarry dust, 90% sand and 10% quarry dust, 85% sand and 15% quarry dust, 80% sand and 20% quarry, 75% sand and 25% quarry dust replacement respectively. The average value of the three trials was used to determine the compressive strengths for each percentage replacements. Table 3 shows the compressive strength results for cube cured for 7, 21 and 28 days. A careful observation of the results from both the tables and the barchartindicates that for initial input of quarry dust into the concrete, there was a slight reduction in the strength of the cube. However,a further increase in the percentage of quarry dust induces the maximum strength of the concrete cubes at 20%.Moreover, then additional percentage introduced yields a declining strength of the concrete cubes. Therefore the minimum strength attained was at 5% quarry dust addition and the maximum strength occurred at 20% quarry dust replacement.

Let; A = 0% Quarry dust and 100% Sand
B = 5% Quarry dust and 95% Sand

C = 10% Quarry dust and 90% Sand
D = 15% Quarry dust and 85% Sand
E = 20% Quarry dust and 80% Sand
F = 25% Quarry dust and 75% Sand

The cube volume is calculate as $(0.15 \times 0.15 \times 0.15)\ m^3$
$= 3.375 \times 10^{-3}\ m^3$

Area of cube = $(150 \times 150)\ mm^2$
$= 22500\ mm^2$
$= 2.25 \times 10^{-2}\ m^2$

The calculations is completed and result is shown in table 3

Table 3: Effect of Curing Time on Compressive Strength of Concrete

Sample	Compressive strength (N/mm^2)		
	7 days	**21 days**	**28 days**
A1	13.56	14.67	16.89
A2	16.89	15.33	16.44
A3	12.89	16.67	16.00
B1	11.11	12.44	15.11
B2	12.00	9.33	16.00
B3	13.33	10.67	16.44
C1	11.56	12.89	15.56
C2	12.22	9.50	16.22
C3	11.33	15.50	17.33
D1	12.00	13.30	16.00
D2	12.50	14.44	16.67
D3	11.56	16.00	17.78
E1	13.78	17.78	21.78
E2	13.33	16.67	18.22
E3	12.89	14.44	20.44
F1	13.56	16.89	18.40
F2	15.56	16.44	18.00
F3	17.33	16.89	16.88

Noticeable among the observations too is the fact that in no small extent, an increase in the curing age tends to increase the strength of the concrete, especially at 20% quarry dust input. The case as cubes having longer curing ages givesa more significant value of compressive strength.

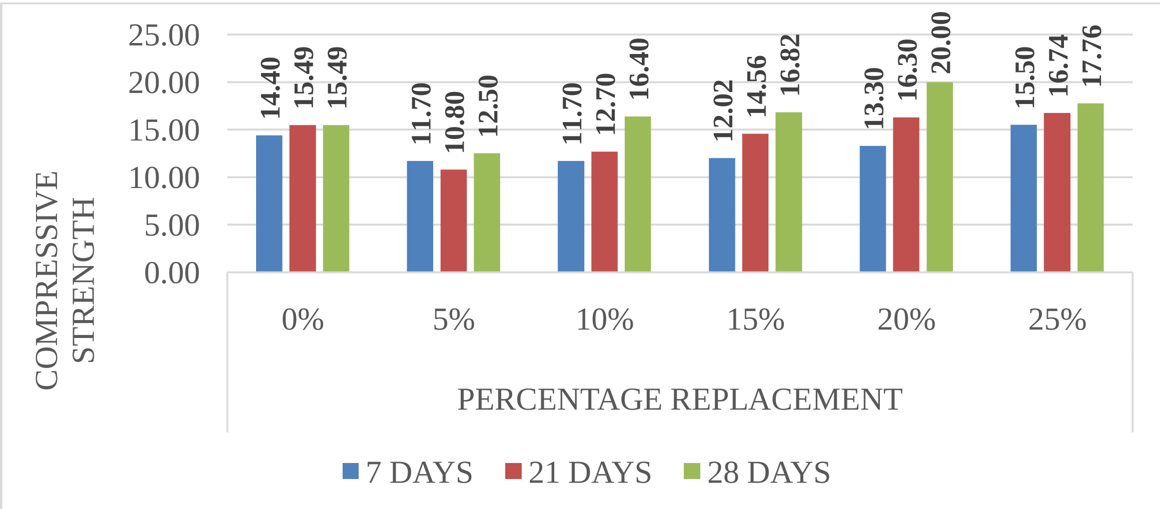

Fig. 1 Multiple Bar chart for Compressive strength versus Curing ages

5. CONCLUSION

Within the limits of experimental accuracy, results of this research study have been together upon which several deductions can be resulting following the characteristic behaviours of both fresh and hardened concrete made from varying proportions of sand to quarry dust replacement.

These deductions include:

- The specific gravity of gravel is relatively high compared to that of sand, and this, therefore, implies that it is a heavy-weight material.
- The workability of fresh concrete varies inconsistently with a subsequent increase in the quantity of quarry dust replacement.
- The compressive strength decreases initially, and then increase sharply to a maximum before further declination on progressive replacement of sand for quarry dust in the concrete.
- The compressive strength is much higher the more the cubes undergoes longer curing period.

REFERENCES

[1]. Anjali H Jamale, Urmila R Kawade (2015). Effect of Quarry Dust and Fly Ash Mix on strength properties of M40 grade Concrete. *International Journal of Engineering Research and General Science, Vol. 3,* 391 – 397.

[2]. C. Sukesh, K.B. Krishna., P.S.L. Sai Teja & J.K. Rao. Partial Replacement of Sand with Quarry in Concrete. Int. Journal of Innovative Technology and Exploring Engineering (IJITEE (2013), ISSN: 2278−3075, Volume 5.

[3]. Lohani T.K., Padhi M., Dash K.P., Jena S. (2012). Optimum utilisation of Quarry dust as partial replacement of sand in concrete. International Journal of Applied Sciences and Engineering Research, *Vol. 1*, 391 – 404.

[4]. K. Lakshmidevi, A.V. Narasimha Rao (2015). Effect of Fly Ash and Quarry dust on properties of concrete.*International Journal of Innovative Research in Science, Engineering and Technology, Vol 4,* 8343 – 8350.

[5]. BS 3148: *Water quality control for the concrete mixture.* British Standards Institute, London, UK.

[6]. BS 5328: Part 1:1997. *Guide to specifying concrete*. British Standards Institute, London, UK.

[7]. BS 812 (1960): *Sampling and testing of mineral aggregates, Sand filters*. British Standards Institute, London, UK.