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Effect of Cement Grades on some properties of Sandcrete

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Abstract

The purpose of this study is to investigate the effects of cement grade on some properties of sandcrete. The cement used for this work was Ordinary Portland cement (Dangote brand) of grade 42.5 and 32.5 meeting the requirement of ASTM C150 type 1 cement. Three types of fine aggregate was also used to produce sandcrete cubes which includes Ovbiogie sharp sand, Okhuahe sharp sand and Iguosa river erosion sand all obtained from Benin city , Edo state, Nigeria. Sieve analyses were carried out on the three fine aggregate samples which fell under zone 3 according to BS 882:1954. Sand/cement ratios of 1:6, 1:8 and 1:10 were used to produce a total of 216 samples of 150mm x 150mm sandcrete cubes. The work studied the compressive strengths of the various sandcrete cubesat curingages of 1, 3, 7 and 28 days respectively.

The results obtained using grade 32.5 cement at 7days with sand/cement ratio 1:6 are 3.48N/mm^2, 3.30N/mm^2 and 3.21N/mm^2 for Ovbiogie sand, Iguosa sand and Okhuahe sand samples respectively. For sand/cement ratio 1:8, the compressive strength of the sandcrete cubes are 3.03N/mm^2, 2.34N/mm^2, and 2.43N/mm^2 for Ovbiogie sand, Iguosa sand and Okhuahe sand samples respectively. These met the Nigerian Industrial Standard (NIS, 1975) for load bearing blocks and non-load bearing blocks. Using grade 42.5 cement, the results also obtained, for 7days with sand/cement ratio 1:6 are 6.52N/mm^2, 6.03N/mm^2 and 6.22N/mm^2 for Ovbiogie sand, Iguosa sand and Okhuahe sand samples respectively. For sand/cement ratio 1:8, the compressive strength of the sandcrete cubes are 5.48N/mm^2, 3.69N/mm^2, and 2.89N/mm^2 for Ovbiogie sand, Iguosa sand and Okhuahe sand samples respectively. These also met the Nigerian Industrial Standard (NIS, 1975) for load bearing blocks and non-load bearing blocks. This study has shown that cement grade does not translate to sandcrete strength.

1.0 Introduction

Sandcrete is very important in modern societies, especially in developing countries like Nigeria. Sandcrete is a mixture of sand, cement and water in varying proportions. They are mostly used as load bearing and non-load bearing members in the building industry [1].

The key in achieving a strong and durable sandcrete, rest in the right proportioning of the sand/cement ratio and water/cement ratio. The compressive strength of sandcrete increases, as the water/cement ratio increases until an optimum value is reached, when a further increase on the water/cement ratio results in a decrease of the compressive strength [1].

A sand/cement ratio of 1:6 have been recommended by Standard Organisation of Nigeria (SON) for sandcrete block but our block making factories use sand/cement ratios of 1:8 and 1:10 for load bearing blocks and non-load bearing blocks [2].

The selection of a fine aggregate is determined in part by the desired characteristics of the sandcrete [3]. Adeola[4] reported that the coarser the sand particles, the higher the compressive strength of the sandcrete . In another study carried out by Asien[5] were he reported that the better the particle size distribution of the sand samples, the more the solid air voids will be filled resulting to a stronger and better sandcrete. The grade of cement does not affect the strength adversely.

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1.1 Types of Portland cement

ASTM [6]has designated five types of Portland cement as Types I-V. Physically and chemically, these cement types differ primarily in their content of Calcium Aluminate Minerals (C_3A), Calcium Silicate Minerals (C_3S) and in their fineness. In terms of performance, they differ primarily in the rate of early hydration and in their ability to resist sulfate attack. The general characteristics of these types are listed in Table 1.

Table 1: General Features of the Main Types of Portland Cement.

	Classification	**Characteristics**	**Applications**
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

(Source: ASTM [6])

The differences between these cement types are rather subtle. All five types contain about 75% Calcium Silicate Minerals, and the properties of mature concretes made with all five are quite similar. Thus these five types are often described by the term “Ordinary Portland Cement”, or OPC.

In Nigeria, we have various brands of Ordinary Portland Cement which includes Dangote Cement, Elephant Cement, Ashaka Cement, Ibeto Cement, Sokoto Cement e.t.c. Allthese falls into Type I class of cement according to ASTM [6]. The various brands have been used for many decades in the construction industry without knowing their various grades and the purposes for each. Not until recently governmental bodies, corporate bodies and non-governmental organizations raised the concern for the grading of cement in Nigeria.

One of these organizations is Standard Organization of Nigeria (SON). In Vanguard newspaper publication [7] SON approved 32.5Mpa, 42.5Mpa and 52.5Mpa grades of cement in the country and directed all cement companies to comply. They recommended that grade 32.5Mpa cement should be used for plastering only; grade 42.5Mpa cement should be used for cast of beams, slabs and block moulding while grade 52.5Mpa cement was meant for construction of bridges and specialized applications.

In a swift reaction, Council for the Regulation of Engineering in Nigeria (COREN) stated categorically in a stakeholder’s meeting held in Sheraton Hotel and Towers, Lagos on 14th March, 2014 that‘cement grades does not translate to sandcrete strength’. It rather depends on the sandcrete mix design. The building collapse experience in the country is as a result of ‘poor sandcrete’ not poor cement grade and encourages members of the public to consult qualified professionals in carrying out their construction needs.However,moreresearch needed to be carried out on the various brands of cement in the country to ascertain their quality.

By definition, the strength that will be achieved at 28 days by a prism of specific dimensions made from particular cement, sand and water (with cement/sand ratio of 1:3) gives the cement grade of 32.5, 42.5 and 52.5 Mpa. It also implies that the cement grade is the strength of a certain mortar size made from the cement. It means invariably, that grades 42.5 Mpa and 52.5 Mpa will yield higher strength than grade 32.5 Mpa [8].

There is therefore the strong need tocarry out experimental work on the compressive strength of sandcrete of various grades ofcement in the country at different sand/cement ratios and using various fine aggregates to actually draw conclusions about the cement grade and compressive strength of sandcrete. This then constitutes the motivation for this study.

2.0 Experimental Details

The cement used for this work was Ordinary Portland cement (Dangote brand) of grade 42.5 and 32.5 meeting the requirement of ASTM C150 type 1 cement. Three types of fine aggregate was also used to produce sandcrete cubes which include Ovbiogie sharp sand, Okhuahe sharp sand and Iguosa river erosion sand all obtained from Benin city , Edo state, Nigeria. Sieve analyses were carried out on the three fine aggregate samples. Sand/cement ratio of 1:6, 1:8 and 1:10 were used to produce a total of 216 samples of 150mm x 150mm sandcrete cubes. The work studied the compressive strengths of the various sandcrete at curingages of 1, 3, 7 and 28 days respectively.

Table 2: Sieve Analysis for Ovbiogie Sharp Sand

Sieve Sizes (mm)	Weight Retained (g)	Weight Passing (g)	Percentage Passing (%)
2.36	1.41	98.59	98.59
2.00	1.02	97.57	97.57
1.18	9.28	88.29	88.29
600µm	31.00	57.29	57.29
425	11.51	45.78	45.78
300	25.22	20.56	20.56
212	13.63	6.93	6.93
150	4.80	2.13	2.13
75	1.31	0.82	0.82

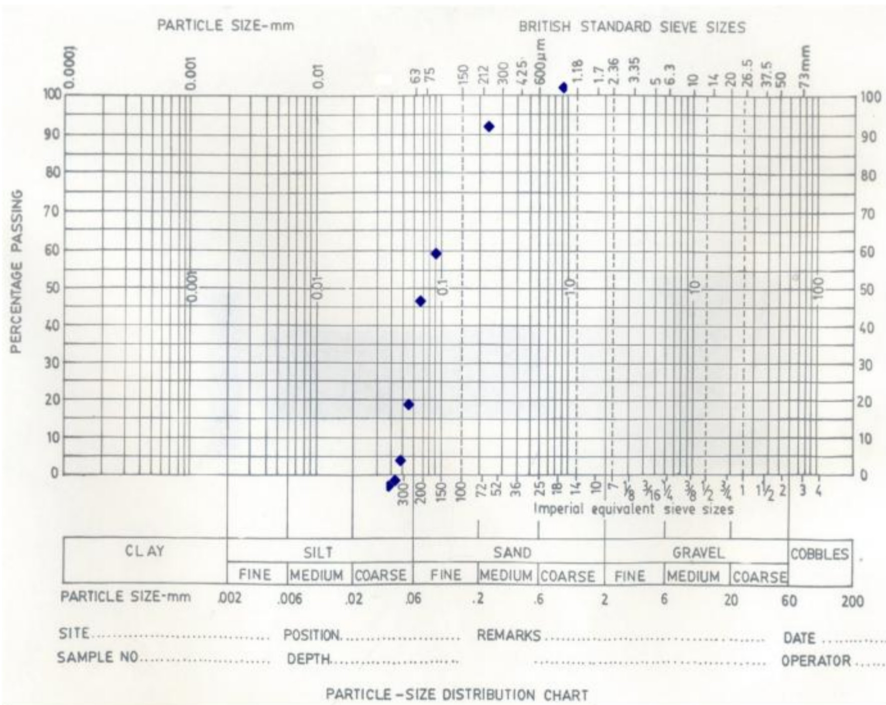

Fig.1: Sieve Analysis Graph for Ovbiogie Sharp Sand

Table 3: Sieve Analysis for Okhuahe Sharp Sand

Sieve Sizes (mm)	Weight Retained (g)	Weight Passing (g)	Percentage Passing (%)
2.36	0.48	99.52	99.52
2.00	0.69	98.83	98.83
1.18	4.95	93.88	93.88
600µm	20.63	73.25	73.25
425	10.65	62.60	62.60
300	28.57	34.03	34.03
212	19.83	14.20	14.20
150	7.86	6.34	6.34
75	5.77	0.57	0.57

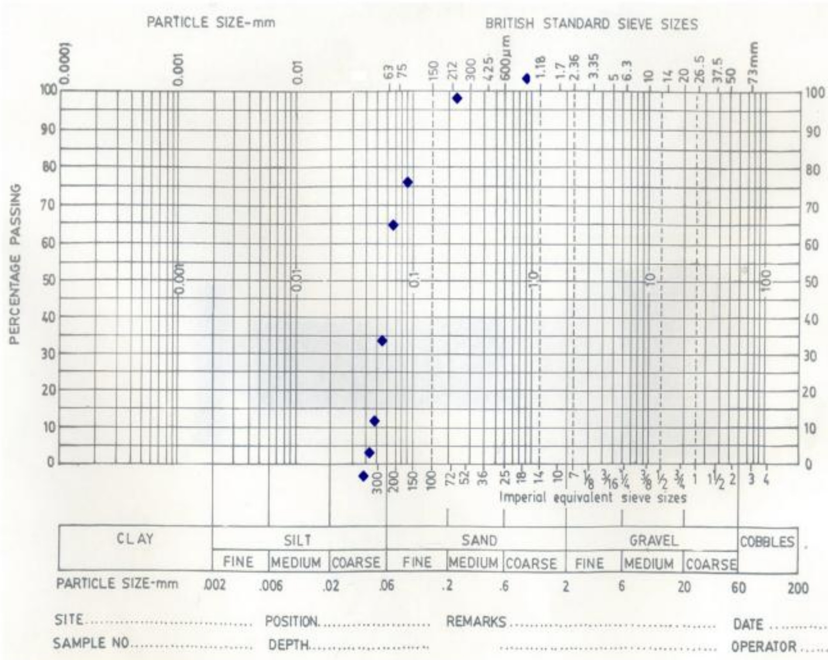

Fig.2: Sieve Analysis Graph for Okhuahe Sharp Sand

Table 4: Sieve Anaysis for Iguosa River Erosion Sand

Sieve Sizes (mm)	Weight Retained (g)	Weight Passing (g)	Percentage Passing (%)
2.36	2.06	97.94	97.94
2.00	1.40	96.54	96.54
1.18	11.83	84.71	84.71
600μm	38.40	46.31	46.31
425	14.04	32.27	32.27
300	20.68	11.59	11.59
212	7.77	3.82	3.82
150	1.59	2.23	2.23
75	1.79	0.44	0.44

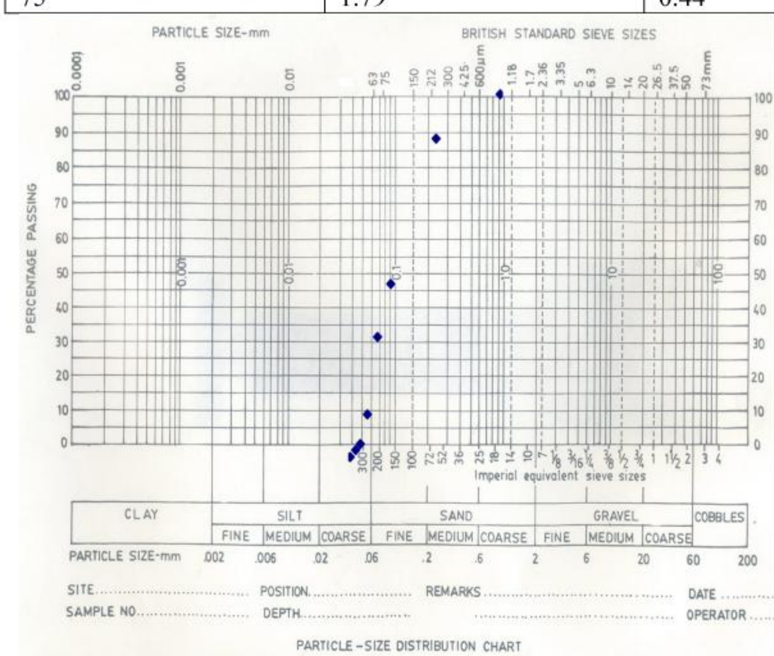

Fig.3: Sieve Analysis Graph for Iguosa Sharp Sand

3.0 Results and Discussions

Table 2 to 4 and fig.1 to 3shows the sieve analysis for Ovbiogie sand, Okhuahe sand and Iguosa sand respectively. They all fell into zone 3 according to BS882:1954 [9] whichmakes it fit for sandcrete use. Table5 and fig.5 reveals the results of the compressive strength of sandcrete using grade 42.5 cement. It was noticed that for Ovbiogie sand samples and Iguosa sand samples,the compressive strength for one(1) day and three(3) days was 0N/mm^2, while that of Okhuahe sand sample gave a reading of 3.93N/mm^2, 1.63N/mm^2, 0N/mm^2 and 4.44N/mm^2, 2.74N/mm^2, 0N/mm^2 at sand/cement ratios of 1:6, 1:8 and 1:10 respectively. These meant that sandcrete blocks must not be used in building construction within 3(three) days of curing. Although at sand/cement ratios of 1:6 and1:8 at seven (7) days and twenty eight (28) days, it met the minimum standard of Nigeria Industrial Standard [10] which stipulates compressive strength of 1.72N/mm^2 for non-loading bearing blocks and 2.07N/mm2 for load bearing blocks.

Table 6 and fig.4 shows the results for the compressive strength of sandcrete blocks using grade 32.5 cement. It was also noticed that, there was zero (0 N/mm^2) reading for the three sand samples and the mix ratios within three (3) days of curing. It also supported the statement that sandcrete blocks must not be used within three (3) days of manufacture. Although at sand/cement ratio of 1:6 and1:8 at seven (7) days and twenty eight (28) days, it met the minimum standard of Nigeria Industrial Standard [10] which stipulates compressive strength of 1.72N/mm^2 for non-loading bearing blocks and 2.07N/mm^2 for load bearing blocks.

Table 5: Compressive Strength for Sandcrete using Grade 42.5 Cement

Curing (Days)	Sand/cement ratio	Average Compressive Strength for Ovbiogie sand (N/mm^2)	Average Compressive Strength for Iguosa river erosion sand (N/mm^2)	Average Compressive Strength for Okhuahe sand (N/mm^2)
1	1:6	0	0	3.93
	1:8	0	0	1.63
	1:10	0	0	0
3	1:6	0	0	4.44
	1:8	0	0	2.74
	1:10	0	0	0
7	1:6	6.74	5.19	6.37
	1:8	4.29	3.48	5.93
	1:10	0	0	0
28	1:6	10.7	9.78	8.67
	1:8	8.15	4.32	6.82
	1:10	6.52	2.79	3.63

Table 6: Compressive Strength for Sandcrete using Grade 32.5 Cement

Curing (Days)	Sand/cement ratio	Average Compressive Strength for Ovbiogie sand (N/mm^2)	Average Compressive Strength for Iguosa river erosion sand (N/mm^2)	Average Compressive Strength for Okhuahe sand (N/mm^2)
1	1:6	0	0	0
	1:8	0	0	0
	1:10	0	0	0
3	1:6	0	0	0
	1:8	0	0	0
	1:10	0	0	0
7	1:6	3.48	3.30	3.21
	1:8	3.03	2.34	2.43
	1:10	1.53	1.49	1.51
28	1:6	6.52	6.03	6.22
	1:8	5.48	3.69	3.05
	1:10	3.88	2.88	2.89

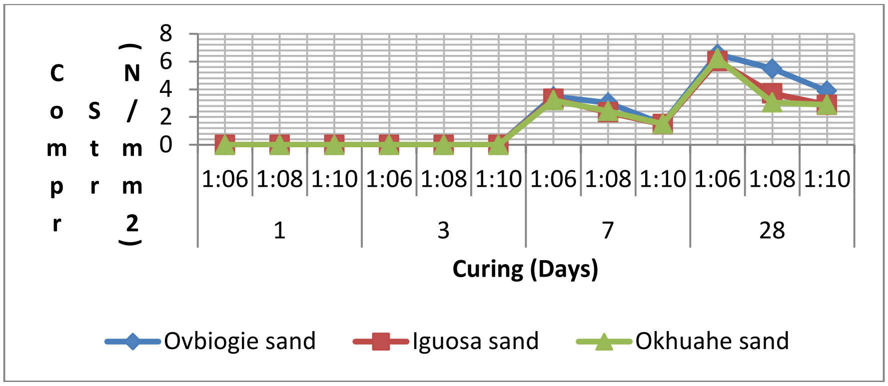

Fig 4: Relationship between three sand samples and compressive strength using grade 32.5 cement

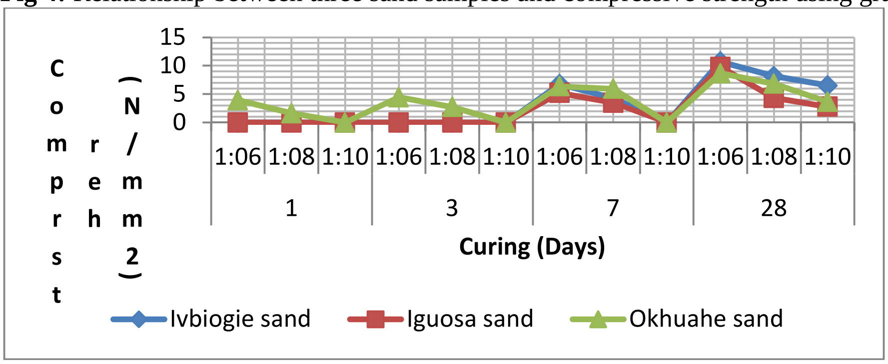

Fig 5: Relationship between three sand samples and compressive strength using grade 42.5 cement

4.0 Conclusion

Due to the compressive strength of sandcrete cubesresults obtained from Figs 4 and 5 made with grade 32.5 and 42.5 cement (Dangote brand) at 7 and 28 days period of curing, the following can be inferred:

i. The grade of cement does not affect the compressive strength of sandcrete block very adversely.
ii. Grade 32.5 cement can be used in manufacturing non-load bearing blocks and load bearing blocks.
iii. This study supports the statements of Council for the Regulation of Engineering in Nigeria (COREN) that the grade of cement does not necessarily translate to the compressive strength of the sandcrete blocks.
iv. The compressive strength of sandcrete blocks depends largely on the sand/cement ratios and the water/cement ratios and minimally on the cement grade.
v. Sandcrete blocks should be used for construction after three (3) days of manufacture**.**

5.0 References

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