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Comparative Study of the Relationship between Physical Properties and Compressive Strength of Commercially Available Block Produced with Quarry Dust Produced in Abuja.

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ABSTRACT

The need to investigate the quality of commercially available blocks produced with quarry dust has become necessary due to non-adherence of commercially available sandcrete blocks produced with river sand to Nigeria industrial Standard (NIS) for compressive strength. This is due to ignorance on the part of the sandcrete block manufacturer of the existing standard requirement or compromise on the quality of materials used in block production. This study, as such, is a comparative study of physical properties of stone dust from selected commercial block manufacturers with view to determine their relationship with mechanical properties of the blocks produced. Ordinary Portland cement of grade 42.5, mix ratio of 1: 10 and 0.8 water/cement ratio was used for this study. Sample of mortar cubes were produced and crushed at 7, 14 and 28 days of curing ages and their values converted to compressive strength of blocks using uzomaka correlation. The results revealed at various curing ages, that sample C showed an optimal compressive strengths of 4.04N/mm^2, 4.98N/mm^2, 5.87N/mm^{2}in comparison with A= 1.60N/mm^2, 1.93N/mm^{2}and 2.00N/mm^2, B= 2.59N/mm^2, 3.22N/mm^2 and 3.70N/mm^2, D= 2.62N/mm^2, 4.71N/mm^{2}and 3.83N/mm^{2}and E= 0.78N/mm^2, 1.08N/mm^{2}and 1.19N/mm^2 respectively. And sample E shows the lowest compressive strength at the various curing ages and there was a decline in the compressive strength of sample D between 14 and 28days curing age. From the results of grading of the quarry dust, sample A, B,C and E are not well graded because Cu= 18 and Cc =0.54(for sample A); Cu= 37.5 and Cc= 3.29(for sample B); Cu = 14.29 and Cc= 0.46(for sample C) and Cu = 20.83 and Cc= 0.53(for sample E) respectively. These values are not in line with (Arora 2011) that indicated when Cc is between 1 and 3, and Cu ≥ 6, for a well graded soil, while Sample D is well graded because Cu = 19.35 and Cc= 1.9 respectively. The study therefore, suggested that sample C should be used in production of dense load bearing walls blocks and sample D is not a good material block production.

Keywords: Compressive Strength, Physical Properties, Block, Quarry Dust.

INTRODUCTION

Hollow sandcrete blocks as defined by BS 882, (1982) is masonry units of larger size in all dimension than specified for bricks but no dimension should exceed 650mm or should the height exceed either its length or six times its thickness, and they are moulded in various sizes, commonly used size is dimensions of 225mm x 450mm x150mm with a width range of 150mm to 225mm.Mohammed and Anwar (2014), noted that producers of commercial sandcrete blocks in Kano do not adhere to standard specification for mix ratio, curing and the blocks produced do not meet the standard required strength.

According to Abdullahi (2005), it was found that the compressive strength of blocks produced in Bosso and Shiroro area of Minna are below Nigerian Industrial Standard (NIS) for compressive strength, and suggested need for improvement in the selection of material and curing.

The works by Danso (2005), Oyekan and Kamiyo, (2008) showed that use of stone dust for sandcrete block production, the partial replacement of sand with quarry dust improved both strength and durability properties of the blocks. They however recommended different optimum percentage replacement.

LITERATURE REVIEW

Manasseh (2010) and Lohani et al. (2012), show that the compressive strength of concrete is greatly improved when sand is partially replaced with quarry dust. Measured strength of commercially available hollow blocks in Nigeria was found to be between 0.5 and 1.0N/mm^2, which is well below the 3.45N/mm^2 that is legally required. This may be due to the need of the manufacturers to keep price low, and since the main cost factor is the Portland cement, they reduce that which result in the block tends to behave like a loose sand. This noticeable differences could be as a result of differences in the properties of the sand and quarry dust used. Mohammed and Anwar (2014), noted that producers of commercial sandcrete blocks in Kano do not adhere to standard specification for mix ratio, curing and the blocks produced do not meet the standard required strength.

According to Abdullahi (2005), it was found that the compressive strength of blocks produced in Bosso and Shiroro area of Minna are below Nigerian Industrial Standard (NIS) for compressive strength, and suggested need for improvement in the selection of material and curing. This improvement on the quality of the blocks produced with quarry dust can be related the grading of the particles of the quarry dust.

The fines in quarry dust contribute in giving the added strength to the concrete and mortar. This is evident in the works of Nagabhushana and Sharadabai (2011) and Sahu et al (2003). They compared the compressive strengths of concrete in which the sand was partially replaced with quarry dust with its finer particles (<75 microns) removed to that in which they were included and found that the later gave relatively higher results. This is because the finer particles helped in creating a more dense structure by effectively filling the spaces between the bigger particles.

Table 1. Summary of Physical Properties of Quarry Dust Samples.

Properties	Quarry Dust				
	A	B	C	D	E
Specific Gravity	2.5	2.6	3.1	2.0	2.4
Compacted Bulk Density (kg/m^3)	1708	1730	1891	1702	1894
Uncompacted Bulk Density (kg/m^3)	1625	1599	1735	1607	1760
Coefficient of Uniformity Cu	18.0	37.5	14.29	19.35	20.83
Coefficient of Curvature Cc	0.54	3.29	0.46	1.90	0.53
Uncompacted/compacted bulk density ratio	0.95	0.92	0.92	0.94	0.93
Fineness Modulus	2.9	4	3.1	4.7	3

Table 2. Results of Compressive Strength of Sandcrete Blocks Samples as Converted using Uzomaka Correlation for 7, 14 and 28 days of Curing strength in N/mm^2

		SAMPLE			
	A	B	C	D	E
Days					
7	1.6	2.59	4.04	2.62	0.78
14	1.93	3.22	4.98	4.17	1.06
28	2.00	3.70	5.87	3.83	1.19

Table 3. Relationship between Physical, Mechanical and Permeability Properties of Blocks.

Samples	Physical properties							Mechanical properties		
	SG	CBD Kg/m^3	UBD Kg/m^3	Cu	Cc	UBD CBD ratio	FM	Average compressive Strength (N/mm^2)		
								7days	14days	28days
A	2.5	1708	1625	18	0.54	0.95	2.9	1.60	1.93	2.00
B	2.6	1730	1599	37.5	3.29	0.92	4.0	2.59	3.22	3.70
C	3.1	1891	1735	14.29	0.46	0.92	3.1	4.04	4.98	5.87
D	2.0	1708	1607	19.35	1.90	0.94	4.7	2.62	4.17	3.83
E	2.4	1894	1760	20.83	0.53	0.93	3.0	0.78	1.06	1.19

SG= Specific Gravity CBD= Compacted Bulk Density
UBD= Uncompacted Bulk Density Cu= Coefficient of Uniformity
Cc= Coefficient of Curvature F= Fineness Modulus

MATERIALS AND METHODS

Materials

The materials used for this work are quarry dust, cement and water. The quarry dust samples was passed through 14mm British Standard test sieve and is free from deleterious substances. The quarry dust sample has specific gravities of A= 2.5, B= 2.6, C= 3.1, D= 2.0 and E= 2.4, Compacted bulk density of A= 1708kgm^3, B= 1730kgm^3, C= 1891kgm^3, D= 1708kgm^{3}and E= 1894kgm^3, Fineness of A= 2.9, B= 4.0, C= 3.1, D= 4.7 and E= 3.0, Coefficient of uniformity of A=18, B= 37.5, C= 14.29, D= 19.35 and E= 20.83 and Coefficient of curvature of A= 0.54, B= 3.29, C= 0.46, D= 1.90 and E= 0.53.The Quarry dust used was collected from five (5) different block industries within Abuja. The results obtained from the tests of the physical properties of the quarry dust samples are recorded in table1.

The quarry dust samples was used to produce mortar cubes which were crushed at 7, 14 and 28days of curing ages to obtain their compressive strengths. The results of the compressive strength tests of mortar cubes were converted to compressive strength of blocks using Uzomaka correlation is presented in table 3 and summary of the relationship between physical and mechanical properties are presented in table 4. The cement used in this research was Ordinary Portland Cement (OPC) produced in Nigeria with a grade of 42.5 which conformed to NIS 441-1:2003 as evidenced by the certification mark (NIS 441-1:2003; ISO 9001: 2008) on the product bags and water used for this research was portable water as specified in NIS 87: 2007 gotten within the University of Jos.

Experimental Procedures

Mortar cube samples of 100mm x 100mm x 100mm were produced using quarry dust selected from the five (5) block producing factories within Abuja. A total of 45 numbers of mortar cubes were produced for this research. The mix ratio of 1:10 and water/ cement ratio of 0.8 was used for the study. The curing of the mortar cubes was by immersion for 7, 14 and 28 days and the specimen were crushed to obtain their compressive strength test at 7, 14 and 28 days curing age. An average value of result of three (3) mortar cubes each from the five (5) selected samples were recorded and used to determine the average compressive strength of the mortar cubes at 7, 14 and 28 days. This values were converted using Uzomaka correlation as shown below.

$$U_C = 1.07 + 2.46\, U_B$$

Where

U_C = Compressive strength of cubes

U_B = Compressive Strength of blocks.

RESULTS AND DISCUSSIONS

The properties of the materials used for this work were determine and the results of the compressive of blocks were presented in table 1 and 2.The results of the average compressive strength developments with curing ages at 7, 14 and 28 days is presented in table 2. The Compressive The results indicated that sample C recorded the highest compressive strength of 4.04N/mm^2, against samples A, B, D and E that recorded 1.60 N/mm^2, 2.95N/mm^2, 2.62N/mm^2 and 0.78N/mm^2 respectively at 7 days of curing age.

At 14 days of curing age sample C maintain a consistency of recording the highest strength development of 4.98N/mm^2, against A, B, D and E that recorded 1.93N/mm^2, 3.22N/mm^2, 4.17N/mm^2 and 1.06N/mm^2 respectively.

At 28 days of curing age sample C maintains an optimal compressive strength of 5.87N/mm^2, in comparison with A, B, D and E with 2.0N/mm^2, 3.83N/mm^2 and 1.19N/mm^2, respectively. From the results of compressive strength analyzed above, samples A and E values of compressive strength for 7, 14 and 28 days of curing ages were less than the (NIS 1987) of 2.50N/mm^2, while samples B, C and D recorded values of strength developments greater than NIS of 2.50N/mm^2 at the same curing ages. And the value of compressive strength of sample D decline from 4.17N/mm^2 to 3.83N/mm^2 at 28days.

It shows that sample B with specific gravity value of 2.6. This falls within the limits of natural aggregates which have specific gravities between 2.6 to 2.7 Neville (1995). While sample A, C, D and E with specific gravities of 2.5, 3.1, 2.0 and 2.4 respectively does not fall within the limits.

The average bulk densities of the uncompacted quarry dust samples A, B, C, D and E are 1625kg/m^3 , 1599kg/m^3 , 1735kg/m^3 , 1607kg/m^3 and 1760kg/m^3 respectively and the average compacted bulk densities are 1708kg/m^3, 1730kg/m^3, 1891kg/m^3 , 1702kg/m^3 and 1894kg/m^3 respectively which is within the limit of dense weight blocks of values greater than 1500kg/m^3 Dio and Morris (2009). The uncompacted to compacted bulk densities ratios of the sample are 0.95, 0.92, 0.92, 0.94 and 0.93 respectively which is within the specified range of 0.87 to 0.96 Neville (1995).

The results of the fineness modulus shows that Sample A= 2.9, C=3.1 and E=3.0 are within ASTM: C33 limits of between 2.3 and 3.1 for sand. While fineness modulus of sample B= 4.0 and D= 4.7 are not within the limits. Sample A with fineness value of 3.1 of yield highest compressive strengths at 7, 14 and 28 days curing ages, while sample D with fineness modulus of 4.7 shows decline in the compressive strength between 14 and 28 days curing age. This indicate that sample A which is within the limit of coarse sand can be recommended for block production while sample D is not good for block production and cannot also be classified as coarse aggregate which is between 6.50 and 8.00 for coarse aggregate less than 38mm.

From the results of the properties of the Quarry dust presented in table 2, sample A, B, C and E are not well graded because: Cu= 18, Cc =0.54;Cu= 37.5, Cc= 3.29 Cu = 14.29, Cc= 0.46 and Cu = 20.83, Cc= 0.53 respectively. These values are not in line with (Arora 2011) that indicated when Cc is between 1 and 3, and Cu ≥ 6, for a well graded soil, while Sample D is well graded because Cu = 19.35, Cc= 1.9 respectively, which falls within the limits of (Arora 2011) of Cc between 1 and 3 and Cu ≥ 6.

CONCLUSION AND RECOMMENDATION

In summary, the following deductions were drawn from the tests carried on the physical properties of the material and compressive strength of the blocks.

i. It was observed that sample C with the lowest values of Cu =14.29 and Cc = 0.46 has optimum compressive strengths values of 4.04N/mm2, 4.98N/mm2 and 5.87N/mm2 at 7, 14 and 28days.
ii. That sample D which is classified as well graded soil and shows a decline in its compressive strength at 28 days of curing should not be recommended for block production.
iii. That the quarry dust samples has bulk densities greater than limit recommended for dense load bearing blocks and hence should be recommended for production of load bearing blocks.

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