Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2017, 4 (4): 273-281

Research Article **ISSN: 2394 - 658X**

Strength and Durability of Concrete Containing Quarry Dust as Partial Replacement of Cement

Ma'aruf A[1], S I Abba[2] and Nuruddeen MM[3]

[1,3]Department of Civil Engineering, Kano University of Science and Technology, Wudil, Nigeria
[2]Physical Planning Unit, North West University, Kano, Nigeria
saniisaabba86@gmail.com

ABSTRACT

Quarry dust as the major by-product of crushing process during quarrying activities in quarry industry is being used in large scale in highways as a surface finishing material, manufacturing hollow sandcrete blocks and in light weight concrete fabricated elements, for many years. In an effort to use the QD in constructions, research has been carried out for its possible utilization in making concrete as partial replacement of cement. The experimental investigation was performed to evaluate the strength and durability properties of concrete mixes, in which cement was partially replaced with quarry dust (QD) with five percentages (0%, 10%, 20%, 30% and 40%) by weight. Compression test was carried out to evaluate the strength properties of concrete at the age of 7, 14, 21 and 28 days. Results showed that there was a decrease in compressive strength with the addition of quarry dust (QD) up to 40% replacement. Resistance of concrete against abrasion (wear), were also improved for all concrete mixes. A result showed that there was better enhanced in strength and durability properties at 20% replacement of cement with Quarry Dust.

Keywords*:* Cement, quarry dust, durability, concrete, pozzolana, sieve analysis

INTRODUCTION

Global research has a tendency of having some sources of alternatives in materials development that has been necessitated by the high cost of conventional materials, difficulties in accessing funds for building/construction, development, the need to recycle agricultural and industrial wastes for construction, need to maintain ecological balances and challenges of housing are among those reasons. These alternatives to widely acceptable materials include the use of pozzolana as an admixture and substitute to cement [1-2]. In search for new material which address the issue aforementioned and which are cost effective and more efficient, pozzolans attract much interest. Pozzolans as a 'siliceous or siliceous and aluminous material, which in itself possesses little or no cementing properties, but will in finely divided form and in the presence of moisture chemically react with calcium hydroxide at ordinary temperature to form compound possessing cementitious properties' [3]. Quarry dust is an example of such materials possessing pozzolanic properties [4].

Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats [5].Combining water with a cementitious material form a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. The construction industries rely on cement for its operation in the development of shelter and other infrastructural facilities. It then becomes extremely important for the majority of people to own their own houses, despite the high cost of building materials. Insufficient production rate of raw materials when compared with the demand rate in construction industries was attributed by the continuous increase in the cost of Portland cement [1]. Quarry dust a waste obtained from quarrying process is used as partial replacement to cement and as pozzolonic material used after identifying the optimum usage of quarry dust in partial replacement of cement. [6].

Since cement is typically the most expensive constituent of concrete, the replacement of proportion of it with Quarry Dust may improve concrete affordability particularly for low-cost housing in Nigeria. The use of Quarry dust may also contribute to the production of concrete of a higher quality at lower cost and reduces the environmental problem resulting from the accumulation of the dust in a large quantity. Quarry dust has been used for different activities in the construction industry such as road construction, and manufacture of building materials such as lightweight aggregates, bricks and tiles. The research presents the result of experimental investigations carried out with 'Quarry dust' as partial replacement of cement [19-22].

Review and Background of the Study

Quarry dust a waste obtained from quarrying process, is a rock particle when huge rocks brakes into fine particles. It is sand like material, mostly grey in colour. Currently, Nigeria has taken a major initiative in developing the infrastructures such as express highways, power projects and industrial structures, etc., to meet the requirements of globalization, in the execution of civil works plays the rightful role and large quantum of concrete being utilized. Cement, which is one of the constituents used in the production of conventional concrete, has become highly expensive and scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste. Most use of the term 'concrete' refers to Portland cement concrete or to concrete made with other hydraulic cement such as ciment pondu (cement offering resistance to sulphate attack). However road surface is also a type of concrete 'asphaltic concrete' where the cement material is Bitumen, [5].

The usage of concrete worldwide is twice as much as steel, wood, plastics and aluminum combined [7-8]. The cement paste glues the aggregates together, fills voids within it, and makes it flow more freely [9]. Concrete is widely used for making architectural structures, foundations, bricks/blocks, walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fencing and poles and even boats, [10]. There are basically three main types of concrete. These are plain, pre-stressed, and reinforced concretes. Another type of concrete includes light-weight concrete, high density concrete, polymer concrete and etc [11].

MATERIALS AND METHODOLOGY

Materials

Cement: An ordinary Portland cement (Dangote 3X Stronger) was used, which was obtained from a local dealer opposite KUST main gate.

Quarry Dust: The quarry dust used in the laboratory investigations was procured from H&M Construction Company's site (KUST WUDIL) along Library Road, near the Faculty of Agriculture.

Fine Aggregate: Clean and air dried river sand free from leaves, sticks, dirt and other impurities, obtained from the Faculty of Engineering Laboratory, (KUST Wudil), was used for this research.

***Coarse Aggregate:* A** crushed stone which is free from impurities having three quarters (3/4-inch) in size, obtained from the Faculty of Engineering Laboratory, (KUST Wudil), was used for this research.

Water: Water is a unique resource because it is essential for all life and it constantly cycles between the land and the atmosphere [12] [13]. Clean and drinkable tap water obtained from the Water Resources Laboratory, Civil Engineering Department, KUST, was used for mixing and curing purposes.

Tetraoxosulphate (VI) Acid: About 2.5liters of concentrated acid, obtained from local dealers in Sabon-Gari along Church Road, Kano Metropolis was used for Durability Test.

TEST METHOD AND ANALYSIS

Sieve Analysis of Aggregates: This test was conducted in accordance with the BS812 part 103-1 (1985) '*method for the determination of particle size distribution'.*

Specific Gravity Test: The Specific gravity of the aggregates tested by the specifications given in *BS812 part 103 1985*, using pycnometer apparatus.

Workability (Slump Test): This test was done according to BS1881 part 102 1983 *'method for the determination of concrete slump.*

Compressive Strength Test*:* Cube specimens of size 150mm were cast for compressive strength as per BS1881: part 116 1983 '*method of determination of compressive strength of concrete cubes'.* Compressive strength tests for cubes were carried out in 7, 14, 21 and 28 days. Others in the series are linear shrinkage test and durability test: (11-12)

Test Method Result

The findings of experimental investigations are presented. Various tests were conducted to evaluate the effect of Quarry Dust on compressive strength, durability and linear shrinkage. Quarry Dust was used as a partial replacement of cement at the percentage of 0, 10, 20, 30, and 40%. As shown in Fig. 1.

Sieve Analysis for Quarry Dust

Table -1 and Fig. 1 shows the query dust result. From the grading curve (Fig.1), it was observed that, the particles grading of Quarry Dust fall within Zone II based on BS882, part 2, 1992. [14] .This shows that, there is a more medium size particle than fine and coarse; it has cohesive characteristics which are desirable in making concrete.

Sieve Analysis of Fine Aggregates

Table -2 Fig. 2 shows the query dust result. From Fig. 2 it was observed that, the particles grading of fine aggregates fall within Zone II based on BS882, part 2, 1992 [14]. This shows that, there is a more medium size particle than fine and coarse; it has cohesive characteristics and is well-graded which is desirable in making concrete, as the space between larger particles will effectively be filled with the finest aggregate particles to produce a well-packed structure.

Table -1 Sieve Analysis of Quarry Dust

			Initial Weight (g)				
Particle Description		Diameter (mm)	Weight (g)	Retained (%)	Passing (%)		
		75	0	0	100		
		63	0	0	100		
Cobles		50	0	0	100	Gravels = 11.13%	
		37.6	0	0	100		
Coarse		28	0	0	100	Coarse Sand = 20.83%	Sand = 76.85%
		20	0	0	100		
		14	0	0	100		
		10	8.0	0.8	99.20	Medium Sand = 48.05%	
Fine		6.3	13.2	2.12	97.88		
		5.0	33.1	5.43	94.57		
		3.4	57.0	11.13	88.87	Fine Sand = 7.97%	
Sand	Coarse	2.0	96.1	20.74	79.26		
		1.18	112.2	31.96	68.04		
	Medium	0.6	185.3	50.49	49.51		
		0.475	245.4	75.03	24.97	Fineness = 12.02%	
		0.3	155.5	90.58	9.42		
	Fine Clay or Silt	0.075	79.7	98.55	1.45		
		0.063	14.8	100.03	0.00		
		Pass 63 microns	0.00	0.00	0.00		
			999.90				

Table -2 Sieve Analysis of Fine Aggregates

			Initial Weight (g)		1000		
Particle Description		Diameter (mm)	Weight (g)	Retained (%)	Passing (%)		
Cobles		75	0	0	100		
		63	0	0	100		
Coarse		50	0	0	100	Gravels = 17.30%	
		37.6	0	0	100		
		28	0	0	100	Coarse Sand = 14.87%	Sand = 72.26%
		20	0	0	100		
		14	0	0	100		
		10	14.0	1.40	98.60	Medium Sand = 51.19%	
Fine		6.3	31.2	4.51	95.49		
		5.0	51.4	9.65	90.35		
		3.4	76.5	17.30	82.70	Fine Sand = 6.20%	
Sand	Coarse	2.0	111.3	28.43	71.57		
		1.18	149.2	43.35	56.65		
	Medium	0.6	259.2	69.27	30.73		
		0.475	165.6	85.83	14.17	Fines = 10.44%	
		0.3	82.8	94.12	5.88		
	Fine Clay or Silt	0.075	31.9	97.31	2.69		
		0.063	26.9	100.00	0.00		
		Pass 63 microns	0.00	0.00	0.00		
			1000.0				

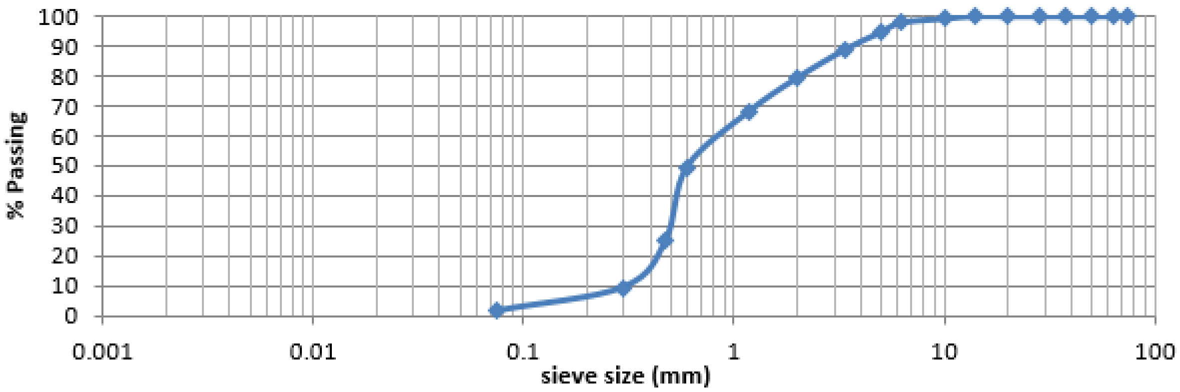

Fig .1 Grading Curve for Quarry Dust

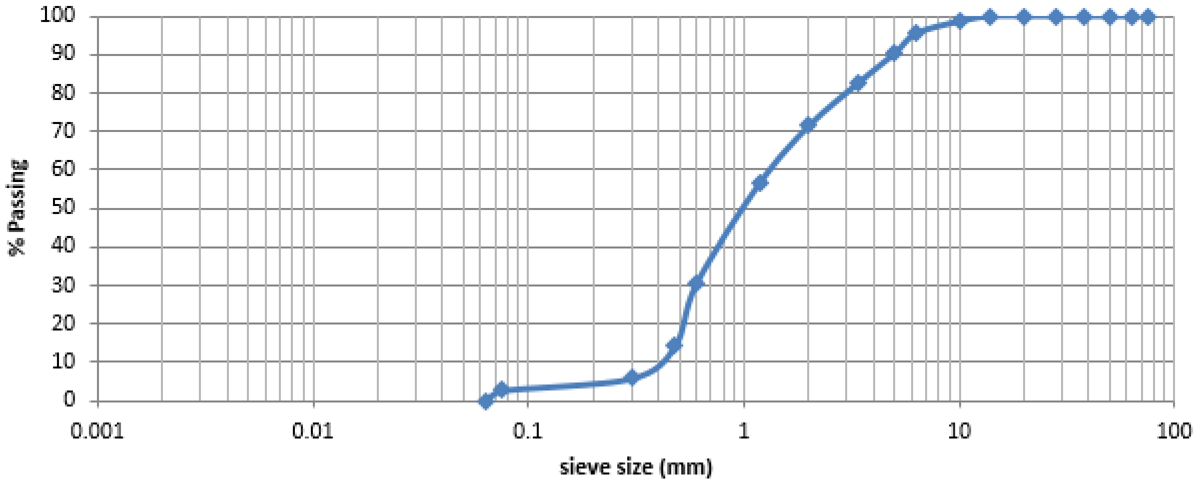

Fig. 2 Grading Curve for Fine Aggregates

Sieve Analysis for Coarse Aggregates

Table -3 and Fig. 3 shows the query dust result. From Table - 3, the majority of coarse aggregates used are coarse gravels, uniformly graded having required properties.

Table -3 Sieve Analysis of Course Aggregate

			Initial Weight				
Particle		Diameter	Weight	Retained	Passing		
Cobles		75	0	0	100		
		63	0	0	100		
Coarse		50	0	0	100	Gravels = 100%	
		37.6	0	0	100		
		28	0	0	100	Coarse Sand = 0.00%	Sand = 0.00%
		20	0	0	100		
		14	1062.2	53.11	46.89		
		10	783.3	92.28	7.72	Medium Sand = 0.00%	
Fine		6.3	121.4	98.35	1.65		
		5.0	33.1	100	0.00		
		3.4	0.00	100	0.00	Fine Sand = 0.00%	
Sand	Coarse	2.0	0.00	100			
		1.18	0.00	100	0.00		
	Medium	0.6	0.00	100	0.00	Fines = 0.00%	
		0.475	0.00	100	0.00		
		0.3	0.00	100	0.00		
	Fine Clay or Silt	0.075	0.00	100	0.00		
		0.063	0.00	100	0.00		
		Pass 63	0.00	0.00	0.00		
			2000.0				

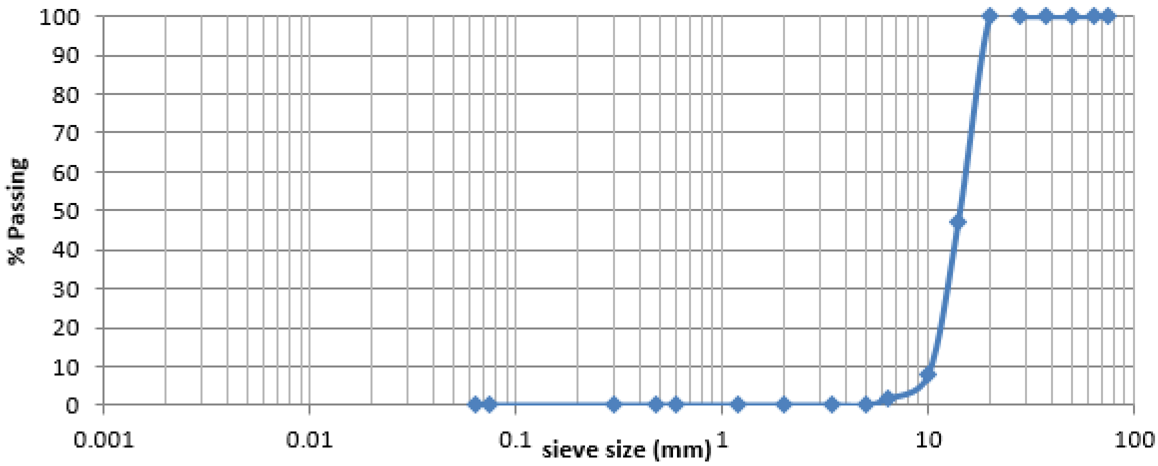

Fig. 3 Grading Curve for Course Aggregates

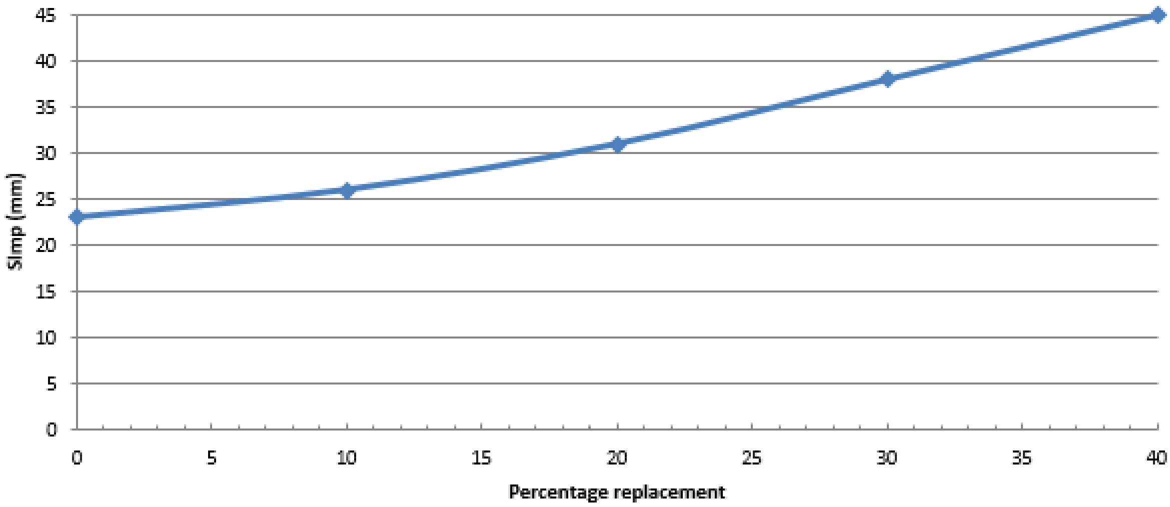

Fig. 4 Slump versus %replacement

Table -4 Slump Values

Quarry Dust Content	Water Added	W/C	Slump
0	0	0.55	23
10	0	0.55	26
20	0	0.55	31
30	0	0.55	38
40	0	0.55	45

Table -5 Summarized Values of Compressive Strength for Normal Water

Quarry Dust (%)	Average Compressive Strength (N/mm^2)			
	7 days	14 days	21 days	28 days
0	20.00	24.94	27.18	28.46
10	16.90	21.41	23.50	24.70
20	19.10	23.92	26.12	27.38
30	16.00	20.37	22.41	23.59
40	14.20	18.27	20.20	21.33

Workability (Slump Test)

The results obtained for the workability test using the testing procedures described are presented in (Table -4 and Fig. 4). From Fig. 4, the slump of all the concrete mixes increases with increase in quarry dust content. This is imputable to the ability of quarry dust to absorb less water than cement. Since water absorption is present it increases the water added to the dry mix.

Compressive Strength

Compressive strength test of (150mm x 150mm x 150mm) test cube specimen was performed according to BS1881: part 116 1983 [15]. Cube specimens were tested at 7, 14, 21 and 28 days using Universal Testing Machine at a constant loading rate. The maximum strength of each specimen was recorded and the average of four samples was considered the compressive strength at the specific day.

Fig. 5(A-D) shows the compressive strength versus quarry dust Variation. It was found that, at the age of 7 days, compressive strength of concrete mix with (0% QD) was 20.00N/mm^2 and mixes with (10%QD), (20%QD), (30% QD) and (40% QD) were 16.90, 19.10, 16.00 and 14.20N/mm^2, respectively. At the age of 14 days, compressive strength of concrete mix with (0% QD) was 24.94N/mm^2 and mixes with (10%QD), (20%QD), (30% QD) and (40% QD) were 21.41, 23.92, 20.37 and18.27N/mm^2, respectively. The Percentage decrease in compressive strength was

15.39, 4.09, 18.32, and 22.73% for mixes 10, 20, 30 and 40% (Quarry Dust) than (0%QD) mix of (24.94N/mm^2). At 21 days, compressive strength of concrete mix with (0% QD) was 27.18N/mm^2 and mixes with (10%QD), (20%QD), (30% QD) and (40% QD) were 23.50, 26.12, 22.41 and 20.20N/mm^2, respectively, concrete mixes exhibited decreases in compressive strength of 13.54, 3.89, 17.55, and 25.68% respectively than (0%QD) with (27.18N/mm^2). Likewise, at the age of 28 days, compressive strength of concrete mix with (0% QD) was 28.46N/mm2 and mixes with (10%QD), (20%QD), (30% QD) and (40% QD) were 24.70, 27.38, 23.59 and 21.33N/mm2, respectively. There was 13.21, 3.79, 17.11 and 25.05% decrease in compressive strength for concrete mixes with 10, 20, 30, and 40% (QD), in comparison to control mix (0%) having a compressive strength of (28.46N/mm^2).

It was observed that the compressive strength of concrete decreased with the increase in Quarry Dust content by 10%, and increases at 20% then, decreases beyond 20% partial replacement of cement.

Effects of Age on Compressive Strength

Effect of age on compressive strength of concrete is shown in Fig .6, it is evident that compressive strength of concrete mixes increased with age. At the age of 7 days, compressive strength of concrete mix (0% QD) was 20.00N/mm^2. It increases to 28.46N/mm^2 (29.73% greater) at 28 days. With the addition of quarry dust, there was an increase in compressive strength with increase in age. There is also a decrease in compressive strength with addition of the dust in comparison with 0% dust addition. There was a remarkable increase in compressive strength with the addition of the dust up to 20% replacement. Beyond 20% replacement, the compressive strength keeps decreasing simultaneously.

Table -6 Summarized Values of Compressive Strength in Sulphuric Acid

Quarry Dust (%)	Average Compressive Strength (N/mm^2)			
	7 days	14 days	21 days	28 days
0	21.30	26.40	28.70	30.00
10	19.10	23.92	26.12	28.34
20	17.30	21.87	23.98	25.20
30	15.60	19.90	21.92	23.09
40	13.80	17.80	19.71	20.82

Table -7 Linear Shrinkage

Quarry Dust Content (%)	Average Linear Shrinkage (%)				
	0 days	7 days	14 days	21 days	28 days
0	0	0.25	0.41	0.52	0.67
10	0	0.21	0.33	0.40	0.41
20	0	0.18	0.29	0.31	0.33
30	0	0.14	0.15	0.15	0.21
40	0	0.13	0.15	0.18	0.18

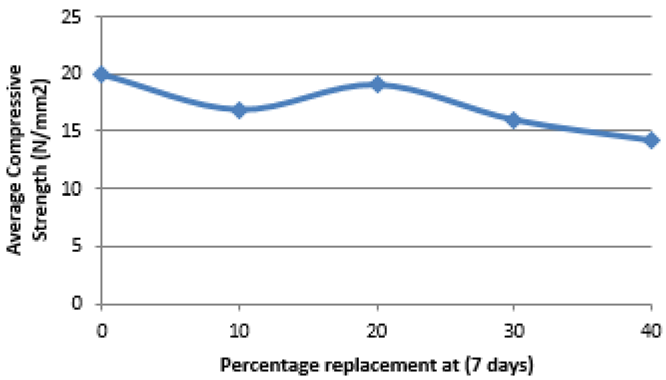

Fig. 5A

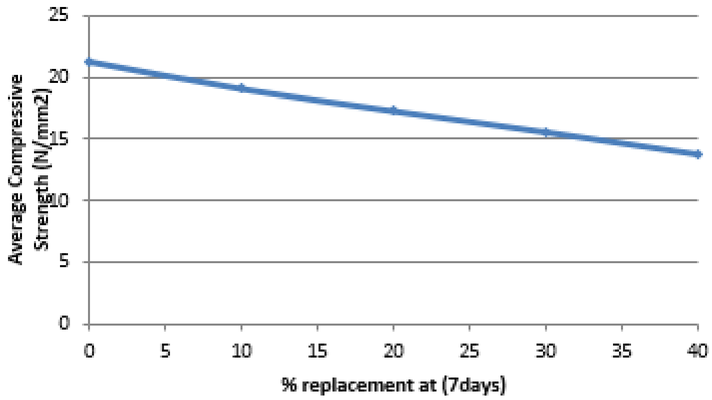

Fig. 6A

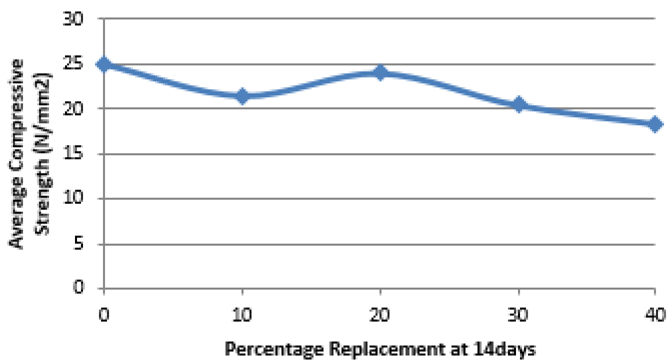

Fig. 5B

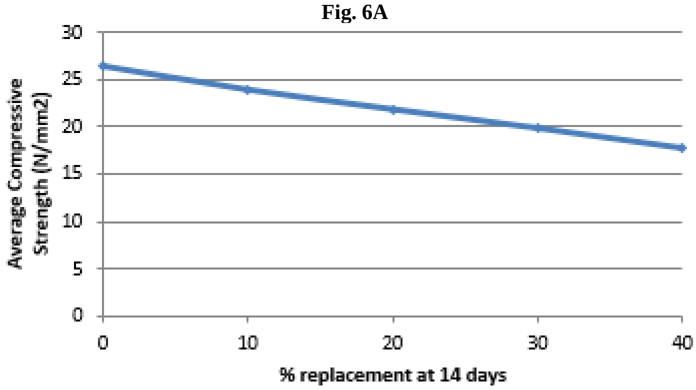

Fig. 6B

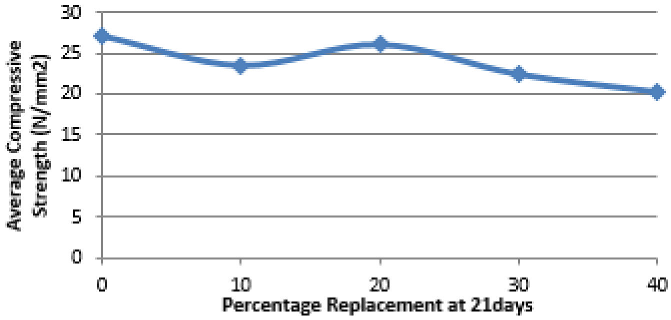

Fig. 5C

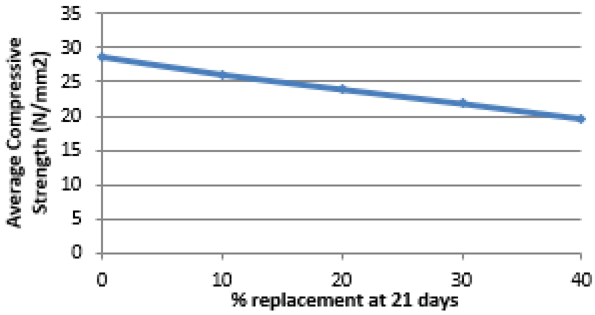

Fig. 6C

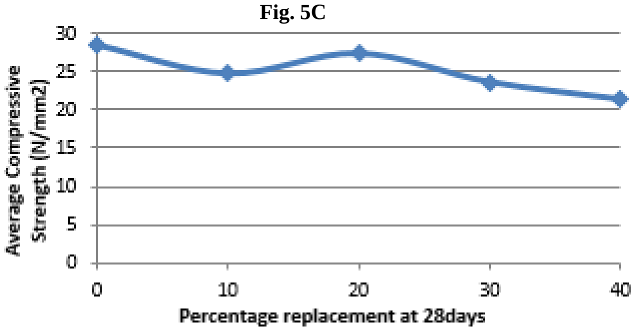

Fig. 5D

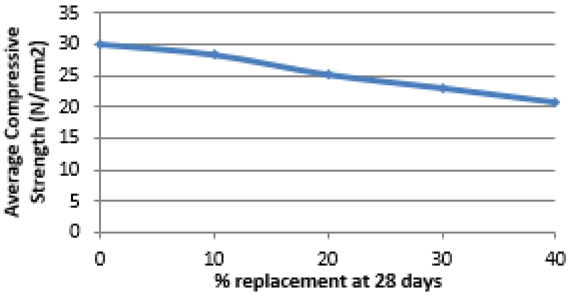

Fig. 6D

Fig. 6 (A-D) Compressive Strength versus Quarry Dust (Durability)

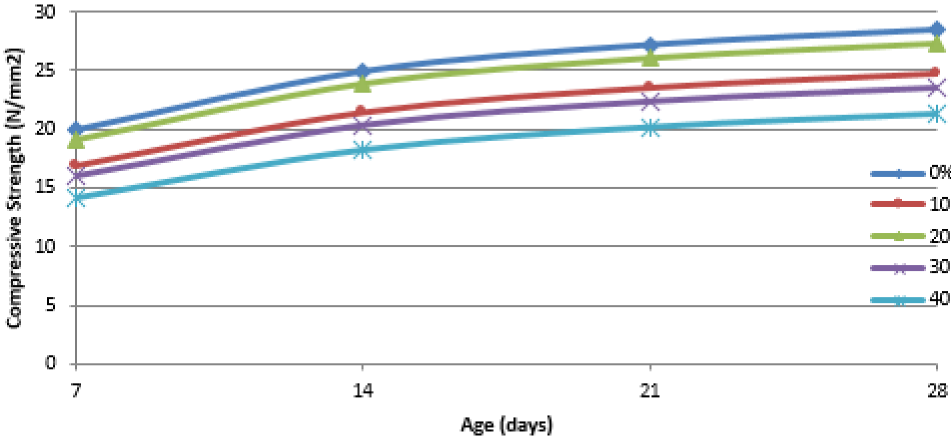

Fig. 7 Compressive Strength versus Age

Durability Test

The durability test result was conducted using dilute sulfuric acid as the curing medium. The summary values, tables and graphs are in Fig. (6A-D), which shows that, the strength decreases with the increase in quarry dust content, this shows that, quarry dust has less pozzolanic property for it to be used as a cement substitute. Similarly, the compressive strength of concrete cubes cured in sulfuric acid is a little bit higher than that cured in normal water at initial stage, i.e. (21.3N/mm^2) at 7 days, but in 14, 21 and 28 days possess a strength of 26.40, 28.70 and 30.00N/mm^2 for 0% replacement respectively, less than that cured in normal water. From Figure 8, Compressive strength of concrete mixes increases with the age (as the age increases the compressive strength also increases) in a supportive environment, this shows that, the dilute sulfuric acid does not prevent the hydration of Ordinary Portland Cement and pozzolanic reaction.

Linear Shrinkage

After the cubes were removed from the mould, the length of the cube was measured as (L_0 mm) at 0 days of curing. The cubes were cured in water for the number of days (7, 14, 21 and 28 days), the cubes were allowed to dry after the curing period, and the new length of the concrete cube was measured as (Li). The percentage linear shrinkage for each specimen was estimated using the equation 1.

$$L_S = [1 - (Li / L_o)] \times 100 \quad (1)$$

Figure 9, shows that the percentage linear shrinkage decreases with the increase in Quarry Dust replacement, this is because, the gel of cement is finer than that of Quarry Dust. The drying shrinkage occurs as a result of loss of water held by the gel pores, and the finer the gel is, the more the loss of water from the gel. Similarly Quarry Dust has a water absorption of (1.20 – 1.50%) as reported by [7].Which is less than that of cement, this allows Quarry dust to absorb less moisture than that absorbed by the cement, and the less the water absorption rate is, the less the drying shrinkage. Linear shrinkage decreases with the increase in quarry dust content; this is due to low water absorption property of the dust used. Linear shrinkage also increases with the increase in age of curing (curing period) [7].

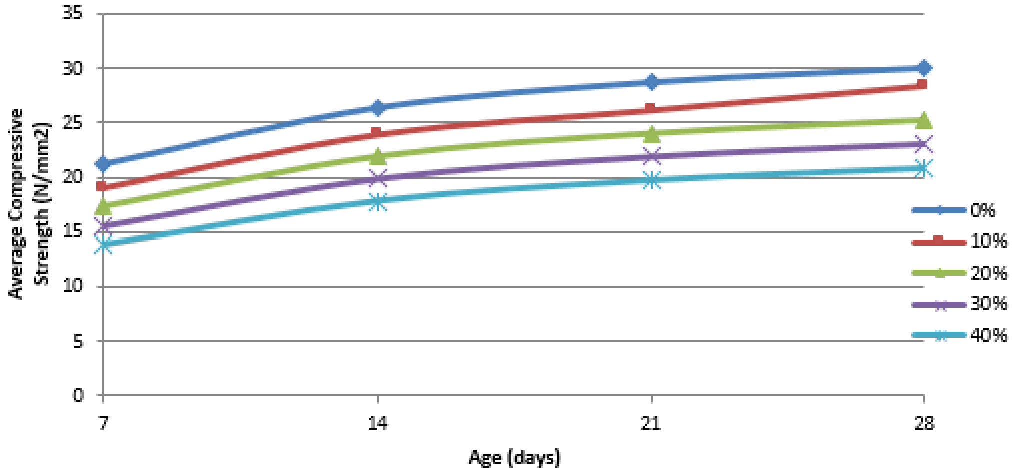

Fig. 8 Compressive Strength versus Age (Durability)

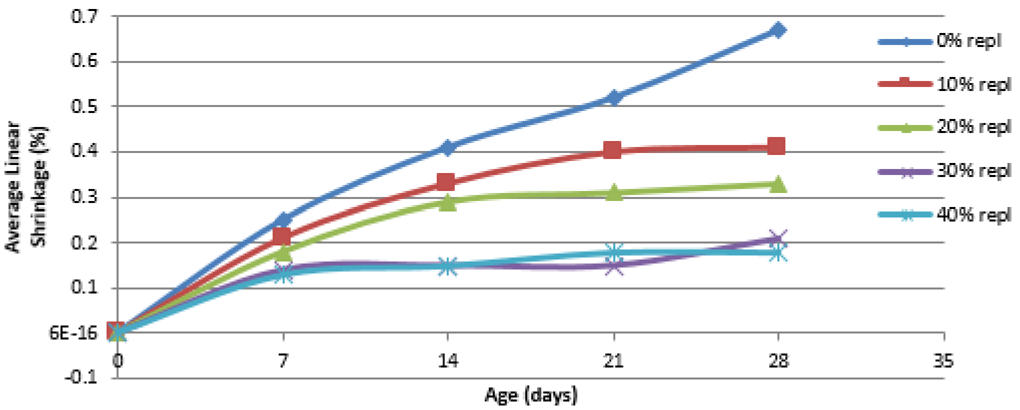

Fig. 9 Linear Shrinkage versus %Replacement

CONCLUSION AND RECOMMENDATION

The research investigated the influence of Quarry Dust as partial replacement of cement on the properties of concrete. Based on the results, the following conclusions are drawn.

Compressive Strength

Compressive strength increased with increase in age for all the percentages of cement replacement concrete. The rate of compressive development of quarry Dust concrete mixes were lower compared to no Quarry Dust concrete mixes. A 27.38N/mm^2 compressive strength obtained in 28-days on 20% replacement of cement with QD, Maximum strength was achieved with 20% replacement of cement with QD. Beyond 20% replacement it decreases, but was yet higher than control strength of 20N/mm2. The Maximum increase in compressive strength was observed at 20% replacement of cement with Quarry Dust at all ages.

Durability

Compressive strength of concrete mix increases with the age (as the age increases the compressive strength also increases) in a supportive environment. Concrete mixes with quarry dust showed higher abrasion resistance (less depth of wear) than that of concrete mixes which contain no Quarry Dust. Abrasion loss of quarry dust, concrete mixes decreased as the replacement of quarry dust increased. Maximum abrasion resistance was observed at 40% replacement of cement with quarry dust. At the age of 28 days, concrete mix with (40%QD) showed more abrasion resistance than control mix of (0%QD).

Linear Shrinkage

Linear shrinkage decreases with the increase in quarry dust content; this is due to low water absorption property of the dust used. Linear shrinkage also increases with the step-up in age of curing (curing period).

Based on the finding, Concrete made with cement being replaced by quarry dust (up to 20%) is recommended to be used for making light weight structural concretes.

- Results have shown that concrete made with cement being replaced by quarry dust (up to 20%) could appropriately be applied for making structural concretes as recommended by reference [6] 25% of partial replacement of cement with quarry dust are beneficial to concrete without loss of standard strength of cement, but could not be used in applications where abrasion (sulphate attack) is also an important parameter.
- Quarry dust as cement replacing material not recommended to be used for applications where abrasion (sulphate attack) is an important parameter.
- Further research is recommended to determine the effect of abrasion resistance (depth of the weir), Splitting Tensile Strength, Rapid Chloride Permeability, Salt Scaling Resistance, Rebound Hammer Modulus of Elasticity etc. on concrete made with quarry dust as a cement substitute.

REFERENCES

[1] AS Sule, Stability of Groundnut Shell Ash (GSA)/Ordinary Portland cement (OPC), *Advances in Applied Science Research*, **2012**, 3(4), 2283-227.

[2] A Ma'aruf Ado, Investigation into the Use of Plantain Peels Ash as an Admixture in Concrete, International Journal of Engineering Science and Computing, **2016**, 6 (5), 5377-5380.

[3] A.M Neville, *Concrete Technology*, Longman Group UK Limited, **2000**.

[4] DA Pofale and SR Quadri, Effective Utilization of Crusher Dust in Concrete using Portland Pozzolana Cement, *International Journal of Scientific and Research Publications*, **2013**, 3(8), 1-10.

[5] WG Goede, *Pervious Concrete: Investigation into Structural Performance and Evaluation of the Applicability of Existing Thickness Design Methods*, Washington State University, **2009**.

[6] S.Sai Kumar, A Study on Strength of Concrete with Partial Replacement of Cement with Quarry Dust and Metakaolin, *International Journal of Innovative Research in Science, Engineering and Technology*, **2014**, 3(3),10467-10473.

[7] Chandana Sukesh, Partial Replacement of Sand with Quarry Dust in Concrete, *International Journal of Innovative Technology and Exploring Engineering*, **2013**, 2(6), 234-258.

[8] A .Ma'aruf, Probabilistic Assessments of Composite Steel Beam in Accordance with Euro Code 4, *International Journal of Engineering Science and Computing*, **2016**, 6 (8), 2964-2967.

[9] U Anya, Mixture Experiment Models for Predicting the Compressive Strength and Water Absorption of Sand-Quarry Dust Blocks, *The International Journal of Engineering and Science*, **2015**, 4(2), 27-31.

[10] SO Ajamu, Evaluation of Structural Performance of Pervious Concrete in Construction, *International Journal of Engineering and Technology*, **2012**, 2(5), 829-836.

[11] SA Raji, Egg Shell As A Fine Aggregate In Concrete For Sustainable Construction, *International Journal of Scientific & Technology Research*, **2015**, 4(9), 8-13.

[12] S.I.Abba, Evaluation of Yearly Water Quality Index and Seasonal Variation of Yamuna River at Hathikund Station (India) using Canadian Council of Ministers of Environment Water Quality Index (CCME) Model, IOSR *Journal of Engineering*, **2017**, 7(1), 12-17.

[13] S.I.Abba, Y Said and A Bashir, Assessment of Water Quality Changes at Two Location of Yamuna River using the National Sanitation Foundation of Water Quality, **2015**, 2(8), 730-733.

[14] BS 882:1992, *Specification for Aggregates from Natural Sources for Concrete*, Online Available: http://shop.bsigroup.com/ProductDetail/?pid=000000000030009856.

[15] B 1881-116:1983, Testing concrete Part 116: Method for determination of compressive strength of concrete cubes, Gibb Limited, **2003**.

[16] B 1881-125:1986, BS 1881-125:1986 *Testing concrete - Methods for Mixing and Sampling Fresh Concrete in the Laboratory*, http://shop.bsigroup.com/ProductDetail/?pid=000000000030258715, **1986**.

[17] Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading), ASTM International, America, **2002**.

[18] SA Region, *BS 1881: Part 102: 1983. BS 1881*, Government Publications Centre, Ground Floor, Low Block Queensway Government Offices, 66 Queensway, Hong Kong, **1990**.

[19] D Muhammad, Impact of Millet Huskn Ash (MHA) as Partial Replacement of Cement in Concrete, Civil Engineering Dept. KUST Kano, **2012**.

[20] G Singh, *Strength and Durability Studies of Concrete Containing Waste Foundry Sand*, Thesis, Patiala University, Punjab, India, **2012**.

[21] Tasnia Hoque, Influence of Stone Dust as Partially Replacing Material of Cement and Sand on some Mechanical Properties of Mortar, *International Journal of Advanced Structures and Geotechnical Engineering*, **2013**, 2(2), 54-57.

[22] A Suribabu, Behaviour of Concrete on Replacement of Sand with Queries Stone Dust as Fine Aggregate, *International Journal of Innovative Research in Science, Engineering and Technology*, **2015**, 4(1), 18503-18510.