

# Comparing the Compressive Strengths of Concrete made with Sharp Sand and Quarry Dust as Fine Aggregates

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**ABSTRACT:** This study investigates the compressive strength (CS) of concrete made with river sand gotten from Osogbo, Osun State, replaced at 0-100% at intervals of 10% with quarry dust gotten from Wasimi, Osun State, Nigeria. Results show the compressive strength (CS) of concrete for 7 days curing as; 19.28, 19.65, 20.38, 20.90, 21.32, 22.66, 20.60, 19.23, 18.16, 17.54, and 16.06 KN/mm<sup>2</sup> respectively for a percentage replacement ratio of sand: quarry dust of; 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90, 100:0 respectively. 14 days curing period results in; 21.08, 21.27, 22.19, 22.80, 23.18, 24.51, 22.31, 21.32, 20.03, 19.32, and 17.20 KN/mm<sup>2</sup> with a replacement ratio of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90, and 0:100 respectively. At 21 days curing period, the study shows the average compressive strength (CS) of concrete as; 22.31, 22.98, 23.21, 23.81, 24.47, 25.17, 23.02, 21.82, 20.95, 20.22, 18.27 KN/mm<sup>2</sup> for 100:0, 90:10, 80:20, 70:30, 40:60, 50:50, 40:60, 30:70, 20:80, 10:90, 0:100 replacement of sand by quarry dust. 28 days curing period yields compressive strength of 24.51, 24.95, 25.31, 25.83, 26.34, 27.11, 24.82, 23.62, 22.77, 22.16, and 20.24 KN/mm<sup>2</sup> for replacement percentage; 100:0, 90:10, 80:20, 70:30, 60:40, 30:70, 20:80, 10:90, and 0:100, sand to quarry dust. This study notes and concludes that, the maximum average compressive strength of concrete was attained at ratio 50:50 at 7, 14, 21, and 28 days curing periods respectively.

**KEYWORDS:** Compressive strength, Concrete, Sharp sand, Quarry dust, Fine aggregates, Nigeria.

## I. INTRODUCTION

Currently Nigeria is under-going infrastructural development in all spheres of civil engineering. Concrete is an important component in almost all infrastructures such as building, bridges, highways etc. Concrete is essentially a mixture of coarse and fine aggregates, cement and water, that is required for the environmental development of the Nation. Its workability allows it to be easily used in many shapes and forms. Concrete is basically of three types: the light weight with density weighing less than 19,200.00 kg/m<sup>3</sup>, normal weight concrete which is most common with density of about 24,000.00 kg/m<sup>3</sup> and heavy weight concrete with density above 28,000.00 kg/m<sup>3</sup>. Concrete is achieved when the paste (water and cement mixture) binds the aggregates into a rocklike mass known as concrete [3]. According to Barritt [2], concrete is that pourable mix of cement, water, sand and gravel that hardens into super strong building material. Concrete is a man-made material used in the building and construction industry and consists of aggregates which are bonded together by cement and water (cement paste). The major constituent of concrete besides the cement is the aggregate.

Various types of aggregates that may be used include sand, crushed-stone, gravel, granite, slag, ashes, burned shale, and burned clay. Fine aggregates refer to the size of aggregate used in making concrete slabs and in providing smooth

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Vol. 6, Issue 3, March 2017

surfaces. Coarse aggregates are used for massive structures or sections of concrete [9]. The most commonly used fine aggregate is sand derived from river banks. River sand has been the most popular choice of fine aggregate component of concrete in the past, overuse of the material has led to environmental concerns, such as; depletion of river sand deposits resulting in flooding and an increase in price of the material. Developing country like Nigeria is facing shortage of good quality natural sand, natural sand deposits are being used up and causing serious threat to the environment as well as the society. The rapid extraction of sand from the river bed causes problem like deepening of the river bed, loss of vegetation on the bank of rivers, depletion of aquatic life as well as climate change and reduction in agricultural production due to lowering of soil nutrients etc.

On the other hand, quarry dust is a by-product which is formed in the processing of granite stones through rock blasting to produce coarse aggregate of different sizes. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Other studies have found that quarry dust is known to increase both fresh and hardened properties of concrete over concrete made with equal quantities of river sand. The fresh and hardened properties of concrete continue to increase with age for all percentage of quarry dust content [10]. The utilization of quarry dust as fine aggregate would turn this waste material that causes disposal problem into valuable resource. In concrete production it could be used as a partial or full replacement of natural sand; besides, the utilization of quarry dust, which itself is a waste material, may reduce the cost of concrete production in the long run. Hence, the purpose of this investigation is to compare the compressive strength of concrete made with sand as fine aggregate and substituted with quarry dust at intervals of 10% replacement.

## II. RELATED WORKS

According to Alexander et al. [1], river sand is derived from rocks of the earth's crust. Their properties are governed first by the chemical and physical properties of the parent rocks. Rocks undergo various processes of alteration, including natural geothermal and/or weathering processes which occur over long periods of geological time. Such processes may produce granular materials in the form of natural gravels and sands that can be used in concrete with a minimum of further processing. On the other hand, production of sand may require processes encompassing human related activities in the form of rock breaking, crushing, mining, dredging and so on. These processes, which convert the rock in a very short period of time into useful engineering material, must be linked to the nature of the parent rock and the required properties of the sand, in order to produce acceptable materials.

Natural sand can be sourced from pits, river banks and beds, the seabed, gravelly or sandy terraces, beaches and dunes, or other deposits that provide granular materials that can be processed with minimal extra effort or cost. Sand and gravel, which are unconsolidated sedimentary materials, are important sources of natural sand. The occurrence of high quality natural sands and gravels within economic distance of major urban areas may be critical for viable concrete construction in those areas [1].

Chijoke et al. [4] submitted that the construction industries in the developing world is looking for alternative materials that can replace the demand for natural sand, in order to reduce environmental degradation, reduction of production cost as well as augmenting the quality of concrete. Troxel et al. [11] argued that compressive strength is the criterion for determining the quality of concrete and as such it is necessary that for a concrete to be used, its compressive strength has to be determined.

## III. METHODOLOGY

### Materials

The aggregates used for this study were sourced locally from:

Coarse Aggregate sourced from Wasimi, with sizes; 25mm, 20mm, 12mm, and 6mm.

Quarry dust sourced from Wasimi,

Fine aggregates (sharp river sand) sourced from Oke-Baale,

Clean water from Uniosun Campus, Oke-Baale,

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Vol. 6, Issue 3, March 2017

Cement: Elephant (Ordinary Portland) brand from Oke-Baale  
1:1.5:3 concrete mix ratio for prescription and performance specification

### Method

Particle size distribution, Slump, Specific Gravity, water absorption, and compressive tests were determined in accordance with BS 882: 1992; BS 1881: Part 102 & 108 (1983) for slump test, BS 812-2: 1995, BS 1881-122: 2011, ASTM D 570 and BS 1881-116: 1983 respectively. Concrete mix design for grade M 25 as per IS-10262-2009 with OPC grade 53 conforming to IS-12269-1987, with water adsorption ratio 0.5. Coarse Aggregate (Granite) obtained from Wasimi, fine aggregate (sharp sand) from Oke-baale and quarry dust from Wasimi, all local resource form the basic ingredient for the concrete mix used by the study. Total number of concrete cubes produced for crushing test was 40 at 10 cubes per curing period of 7,14,21 & 28 days respectively. All tests were carried out at the Osun State University Civil Engineering test laboratory Osogbo, observing all details to be followed in carrying out such tests.

## IV. RESULTS AND DISCUSSION

Table 1 below shows the result of sieve analysis carried out by the study using coarse aggregate (granite) weighing 6453.50 g.

TABLE 1: SIEVE ANALYSIS RESULT FOR COARSE AGGREGATE

SEIVE SIZE(mm)	WEIGHT RETAINED (g)	WEIGHT PASSING (g)	%PASSING	AASHTO %PASSING	BS 410:1976 %PASSING
38.1	0	6453.50	100	90 - 100	90 - 100
20	1426	5027.5	77.90	35 - 80	35 - 80
15	1152.5	3875.0	60.04	-	-
10	2064.5	1810.5	28.05	20 - 55	20 - 55
5	707	1103.5	17.10	-	-
2.36	118	985.5	15.27	-	-
1.40	985.5	0	0	0.0 - 5	0.0 - 5

TABLE 2: SIEVE ANALYSIS OF FINE AGGREGATE (SHARP RIVER SAND); WEIGHT 425G

STUDY RESULTS				STANDARDS	
SEIVE SIZE(mm)	WEIGHT RETAINED (g)	WEIGHT PASSING (g)	%PASSING	AASHTO %PASSING	BS 410:1976 %PASSING
4.75	4.9	420.1	98.8	95 - 100	95- 100
2.36	27.9	392.2	92.8	-	-
1.18	82.9	309.3	72.78	45 - 75	45 - 75
0.6	120.1	189.2	44.5	-	-
0.425	89.2	100.0	23.53	-	-
0.3	33.3	66.7	15.74	10 - 40	10 - 40
0.212	36.1	30.6	7.2	-	-
0.125	19.2	11.4	2.68	-	-
0.075	3.2	8.2	1.92	5 - 20	5 - 20
Pan	8.2	-	0.00	-	-

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(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 3, March 2017

TABLE3: SIEVE ANALYSIS OF THE QUARRY DUST WEIGHING 332G

STUDY RESULTS				STANDARDS	
SEIVE SIZE(mm)	WEIGHT RETAINED(g)	WEIGHT PASSING (g)	%PASSING	AASHTO %PASSING	BS 410:1976 %PASSING
4.75	2.2	329.8	99.34	95 - 100	95- 100
2.36	45.4	284.4	85.66	-	-
1.18	40.3	244.1	73.52	45 - 75	45 - 75
0.6	44.9	199.2	35.90	-	-
0.425	53.3	145.9	43.95	-	-
0.3	19.4	126.1	38.10	10 - 40	10 - 40
0.212	34.6	91.9	27.68	-	-
0.125	39.6	52.3	15.75		
0.075	14.3	37.0	11.14	5 - 20	5 - 20
pan	38.0	-	0.0	-	-

Table 4, shows the batching by weight using mix ratio 1:1.5:3 for the concrete cubes produced for crushing test in the laboratory.

TABLE 4: RESULT OF BATCHING FOR CONCRETE CUBES; RATIO 1:1.5:3

BATCHING RESULTS FOR THE STUDY TEST CUBES				
Sand %Replacement	Mass of cement(Kg)	Mass of quarry dust(Kg)	Mass of river sand(Kg)	Mass of coarse aggregate(Kg)
0	3.1	0	4.6	9.3
10	3.1	0.46	4.14	9.3
20	3.1	0.92	3.68	9.3
30	3.1	1.38	3.22	9.3
40	3.1	1.84	2.76	9.3
50	3.1	2.3	2.3	9.3
60	3.1	2.76	1.84	9.3
70	3.1	3.22	1.38	9.3
80	3.1	3.68	0.92	9.3
90	3.1	4.14	0.46	9.3
100	3.1	4.6	0	9.3

TABLE 5: COMPACTION FACTOR OF DIFFERENT REPLACEMENT MIX-RATIOS AT 0.5W/C RATIO

Sand %Replacement	Partially compacted(Kg)	Fully compacted (Kg)	Compaction factor
0	8.7	10.7	0.81
25	9.2	11.0	0.83
50	9.3	11.1	0.84
75	9.5	11.5	0.83
100	9.6	11.7	0.82

The variation of workability was also measured in terms of compaction factor with constant w/c ratio (0.5).The values were obtained from different mixes such as 0%, 25%, 50%, 75% and 100% quarry dust/river sand replacement 0.81,

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(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 3, March 2017

0.83, 0.84, 0.83 and 0.82 respectively. As per the data above, concrete does not give adequate workability with the increase of quarry dust as fine aggregate.

TABLE 6: BATCHING RESULT FOR CONCRETE MIX RATIO 1:1.5:3

<b>BATCHING FOR THE CUBES USED IN CRUSHING TEST BY STUDY</b>				
<b>Sand Replacement (%)</b>	<b>Mass of cement(Kg)</b>	<b>Mass of quarry dust(Kg)</b>	<b>Mass of river sand(Kg)</b>	<b>Mass of coarse aggregate(Kg)</b>
0	3.1	0	4.6	9.3
10	3.1	0.46	4.14	9.3
20	3.1	0.92	3.68	9.3
30	3.1	1.38	3.22	9.3
40	3.1	1.84	2.76	9.3
50	3.1	2.3	2.3	9.3
60	3.1	2.76	1.84	9.3
70	3.1	3.22	1.38	9.3
80	3.1	3.68	0.92	9.3
90	3.1	4.14	0.46	9.3
100	3.1	4.6	0	9.3

The results obtained for fine aggregates (both river sand and quarry dust) were within grading requirements as required by BS 410:1986. Quarry dust was found to contain more fine particles compared to river sand which contained more coarse particles.

TABLE 7: COMPACTION FACTORS FOR DIFFERENT REPLACEMENT MIX RATIOS FOR FINE AGGREGATES AT 0.5 WATER/CEMENT RATIO

<b>Sand replacement (%)</b>	<b>Partially compacted(Kg)</b>	<b>Fully compacted (Kg)</b>	<b>Compaction factor</b>
0	8.7	10.7	0.81
25	9.2	11.0	0.83
50	9.3	11.1	0.84
75	9.5	11.5	0.83
100	9.6	11.7	0.82

The variation of workability was also measured in terms of compaction factor with constant w/c ratio (0.5). The values obtained from different replacement mixes such as 0%, 25%, 50%, 75% and 100% quarry dust was 0.81, 0.83, 0.84, 0.83 and 0.82 respectively. As per the data above, concrete does not give adequate workability with increase in quarry dust as river sand.

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Vol. 6, Issue 3, March 2017

TABLE 8: SLUMP TEST RESULT FOR ALL REPLACEMENT MIX-RATIOS

Sand replacement (%)	Slump (mm)
0	31
25	22
50	15
75	10
100	6

The measured slump values of quarry dust with constant water/cement ratio 0.5 are 31mm, 22mm, 15mm, 10mm and 6mm for different mix-ratio of 0%, 25%, 50%, 75% and 100% quarry dust percent replacement respectively. It was observed that the slump value decreases with increase in percentage replacement of sand with quarry dust for the same w/c ratio (0.5). This result shows that quarry dust requires increased w/c ratio than river sand. As a result, the study concludes that concrete does not give adequate workability with increase of quarry dust. This may be due to the fineness of quarry dust compared to sharp sand. Increased fineness require greater amount of water for the mix ingredients to get closely packed, which may result in decreased workability of the mix.

TABLE 9-12: AVERAGE CS OF TEST CUBES AT 7, 14, 21 & 28 DAYS CURING PERIOD

SUMMARY OF AVERAGE CUBE CRUSHING STRENGTHS AT 7 DAYS (IN N/MM<sup>2</sup>)

Sand: Quarry dust	Sample 1	Sample 2	Sample 3	Sample 4	Average
100:0	19.25	19.20	19.30	19.35	19.28
90:10	19.67	19.59	19.66	19.67	19.65
80:20	20.35	20.45	20.40	20.30	20.38
70:30	20.89	20.80	20.87	21.00	20.90
60:40	21.33	21.30	21.33	21.32	21.32
50:50	22.67	22.66	22.67	22.65	22.66
40:60	20.44	20.46	20.51	21.00	20.60
30:70	19.25	19.23	19.31	19.12	19.23
20:80	18.15	18.10	18.20	18.19	18.16
10:90	17.70	17.61	17.31	17.52	17.54
0:100	15.85	16.00	16.11	16.29	16.06

SUMMARY OF AVERAGE CUBE CRUSHING STRENGTHS AT 14 DAYS CURING PERIOD (N/MM<sup>2</sup>)

Sand: Quarry Dust	Sample 1	Sample 2	Sample 3	Sample 4	Average
100:0	21.15	21.10	21.17	20.91	21.08
90:10	21.50	21.11	21.21	21.24	21.27
80:20	22.25	22.01	22.17	22.31	22.19
70:30	22.73	22.86	22.69	22.91	22.80
60:40	23.21	23.12	23.31	23.09	23.18
50:50	24.51	24.50	24.51	24.51	24.51
40:60	22.30	22.29	22.33	22.31	22.31
30:70	21.31	21.39	21.31	21.27	21.32
20:80	20.08	19.99	20.01	20.02	20.03
10:90	19.01	19.33	19.32	19.30	19.32
0:100	17.27	16.91	17.21	17.39	17.20

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Vol. 6, Issue 3, March 2017

SUMMARY OF AVERAGE CUBE CRUSHING STRENGTH AT 21 DAYS CURING PERIOD (N/MM<sup>2</sup>)

Sand: Quarry Dust	Sample 1	Sample 2	Sample 3	Sample 4	Average
100:0	22.31	22.32	22.31	22.30	22.31
90:10	22.97	22.97	22.59	23.00	22.98
80:20	23.21	23.20	23.22	23.21	23.21
70:30	23.82	23.87	23.79	23.80	23.81
60:40	24.49	24.48	24.47	24.44	24.47
50:50	25.19	25.10	25.19	25.19	25.17
40:60	22.97	22.99	23.01	23.11	23.02
30:70	21.79	21.91	21.78	21.78	21.82
20:80	20.95	20.92	21.00	20.93	20.95
10:90	20.20	20.22	20.23	20.21	20.22
0:100	18.31	18.21	18.22	18.33	18.27

SUMMARY OF AVERAGE CUBE CRUSHING STRENGTH AT 28 DAYS CURING PERIOD (N/MM<sup>2</sup>)

Sand: Quarry Dust	Sample 1	Sample 2	Sample 3	Sample 4	Average
100:0	24.50	24.50	24.51	24.52	24.51
90:10	24.90	24.93	24.97	25.00	24.95
80:20	25.33	25.33	25.31	25.32	25.31
70:30	25.81	25.83	25.83	25.84	25.83
60:40	26.37	26.37	26.27	26.36	26.34
50:50	27.12	27.10	27.10	27.13	27.11
40:60	24.81	24.82	24.84	24.81	24.82
30:70	23.62	23.60	23.62	23.62	23.62
20:80	22.77	22.78	22.77	22.77	22.77
10:90	22.17	22.17	22.09	22.19	22.16
0:100	20.18	20.20	20.21	20.37	20.24

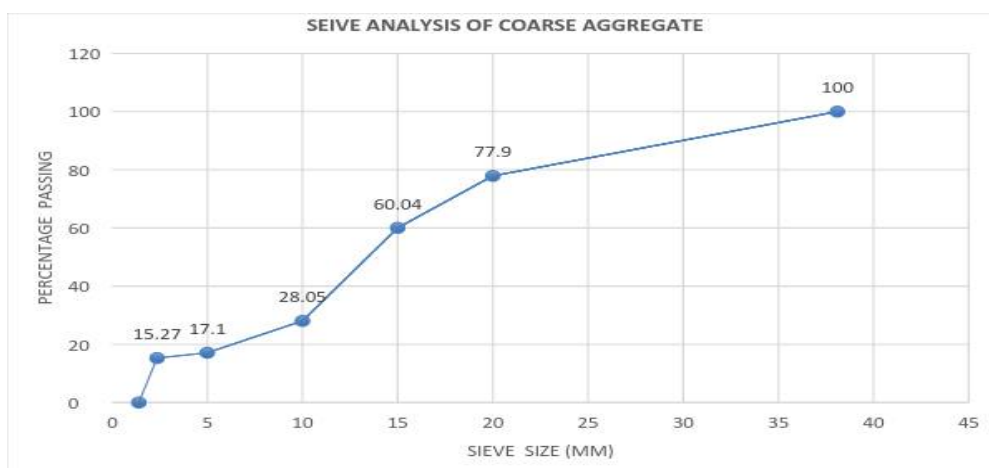


Fig. 1 Graph of the sieve analysis for coarse aggregate

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 3, March 2017

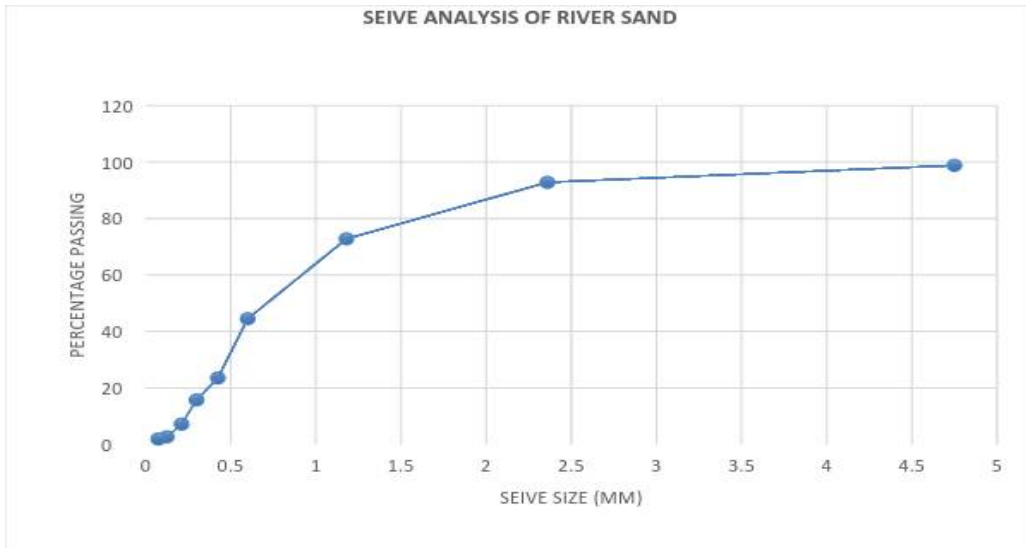


Fig. 2 Graph of the Sieve Analysis for Sharp River Sand

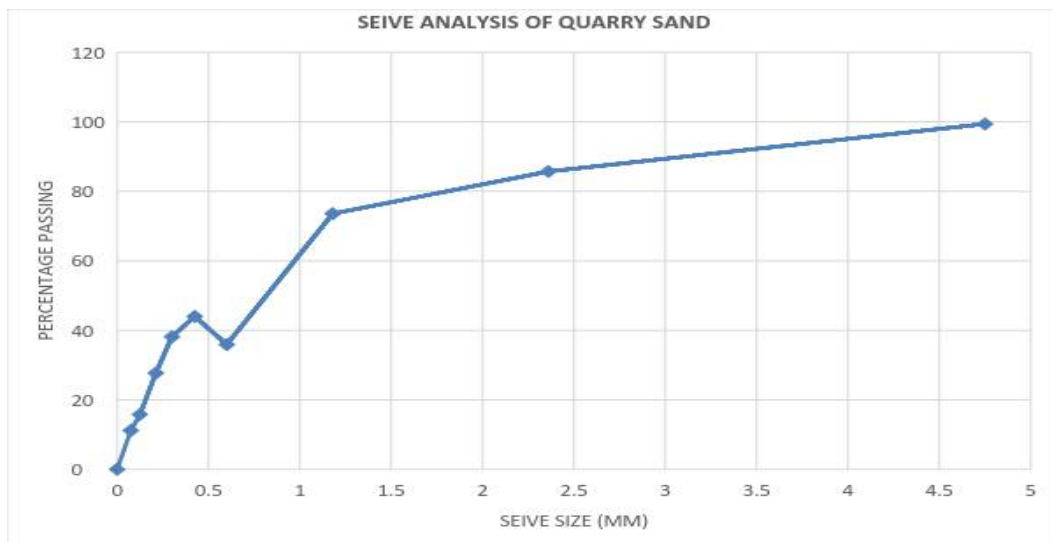


Fig. 3 Graph of the Sieve Analysis for Quarry Dust



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Vol. 6, Issue 3, March 2017

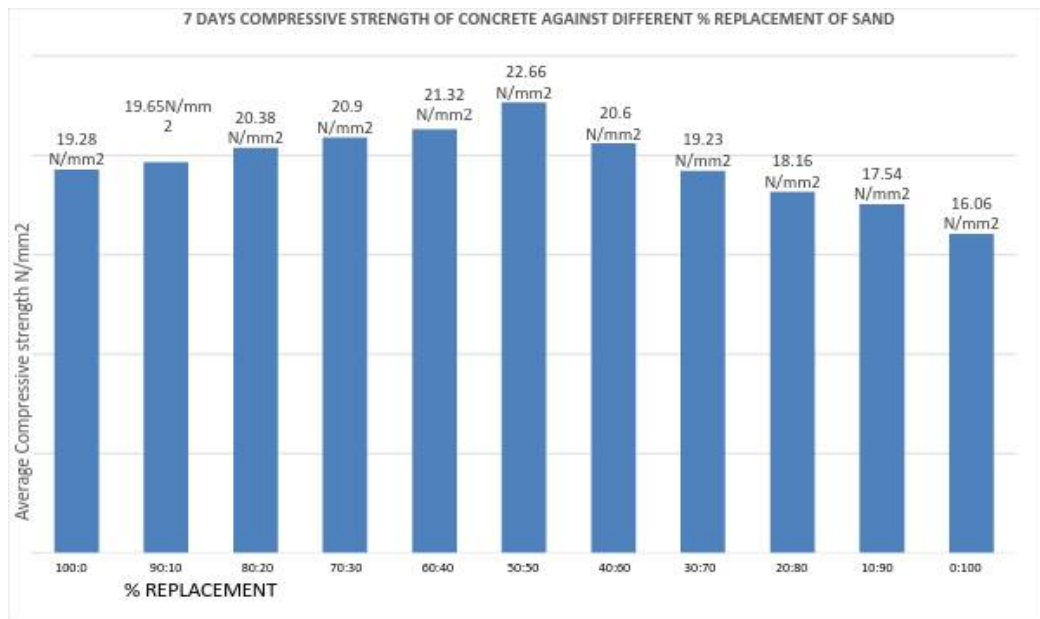


Fig. 4 Result of 7-Days Curing Period CS for Different % Replacement of Sand: Dust

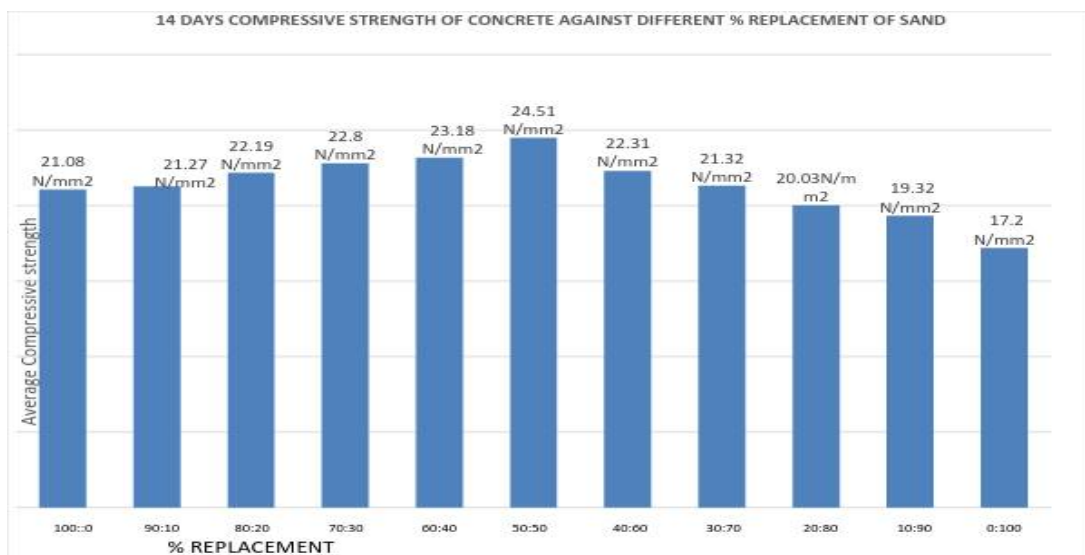


Fig. 5 Result of 14-Days Curing Period CS for Different % Replacement of Sand: Dust

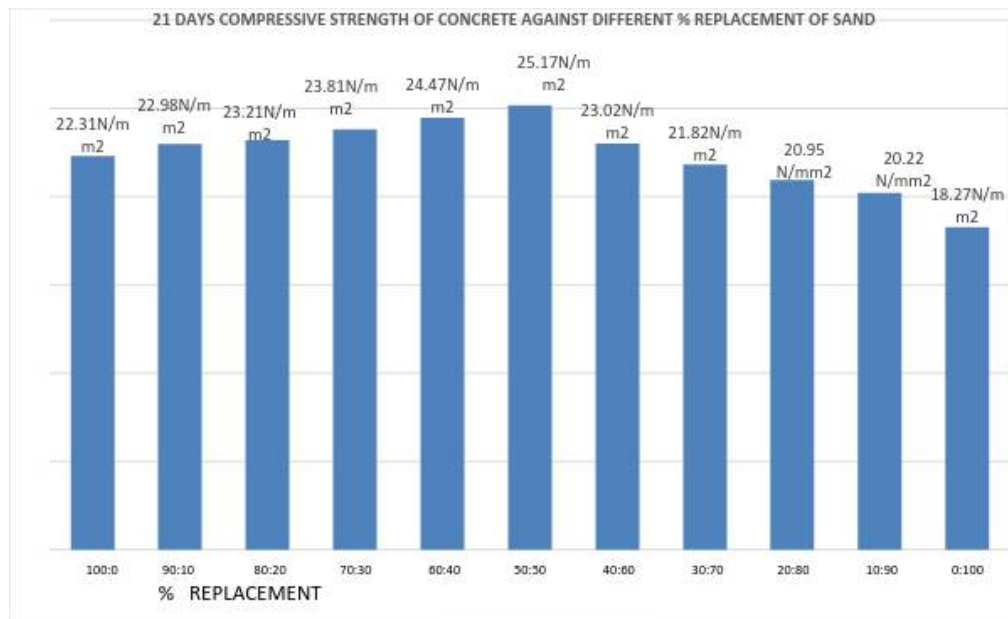


Fig. 6 Result of 21-Days Curing Period CS for Different % Replacement of Sand: Dust

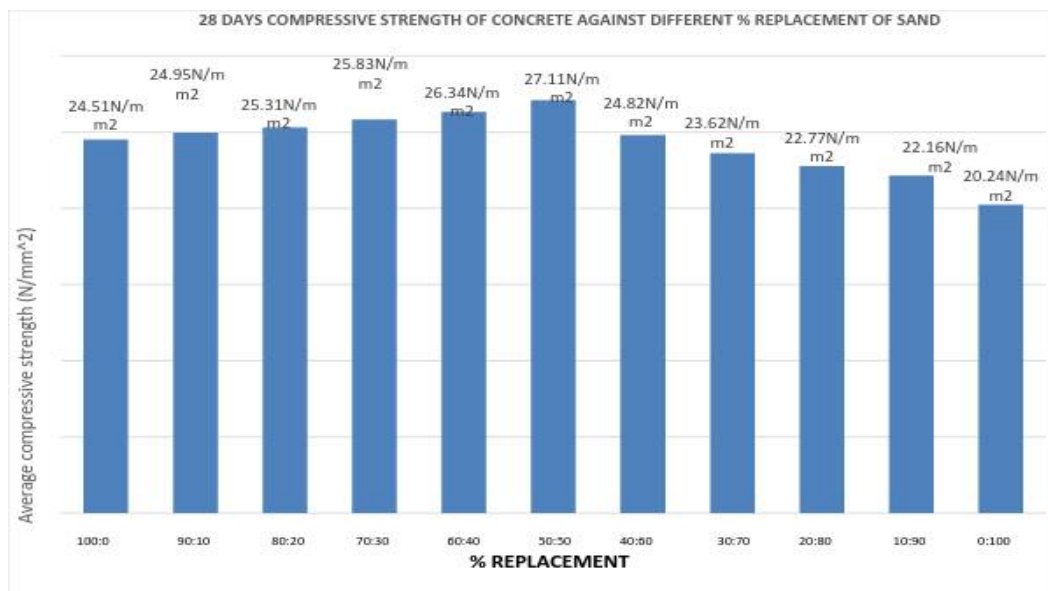


Fig. 7 Result of 28-Days Curing Period CS for Different % Replacement of Sand: Dust

The results show that there is an increase in the compressive strength of the tested concrete cubes with the increment of quarry dust up to about 50% replacement then strength begins to reduce up to 100% replacement both for 7, 14, 21 and 28 days strength. At 70% replacement, compressive strength is almost equal to the value at 0% replacement. One can deduce that the increase noticed in compressive strength at different percentage replacement of river sand by quarry dust is, as a result of quarry dust particles being finer than that of sand and acts as filler; hence fewer voids are

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Vol. 6, Issue 3, March 2017

created resulting in the reduction in compressive strength at 100% replacement of sand with quarry dust. This may have also affected the workability of the concrete. At 0% replacement of Sand with quarry dust, the study shows there is a slight increase in the compressive strength of concrete compared to 100% replacement of sand with quarry dust. This result proves that quarry dust can be used wholly as replacement for river sand in concrete without consequential effect on the compressive strength of the concrete. Although the study result shows that the highest strength is attained at 50-50% replacement as fine aggregate, at 7, 14, 21, and 28 days curing periods respectively.

## V. CONCLUSION

The study results show that the addition of quarry dust improves the compressive strength of concrete. The study concludes that quarry dust may be used as partial replacement material for fine aggregate at up to 50% replacement, maximally in concrete. This study therefore concludes as follows;

1. Quarry dust may be employed as a quality replacement in concrete as fine aggregate,
2. Slump value decreases with increase in percentage replacement of sand with quarry dust due to higher percentage of smaller particles present in quarry dust compared to sand,
3. Compressive strength of concrete at 50% replacement has the highest value at all curing periods investigated,
4. It was observed during compaction test that the density of concrete increases with increase in percentage of quarry dust content, causing as expected increase in compressive strength as density of concrete increases,
5. Quarry dust being cheaper per cubic meter and environmentally friendly than river sand should be encouraged as alternative to river sand, if at partial replacement only,
6. Further research should be carried out to determine the long term strengths of quarry dust concrete and also the compressive strengths of quarry dust in reinforced concrete.

## REFERENCES

- [1] K Alexander, J. Wardlaw and I. Ivanusec, "The Influence of SO<sub>3</sub> Content of Portland Cement on the Creep and Other Physical Properties of Concrete", *Cement and Concrete Research*, Vol. 9, 1979.
- [2] C. Barrit, "Advanced Building Construction", Vol. 1, 2<sup>nd</sup> Edition, J. W. Arrowsmith Ltd, Bristol, 1984.
- [3] Gideon Olakunle Bamgboye, Anthony Nkem Ede, Uwanabasi Edet Umama, Tajudeen Odeniyi Odewumi, and Oluwaleke Adekunle Olowu, "Assessment of Strength Characteristics of Concrete Made from Locally Sourced Gravel Aggregate from South-South Nigeria", *British Journal of Applied Science & Technology*; Vol.12, No. 5, pp.1-10, Article no. BJASt, 20365, ISSN: 2231-0843, NLM ID: 101664541, 2016.
- [4] Chijoke Chiemela, Igwegbe Walter, Ibearugbulem Ogedi, Okoye Peter & Oke Mong, "Comparing The Compressive Strengths of Concrete Made with River Sand and Quarry Dust as Fine Aggregates", *International Journal of Recent Research and Applied Sciences (IJRRAS)*, Vol. 221, No. 2/IJRRAS\_22\_2\_01.pdf, 2015.
- [5] British Standard Institutions, "Specification for Aggregates for Natural Source for Concrete", BS 882, London, 1992.
- [6] British Standard Institutions, "Methods for Determination of Slump", BS 1881: Part 102, London, 1983.
- [7] British Standard Institutions, "Methods for Making Test Cubes from Fresh Concrete", BS 1881: Part 108, London, 1983.
- [8] British Standard Institutions, "Specification for Sieve Test", BS 410, London, 1986.
- [9] K. Krishna, C. Sukesh, P. Sai Teja, and J. Rao, "Partial Replacement of Sand with Quarry in Concrete", *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* ISSN: 2278-3075, 2013.
- [10] T. Lohani, M. Padhi, K. Dash, and S. Jena, "Optimum Utilization of Quarry Dust as Partial Replacement of Sand in Concrete", *International Journal of Applied Science and Engineering Research*, Vol.1, No. 2, 2013.
- [11] G.E. Troxel, H.E. Davies, & J.W. Kelly, "Composition and Properties of Concrete: 2<sup>nd</sup> Edition", McGraw Hill Books Company New York, pp. 528, 1968.