

Effect of Acidic Environment on Hollow Sandcrete Blocks

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ABSTRACT

This research investigated the effects of Tetraoxosulphate VI acid on commercially produced hollow sandcrete blocks. Seventy two (72) hollow sandcrete blocks were produced for this research. Acid concentrations of pH 1.3, 1.4, 1.5, 1.7, 2.0 and 7.0 (control sample) were prepared and the sandcrete blocks immersed in the various acid concentrations for 24, 72, 168 and 672 hours. The density, water adsorption and compressive strength of the blocks were measured. The research concluded that there was a slight effect of acid concentration on compressive strength of the blocks with the control sample immersed at (pH 7) having the overall highest value of 5.52N/mm² at the end of 672hour sampling while the others (pH 1.3, 1.4, 1.5, 1.7, 2.0) have highest compressive strength values at the 72hour sampling (corresponding to 5.65, 5.52, 5.41, 5.21 & 5.25 N/mm² respectively). There was also a reduction in water absorption in the acidic medium while there was no effect of acidity on the density of blocks.

Keywords: sandcrete blocks, compressive strength, low pH, acid, Tetraoxosulphate VI acid.

I. INTRODUCTION

Sandcrete blocks are widely used in Nigeria as building structural units; they come in different sizes and can be solid or hollow. The constituents of sandcrete blocks usually include aggregate (sand and in some cases, coarse or stone dust), binder and water in varying ratios [2].

Sandcrete hollow or solid blocks are used as load bearing or partition units in construction and its most important characteristics are its compressive strength, density and water absorption just to mention a few [9]. The constituents used and the procedure for the production of the blocks determines the characteristics of the block and suitability of its application. In the construction industry sandcrete blocks are significant to physical infrastructural development mainly in areas of residential, commercial and public projects [2]. This role (that it plays in infrastructure development) is an important element of a city's holistic development and in an economy like Nigeria.

Whilst sandcrete blocks may be properly produced, it is important to know its behavior in different environments so that its suitability for use in that environment will not be questionable. This research sought to investigate the behavior of commercially produced hollow sandcrete blocks when continually subjected to acidic environment. Tetraoxosulphate

(VI) H₂SO₄ Acid was used to simulate the acidic environment. Parameters studied on the hollow sandcrete blocks include compressive strength, density and water absorption. Other parameters tested are the materials used to produce the blocks, this include-cement and fine aggregates.

A. Binder-Cement

A binder is a substance that creates an adhesion between the materials due its reaction with water which makes it set and hardens. The main binder used in sandcrete block production is usually ordinary Portland cement [15]. The cement to be used in sandcrete block production is dependent on its soundness, setting time, compressive strength and fineness. The test results should meet the requirement stated by BS 12: 1996-Specification of Portland cement and NIS 444-1:2003-Portland Cement [12], [4].

B. Sharp Sand

This consists of mostly silica and alumina substances occurring naturally or synthetically [1]. Sharp sand used in sandcrete block production should have no cohesion, have high strength and have no organic matter present. It has to be a well graded soil, falling within zone II and III classification based on [8] and should have silt content less than 6%.

C. Water

Water used for the hollow sandcrete block production should be free from impurities including particles (suspended or dissolved), alkalis, acids, contaminants (oil) and organic matter like algae; it should have a pH of 7 (i.e. neutral); the water must be almost fit for drinking [1], [2], [15].

D. Acid Effect on Concrete and Cement Product

Reference [7] stated that acids' effect on cement products occurs externally and internally though adequate compaction and low permeability can greatly reduce its effect. Their research also showed that duration of exposure (alternating, partial or perpetual) and the type of acid is important to understanding the effect on the external attack it has on the cement products. The results have shown a reduction in compressive strength, durability and modulus of elasticity modulus of the cement based materials.

II. METHODOLOGY

The procedure adopted in the research was summarized as follows-Test on the raw materials

(sand and cement), preparation of hollow sandcrete blocks, preparation of acidic media, immersion of blocks in the media and testing of the hollow sandcrete blocks for compressive strength, density and water absorption.

The procured hollow sandcrete blocks were prepared using Sand, Ashaka brand of Portland cement and water in the ratio (6:1:0.8). Particle Size Distribution (PSD) was carried out on the sand according to [11] which in addition specifies the allowable silt content of the sand sample. The cement was subjected to the following tests-initial setting time, final setting time, soundness and compressive strength according to [6]. No test was carried out on the water used to produce the blocks. A total number of seventy two (72) blocks of size 230mmX230mmX460mm were produced for the research. The blocks were produced in line with [10] specification. Proper curing was achieved by spraying water morning and evening (twice per day) for a period of seven (7) days.

The acid media was prepared using concentrated Tetraoxosulphate (VI) acid (i.e. H₂SO₄). The control sample pH of 7 (neutral) was used which contained deionized water only, while pH concentrations of 1.3, 1.4, 1.5, 1.7 and 2.0 were prepared by carefully diluting the acid in deionized water and testing their pH levels with a pH meter.

The blocks were immersed in various acid concentrations while noting the physical appearance of the blocks and weight of the blocks before and after immersion. The blocks were immersed in acidic environment for 24hrs, 72hrs, 168hrs and 672hrs; while the control samples was considered to the blocks immersed in the pH of 7.0. A compressive strength test carried out on each sampled block using standard compressive test equipment. Average of three results was presented.

A. Compressive Strength

The compressive strength was calculated based on the solid bearing area (effective area) of the hollow block since the block is not filled with grout when used in construction [5]. Equation (1) was used for calculating compressive strength:

$$\text{Compressive Strength} = \frac{\text{Failure load on Block}}{\text{Gross Area of Block}} \text{ (N/mm}^2\text{)} \dots \dots \dots \text{ (Eqn. 1)}$$

B. Density Test

The test is aimed at determining the density of the blocks. The test was conducted in accordance to Appendix B[10]. The density was determined by using Equation (2):

$$\text{Density} = \frac{\text{mass of dry sandcrete block}}{\text{actual volume}} \text{ (kg/m}^3\text{)} \dots \dots \dots \text{ (Eqn. 2)}$$

C. Water Absorption

Water absorption is a good indicator of the apparent porosity of the blocks. The water absorption

was carried out in accordance with Appendix B.1 [14]. The water absorption was determined using Equation (3):

$$\text{Water Absorption} = \frac{\text{mass of wet sandcrete block} - \text{mass of dry sandcrete block}}{\text{mass of dry sandcrete block}} * 100\% \text{ (Eqn. 3)}$$

III. RESULTS AND DISCUSSION

The test results of the Sieve analysis, silt content, cement testing; compressive strength, density and absorption of samples are presented below.

A. Sieve Analysis and Silt Content

1) Silt Content:

To determine the silt content the weight of soil passing 0.075mm sieve was used (see Table 1). Note that for this research the weight retained on the 0.063mm and pan is summed and used as the weight of soil sample passing the 0.075mm sieve:

$$\text{Weight of Soil passing 0.075mm sieve} = (1.4 + 0.2)g = 1.6g$$

$$\text{Total Weight of Soil Sample Sieved} = 200g$$

$$\text{Silt Content} = \frac{1.6g}{200g} * 100\% = 0.8\%$$

From the particle size distribution table and curve (Table 1 and Figure 1), it was noted that less than 5% of soil sample sieved passed the 0.075mm sieve size and by Unified Soil Classification System (USCS) the sample is classified as Sand Well-Graded denoted by SW [3]. It also conforms to [8] classification and standard of silt content less than 6%.

B. Cement Testing:

Table 2 shows the test results of the cement. The Initial setting time of 110mins, soundness of 1.5mm and initial compressive strength of approximately 10.2N/mm² was obtained. The results obtained conforms to [6]. While compressive strength of approximately 15.7N/mm² was obtained which was slightly less than 16N/mm² which is the minimum strength recommended after curing for seven (7) days. This confirms that the cement used for the production of hollow sandcrete blocks met the standard specification.

C. Compressive strength of blocks

From Table III and Figure 2, all the samples showed compressive strengths above the [13] standard of 2.5N/mm² and 3.45N/mm² as requirement of hollow sandcrete blocks. It is worthy to note that the highest compressive strength recorded (at the end of 672hour sampling) was 5.5168N/mm² on the pH 7.0 sample. The cases for pH of 1.3, 1.4, 1.5, 1.7 and 2.0 generally showed an initial increase in compressive strength on the second sampling day (72hrs) compared to the first sampling day (24hr), but the values for compressive strength gradually declined at latter sampling days. This decrease in compressive strength between the first and last sampling days was in 2.38%,

1.26% and 4.71% for pH 1.3, 1.4 and 1.7 respectively. While for pH 1.5 and 2.0 there was an increase in compressive strength (7.23% and 5.57% respectively) at the last sampling day (672hrs) compared to the first sampling day (24hrs). The value of the compressive strength for the two cases (5.3 N/mm² and 5.2 N/mm²) was however lower than that of the control sample (pH 7.0 at 5.52 N/mm²). There seems to be an indication that the varied concentration of acid has an effect on the compressive strength of sampling blocks, since for example the highest compressive strength was recorded in the control sample (pH 7.0) as against that of the lower pH values for the same last sample time (672hrs). This may probably be due to immersion of the blocks in acidic solution, type of acid used and temperature.

D. Density

From Table IV and Figure 3, the densities of all the samples are above the [13] minimum value of 1500kg/m³ for type B and 2400kg/m³ for type A blocks. The highest density value of 2753.1kg/m³ was noted at 672hr sample of pH 1.3. The control sample (pH 7) and pH 1.5 showed highest density values (2433.07kg/m³ and 2389.7kg/m³ respectively) at 168hr sample time. While the pH 2.0 sample showed highest density value (2468.11kg/m³) at the 24hr sample with about 3.5% reduction when compared with the 672hr sample of the same sample. The others pH 1.3, 1.4 and 1.7 showed a corresponding of 16.27%, 7.33% and 1.82% increase in densities at 672hr samples compared to the 24hrs samples. The nature of the results does not show a clear indication that acidity or immersion time affects the density of sandcrete blocks.

3.5 Water Absorption

Reference [13] specifies that the water absorption should not exceed 12%, beyond this the sandcrete blocks will be weakened and ultimately fail when exposed to flooding. From the test results presented in Table V and Figure 4 shows the case of pH 1.3 having the lowest absorption value of 1.3% at 672hr sample time. The highest absorption value of 9.31% was recorded at the 72hr of the control sample (pH 7). Samples of pH 1.3 and pH 1.4 showed a 79.4% and 29.5% reduction in water absorption between the 24hr and 672hr sampling, pH 7, 1.5, 1.7 and 2.0 showed a 4.01%, 65.83%, 13.59% and 78.29% respective increase in water absorption values when compared with that of 24hr and 672hrs sample. This would be attributed to the fact that at early immersion periods the voids are empty, which gives more room for more of the medium to be absorbed, as compared to when the voids are saturated at later immersion periods. There was no much distinct effect of the acid or time of immersion on the water absorption of the hollow sandcrete blocks.

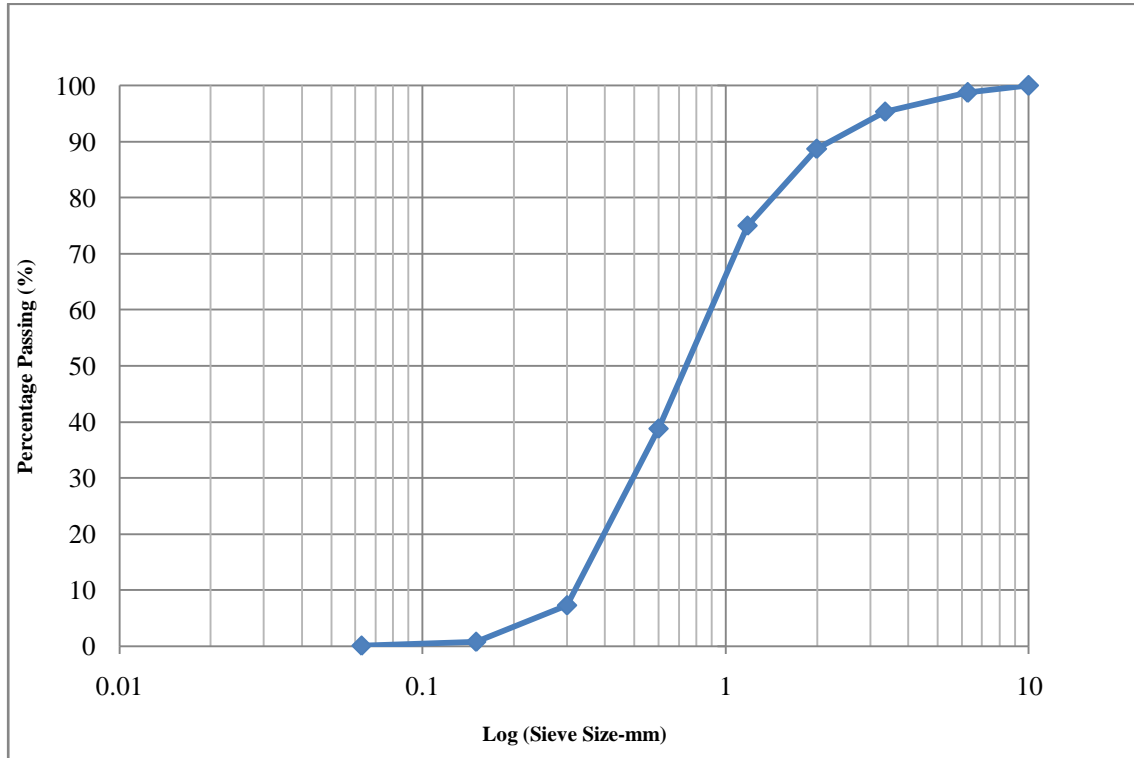


Figure 1: Particle Size Distribution Curve

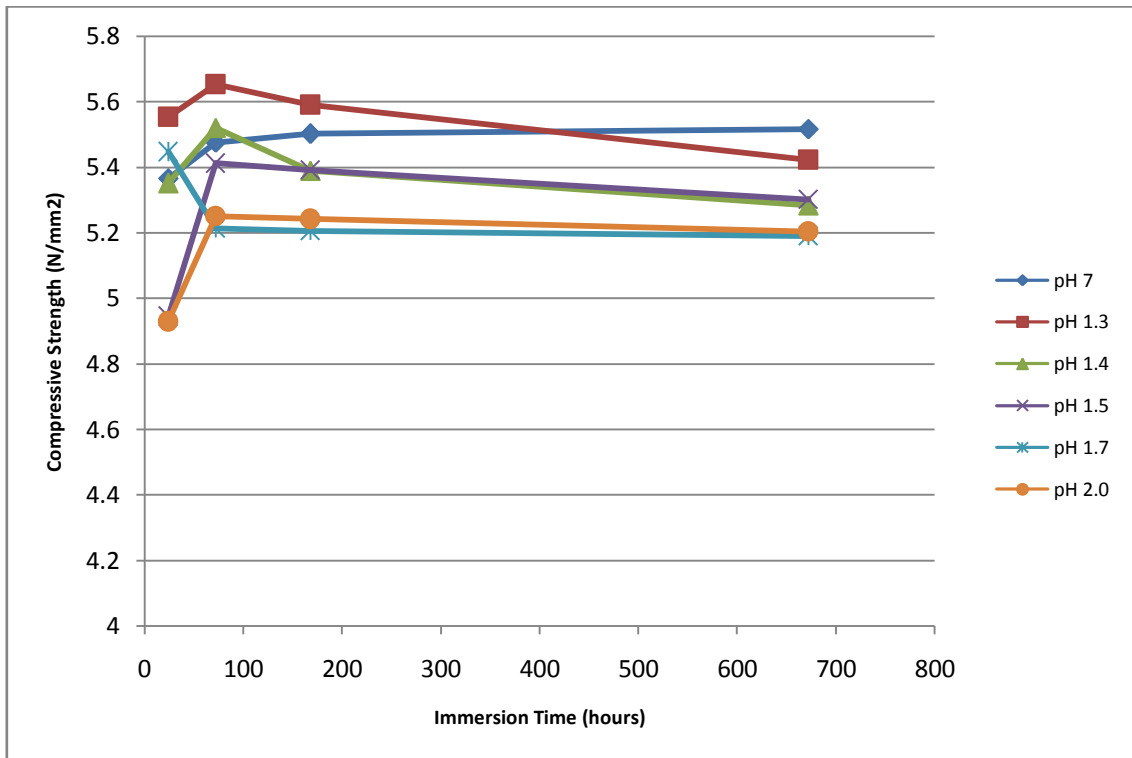


Figure 2: Relationship between Compressive Strength and Time for Various pH

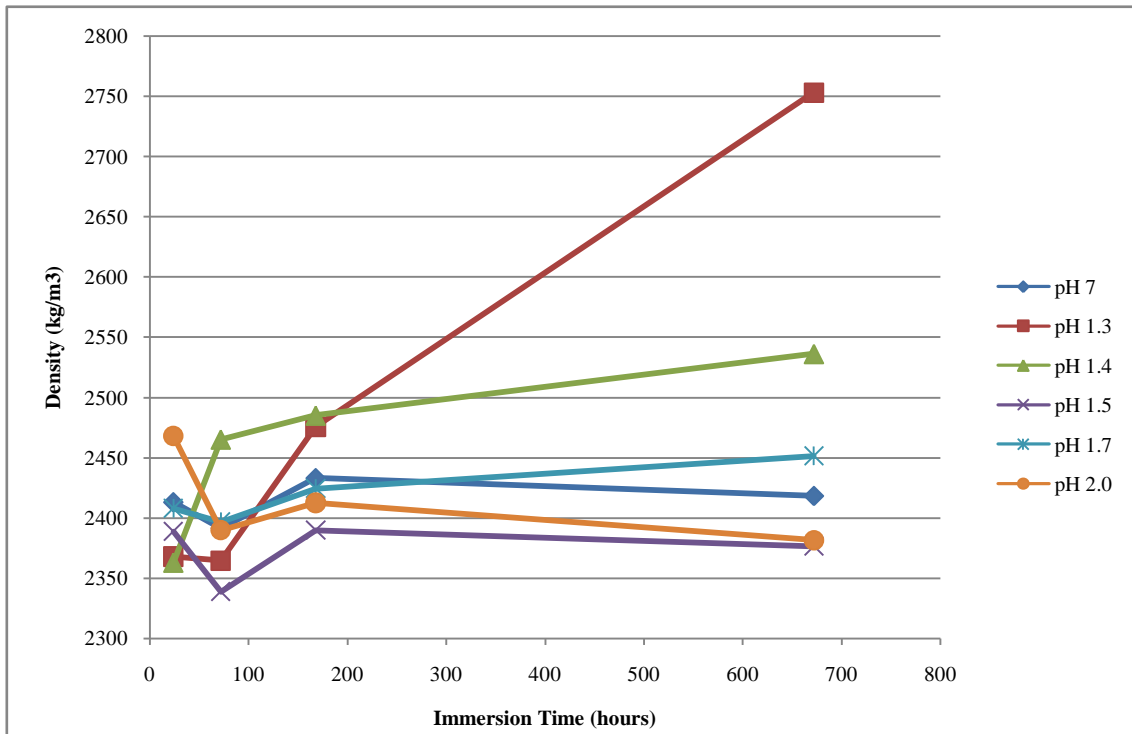


Figure 3: Relationship between Density and Immersion Time for various pH

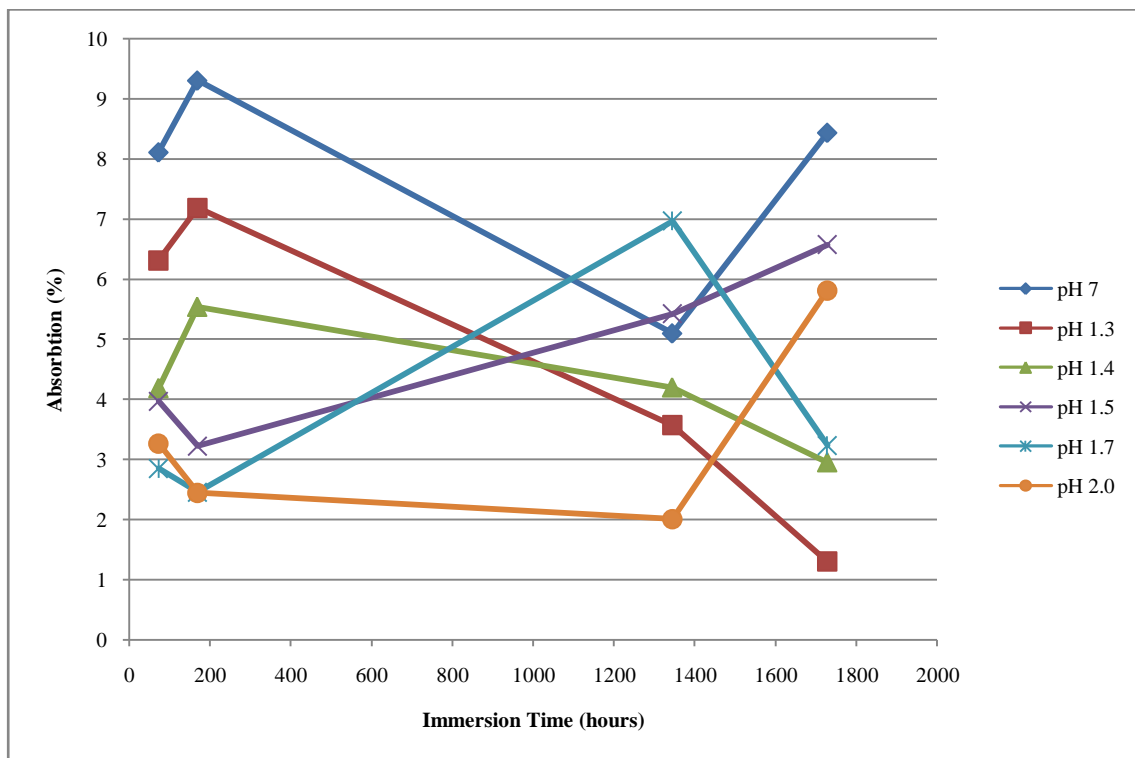


Figure 4: Relationship between Absorption and Immersion Time for various pH

Table I: Particle Size Distribution
Total Weight of Sample = 200g

Sieve Size (mm)	Weight Passed (g)	Percentage Weight Passed	Weight Retained (g)	Percentage Weight Retained	Cumulative Percentage Retained
10	200	100	0	0	0
6.3	197.5	98.75	2.5	1.25	1.25

3.35	190.8	95.4	6.7	3.35	4.6
2	177.5	88.75	13.3	6.65	11.25
1.18	150	75	26.9	13.45	24.7
0.6	77.64	38.82	72.9	36.45	61.15
0.3	14.7	7.35	63	31.5	92.65
0.15	1.6	0.8	13.1	6.55	99.2
0.063	0.2	0.1	1.4	0.7	99.9
pan	0	0	0.2	0.1	0
TOTAL			200	TOTAL	394.7

Table II: Result of Cement Testing

S/No.	Experiment	Result	Standard	Remarks
1	Initial setting time	110mins	≥75mins EN 197-1	okay
2	Final setting time	145mins	>10hrs	okay
3	Soundness of Cement	1.55mm	≤10mm EN 197-1	okay
4	Compressive Strength	10.198916 N/mm ² 15.69064 N/mm ²	Nil after 3 days ≥16N/mm ² after 7 days of curing EN 197-1	Not okay

Table III: Result for Compressive Strength for Immersion Time and Various pH

Immersion Time (hrs)	Compressive Strength (N/mm ²)					
	pH 7	pH 1.3	pH 1.4	pH 1.5	pH 1.7	pH 2.0
24	5.3659276	5.5541441	5.3512704	4.94477985	5.4469498	4.929447
72	5.4746654	5.6537255	5.5205072	5.41189469	5.2142251	5.2504777
168	5.5017235	5.5906868	5.3890724	5.39168592	5.2050928	5.2417768
672	5.5168331	5.422158	5.283683	5.30210364	5.1902832	5.2037709

Table IV: Results for Density from Immersion Time for various pH

Immersion Time (hrs)	Density (kg/m ³)					
	pH 7	pH 1.3	pH 1.4	pH 1.5	pH 1.7	pH 2.0
24	2412.990294	2368.0344	2363.0021	2388.5943	2407.8667	2468.1100
72	2391.424481	2364.6225	2465.2611	2338.8163	2396.7770	2389.9705
168	2433.071672	2475.7880	2485.1386	2389.7033	2424.2608	2412.7008
672	2418.210211	2753.2951	2536.3085	2376.4064	2451.6024	2381.7224

Table V: Results for Absorption for Immersion Time for various pH

Immersion Time (hrs)	Absorption (%)					
	pH 7	pH 1.3	pH 1.4	pH 1.5	pH 1.7	pH 2.0
24	8.112611	6.315972	4.186481	3.96599095	2.84453891	3.259944
72	9.305794	7.187848	5.540276	3.22203973	2.45369049	2.444134
168	5.102056	3.573418	4.197665	5.42349685	6.97096328	2.006394
672	8.438188	1.300958	2.951396	6.57688719	3.23116281	5.812251

IV. CONCLUSION AND RECOMMENDATION

From the research and investigations carried out it can be deduced that:

1. There is an effect of the acid on the immersed sandcrete blocks; it was observed that there was a decline in compressive strength of sandcrete blocks immersed in acid though the compressive strengths of all samples exceeded the minimum allowable values as prescribed by [13].
2. The density of sandcrete blocks was not affected by the concentration of acid contained in the immersion solution.
3. There was also a reduction in water absorption of the sandcrete blocks in cases of high acidity than that of the control sample which was neutral.

The following recommendations are suggested:

1. A research should also be conducted with increased immersion times, while varying the temperature.
2. The block industry in Nigeria should adhere to the production process, while the regulatory bodies like Standard Organization of Nigeria (SON), Nigerian Building and Road Research Institute (NIBBRI), Council for the Regulation of Engineering in Nigeria (COREN) and Council of Registered Builders in Nigeria (CORBON) should periodically monitor the use of the hollow sandcrete blocks in various environments.
3. Public awareness on the importance of quality control in infrastructural products/materials development should be conducted.

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