IMPACT OF MAGNETIZED WATER ON COMPRESSIVE STRENGTH AND DURABILITY OF SANDCRETE BLOCK

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ABSTRACT
Cases of collapse of buildings is common in Nigeria due to failure of materials used for the construction and poor design. Sandcrete block is commonly used for the construction of buildings in the country but the sandcrete blocks are normally fragile which demands ways to improve the strength of the sandcrete block. Magnetized water is water that has passed through a magnetic field which enhances proper hydration when it is used for producing sandcrete block and it has the ability to improve the strength of the block. The magnetic water treatment unit was fabricated using a broken permanent magnet from speaker with magnetic flux of 997 Gauss and neodymium magnet rated 1.3 T (1.3 x 10^4 G), a hose of 25.4 mm diameter, 25.4 mm diameter pipe, 50 litres storage bucket and water control tap. The magnetic treatment unit is 900 mm long with 450 mm hose surrounded by a broken magnet from speaker and a 450 mm long pipe surrounded by 12 pieces ofneodymium magnet. The magnetized water was treated for 11 s (T_1), 33 s (T_2) and 55 s (T_3) but the control was non-magnetized water (T_0). Dangote Portland cement and sand sieved through 4.75 mm were mixed (batching) and the ratio of cement to sand was 1 : 6 by weight and optimum moisture content used for producing the block was 9%. The solid sandcrete block (230 x 100 x 100 mm) was produced using a manually operated moulding block machine. The blocks with 3 replicate for each treatment were cured for 7, 14 and 28 days. After curing for 28 days, the force at peak, compressive strength were determined using Universal Testing Machine of capacity 300 kN (model FT300CT by Testometric Company Limited, United Kingdom). After curing for 28 days, the compressive strength for T_0, T_1, T_2 and T_3 were 2.358, 4.742, 3.406 and 4.903 N/mm^2, respectively. The compressive strength for T_1, T_2 and T_3 increased by 7.97 - 18.24, 17 - 39.51 and 44.44 - 107.93% after curing for 7, 14 and 28 days, respectively when compared to T_0. Young's modulus for T_1, T_2 and T_3 increased by 41.74 – 74.48, 14.33 – 39.01 and 43.28 – 79.02% after curing for 7, 14 and 28 days, respectively. The magnetized water increased the compressive strength of the sandcrete block and is recommended for producing sandcrete blocks in the country.

KEYWORDS: Compressive strength of block, Durability, Magnetized water, Optimum moisture content, Sandcrete block

1. INTRODUCTION

There are several reports of building collapse where lives and properties were lost (Awoyera *et al*., 2021). The collapse of buildings is normally due to failure of the materials used for the construction and poor design (Odeyemi, 2018; Wordu and Kanu, 2021). Sandcrete block is commonly used in Nigeria for the construction of residential buildings especially in the rural areas, crop storage houses, and farm buildings for man and animals (Anosike and Oyebade, 2012). Sandcrete block consists of fine aggregate (sand), cement and water which are mixed in the right proportion.The cost of cement for producing sandcrete block is high in the country and this could lead to cut down the quantity of cement for the construction and the cementfor thesandcrete block which results to poor materials for the construction. There is a need for economical ways of improving the strength of the sandcrete block and concrete to reduce the cases of collapse of building in the country.

Magnet (magnetic field) has many applications in society for the benefit of mankind which not being properly harnessed. The natural earth's magnetic field is essential for good health, the sun is for solar energy, photosynthesis, giving out light and the buoyant force (upthrust)is to ease transportation of goods through the ocean for benefit of man. Magnets (magnetic field) have been used in electrical engineering, elctronics, mechanical engineering, machines, wastewater treatment and agriculture. The magnetic field has also been used for treating irrigation water to produce magnetized water (magnetically treated water) for high crop yield, magnetized water for dairy animals to increase lactation (milk production) and for wastewater treatment (Othman *et al*., 2009; Babu, 2010; Yusuf and Ogunlela, 2015; Yusuf and Ogunlela, 2017). Magnetized water also improved the nutritional quality of tomatoes (Yusuf and Ogunlela, 2016). When water flows through the magnetic field, it becomes magnetically treated water or magnetized water. The properties of magnetized water are modified by reducing the bonding angle from 104° to 103°, reduced the surface tension, increased its solubility and reduced the rate of carbonate deposition in the pipe (Babu, 2010).

Magnetized water could also be used in Civil Engineering and Farm structures to increase the strength of the concrete and sandcrete blocks which are the materials that are commonly used for the construction of buildings in Nigeria. The paste (cement and water) binds the aggregate together and hardening of concrete occurs as a result of the chemical reaction between the cement and water during the time of curing which makes the concrete stronger (Patil and Pathak, 2016). Reddy *et al*. (2014) concluded that magnetized water increased the compressive strength of concrete by 55% because magnetized water enhances proper hydration of the concrete thereby making it stronger. Production of sandcrete block using magnetized water enhances the high strength of the sandcrete block. The technology could be used by commercial sandcrete block producers to improve the strength of the block and reduce the quantity of cement needed for block production and reduce the cost of producing sandcrete blocks. Albahrani (2018) treated water for 28 days using static flow method but the compressive strength of concrete produced using the magnetized water was increased by 26.2% while Kiranmai and Rao (2018) treated the water for 24 hours and the compressive strength of concrete was increased by 38.1% after curing for 7 days. Shynier *et al*. (2012) discovered that magnetized water used for mixing the concrete improved the compressive strength of the concrete by 10 - 22 N/mm^2 but Nilson (1987) reported that magnetized water improved the mechanical properties of concrete without adding any admixture to the concrete and increased the strength of the concrete by 10 - 22%. David (2018) found out that magnetized water increased the compressive strength of concrete but recommended that magnetized water should be used for sandcrete that does not contain crushed granite to really check the impact on the sandcrete block. Podlesny *et al*. (2004) stated that 15 s is effective for producing magnetized water but Aladjadjiyan (2007) pointed outthat 1-10 minutes is adequate for the production of magnetized water using the circulation flow. The Circulation flow method is by allowing water to flow through a pipe surrounded by pieces of permanent magnets.

Concrete consists of aggregate and paste which are mixed to form a strong rock-like mass called concrete. The aggregate comprises sand and crushed granite while the paste consists of cement and water. The paste binds the aggregate together and hardening is due to the chemical reaction between the cement and water during the time of curing which makes the concrete or sandcrete block stronger (Patil and Pathak, 2016; Yusuf *et al*., 2021). Sandcrete block comprises the fine aggregate (sand), cement and water but no crushed granite. Curing is a process through which the strength and durability of concrete and sandcrete blocks are improved by providing adequate moisture (water) for the concrete or sandcrete to have an uninterrupted hydration at the desired temperature and over a given period (7 - 28 days). Magnetized water for concrete and sandcrete block production enhances proper hydration of the concrete thereby increasing the strength of the sandcrete and concrete blocks. The hydration of cement (Ca_3SiO_5) by water (H_2O) to form Calcium Silicate hydrate ($Ca_3SiO_5OH_3$) and Calcium hydroxide ($Ca(OH)_2$) which subsequently forms a strong crystalline structure (Shynier*et al*., 2012). The hydration reaction of cement with water is shown in Equation (1) as reported by Yusuf *et al*. (2021). The water cluster of magnetized water and non-magnetized water for easy penetration during hydration is shown in Figure 1. The specific objectives of this study were to determine the impact of magnetized water on the compressive strength and the durability of sandcrete blocks.

$$2Ca_3SiO_5 + 6H_2O \rightarrow Ca_3SiO_5OH_3 + 3Ca(OH)_2 \qquad (1)$$

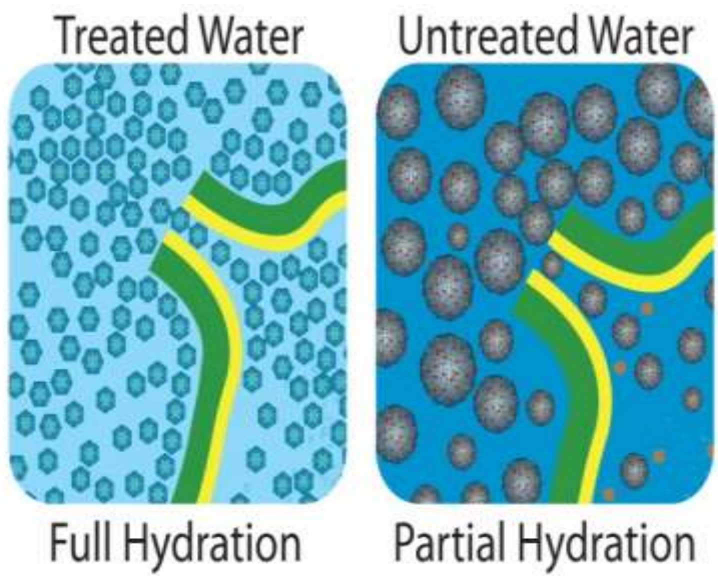

Figure 1: Water cluster of magnetized water (treated water) and non-magnetized water (untreated water)
Source: Malathy*et al*. (2017)

2. MATERIALS AND METHODS

2.1 MagneticTreatment Unit and Production of the Magnetized Water

The magnetic treatment device was developed using 25.4 mm (1 inch) hose, 25.4 mm PVC pipe, broken permanent magnets from speaker and a 50 x 25 x 10 mm Neodymium magnet. Neodymium magnet is produced by adding Neodymium (Nd), Iron (Fe) and Boron (B) together to form NdFeB magnet which is the strongest magnet available globally with magnetic flux density of 1.0Tesla (1 T = 10,000 G) and effective at room temperature and high temperatures up to 80 °C without demagnetization. The magnetic flux density inside the hose through which the water was flowing was measured using a gaussmeter (Model GM-2 by Alpha Lab Inc).

The permanent magnets were arranged by the sides of the hose which was put in between an adjustable iron plate (50 mm by 450 mm and 3 mm in thickness) and 12 pieces of 50 x 25 x 10 mm neodymium magnet arranged by the side of 450 mm rectangular pipe but the hose and the pipe were connected. Figure 2 shows the pictorial view of the magnets from the speaker and Figure 3 shows the neodymium magnet. Three (3) pieces of neodymium magnet were arranged on the side of the 15 by 60 mm and 200 mm long rectangular plastic pipe (transparent plexiglass) as shown in Figure 3. The rectangular plastic pipe is folded (bend) to form 3 layers to maximize the 12 pieces of neodymium magnets and to make it compact. The neodymium magnet covers a total length of 450 mm while the broken magnet also covers 450 mm (the total length for the magnetic treatment unit is 900 mm). The magnetic treatment unitwas connected to a 50 litres bucket with a 25.4 mm diameter (1 inch) pipe and a control tap for regulating the flow of the water. The isometric view of the magnetic treatment unit is shown in Figure 4 and the pictorial view of the magnetic treatment unit is shown in Figure 5 in which Figures 2 and 3 were connected. The water for preparing the sandcrete was allowed to flow through the magnetic treatment device 1 time for 11 s as T_1, T_2 for 33 s when the water was allowed to flow through the magnetic treatment device 3 times and T_3 for 55 s when the water was allowed to flow through the magnetic treatment device 5 times. T_0 is the control experiment (non-magnetized water). The magnetized water was used immediately after the water has been treated with the magnetic field to prepare the sandcrete block. The molecular structure of the water before and after passing the magnetic field is shown in Figure 6.

Figure 2: Pictorial view of the broken magnet from speaker

Figure 3: Pictorial view of Neodymium magnet

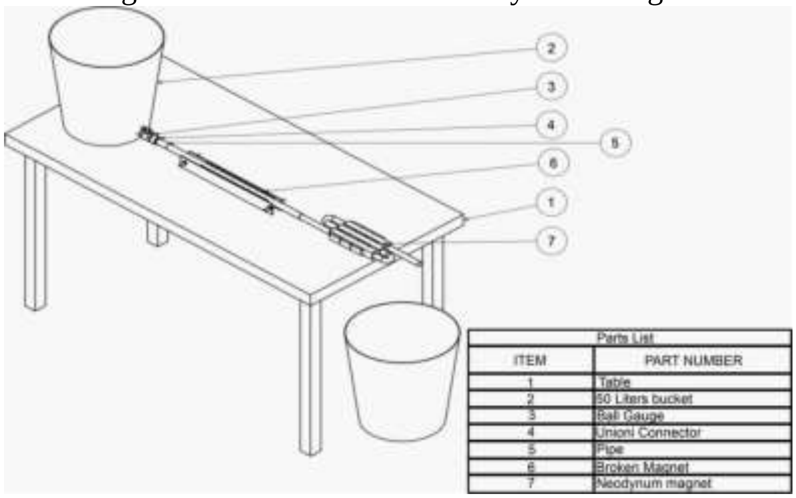

Figure 4 Isometric view of the magnetic treatment device

Figure 5: Pictorial view of a simple magnetic treatment water device for producing magnetized water

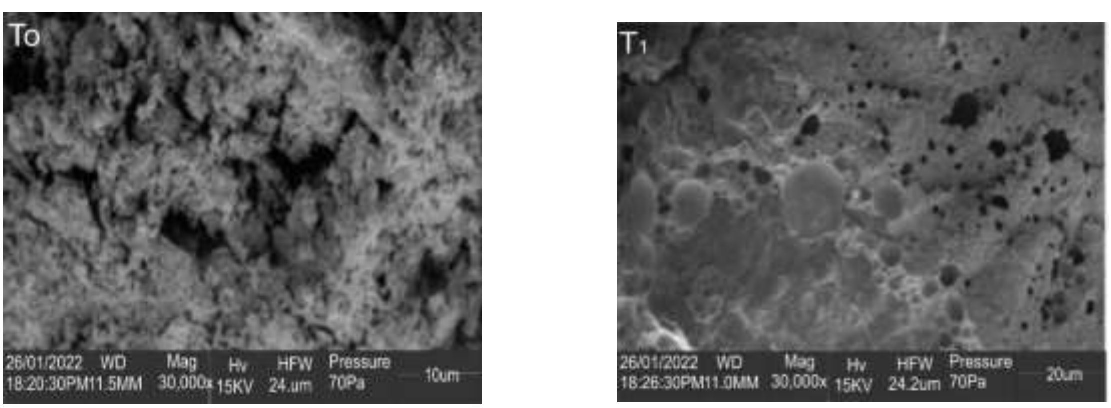

Figure 6: Scanned Electronics Microscope (SEM) of the molecular structure of the water (Magnification = 30000×)

T_0 = Non-magnetized water (Control)

T_1 = Magnetized water after flowing through the magneticfield for 33 s

2.2 Determination of Optimum Moisture Content

The sand that was used for the moulding of the sandcrete block in this study was sieved through a 4.75 mm sieve and sun dried for 48 hours. The ratio of cement and sand to produce the sandcrete block was 1 : 6 and based on this ratio the cement and sand were mixed together. Standard Proctor compaction test (mould with an internal diameter of 4 inches (101.6 mm) and effective height of 4.6 inches (116.84 mm) and rammer of 2.5 kg and height of 305 mm) was used for the soil compaction and to determine the optimum moisture content (OMC) that was needed for the production of the sandcrete block. Some quantity of the water was added to the sample gradually, mixed with the cement and sand, the sample was put into the Standard Proctor Compaction Test (Figure 7) in three layers, one after the other and each layer was subjected to 25 blows by the rammer for the compaction.

The mass of the mould and the base without the collar was weighed and recorded as M_1, The mass of the mould with the base and the compacted lightly wet mixed sand-cement was weighed and recorded as M_2 and the volume of the mould was denoted by V_m. The same procedure was repeated for more compaction tests using part of the remaining sample but more water was added to increase the moisture content. The bulk density (ρ_b) and the dry density were determined using Equations (2) and (3a or 3b), respectively. The graph of dry density (ρ_d) was plotted against moisture content and the optimum moisture content was determined at the point with the highest dry density. The bulk density is the ratio of the mass of the wet soil sample to the internal volume of the mould while the dry density is the ratio of the mass of oven-dry soil to the volume of the mould.

The moisture content (water content) was determined by putting each of the compacted soil samples from the mould into the evaporating can and oven dry in an electric oven for 24 hours at 105 °C. The mass of the compacted wet soil sample was denoted as M_w ($M_w = M_2 - M_1$) and the mass of the compacted oven dry soil was denoted as M_d. The water content (w) was determined using Equation (4). The optimum moisture content from the graph of dry density against moisture content was found to be 8.8% but 9% was used in this study for the production of the sandcrete block.

$$\rho_b = \frac{M_2 - M_1}{V_m} \qquad (2)$$

$$\rho_d = \frac{\rho_b}{1 + w} \qquad (3a)$$

$$\rho_d = \frac{M_d}{V_m} \qquad (3b)$$

$$w = \frac{M_w - M_d}{M_d} \qquad (4)$$

Figure 7: Standard Proctor compaction test

2.3 Production of the sandcreteblock

The study was conducted between 26th October, 2019 and 20thMarch, 2020 at the Laboratory of the Department of Civil Engineering, University of Ilorin, Ilorin, Nigeria. The University of Ilorin is located in Ilorin South Local Government Area of Ilorin city, Kwara State. Ilorin lies on latitude 8°30¹N and longitude 4°35¹E, about 340 m above the mean sea level with an annual rainfall of 1300 mm (Ejieji and Adeniran, 2009). In this study, the sandcrete block was chosen because it does not contain crushed granite (coarse aggregate) which could introduce variation in the strength of the concrete but any variation in the strength of the sandcrete in this study was due to the treatment (s) given to the material during the production of the solid sandcrete block. The treatments used for producing the sandcrete block were non-magnetized water (T_0), magnetized water treated for 11 s (T_1), magnetized water treated 33 s (T_2) and magnetized water treated for 55 s (T_3). In addition to that, a moulding machine (Figure 8) was used in this study to remove variation in the level of compaction which could occur if it is done by a human.

The sand that was sieved through 4.75 mm sieve was mixed with cement in the ratio of 1 : 6 by weight. The mixture of sand and cement (batching) was properly done to ensured uniformity and it was divided into 4 portions. The optimum moistutre content (OMC) for the compaction of sand and cement was 8.8% but 9.0% was used by weight. For preparing the sandcrete blocks, 9.0% of T_0, T_1, T_2 and T_3 were added to each portion of the sand-cement mixture. The manually operated block moding machine could produce 4 solid blocks (230 x 100 x 100 mm dimension) at a time. Samples mixed with T_0, T_1, T_2 and T_3 were put into each mould and compacted at the same rate by releasing the handle and 10 blows were used to compact the block. The lever was pressed to push the sandcrete block up, and the blocks were removed from moulding machine and air dried for 24 hours as shown in Figure 8. The same procedure was used to produce more sandcrete blocks and cured for 7, 14 and 28 days in the curing tank to improve the strength of the blocks.

Figure 7: Pictorial view of manually operated block moulding machine for sandcrete block

Figure 8: Pictorial view of the sandcrete blocks produced using magnetized and non-magnetized water

2.4 Determination of force at peak, compressive shear stress and young's modulus required to break the sandcrete block

The sandcrete blocks produced were cured in the curing tank for 7, 14 and 28 days. Samples of the block were tested using a Universal Testing Machine (UTM) (model FT300CT: capacity of 300 kN and at a speed of 50 mm/min, Testometric Company Limited, United Kingdom as shown in Figure 9). The force at the peak required to break the sandcrete blocks, the compressive strength and the Young's modulus were determined using a Universal Testing Machine as shown in Figure 9. The force at the peak required to break the sandcrete block, the compressive shear stress and Young's modulus to break the block were obtained.

Figure 9: Determination of compressive strength of the sandcrete block using Universal Testing Machine

2.5 Determination of durability (resistance to abrasion) of the sandcreteblock

The durability test conducted on the sandcrete was the resistance to abrasion. The sandcrete blocks were produced using T_0, T_1, T_2 and T_3 and were cured for 7 days. The blocks were removed from the curing tank and allowed to dry for 3 days, weighed and the weight was recorded as the initial weight (W_1). The blocks with two samples labelled A and B for each treatment were submerged in water for 24 hours. The blocks were then removed from the water, weighed and recorded as weight after being submerged (W_2). The blocks were put in the electric oven for 24 hours at 110 °C. The blocks were removed from the oven, weighed and recorded as weight after oven-dry (W_3). The durability was done by using a standard wire brush with a load of 13.3 N (1.36 kg) mounted on it to scratch the block. The wire brush with the load was put on the block and dragged on the block to scratch the block and the weight of the sandrete block after scratching was recorded as weight after scratching (W_4). The procedure was repeated at 3 days interval and the durability was computed using Equation (5) given by ASTM (2012). The mean of durability for each treatment was calculated and the data for the first durabilty test is shown in Table 1.

$$D_{T0} = \frac{W_3 - W_4}{W_1} \tag{5}$$

Table 1 Data for the computation of the durability (resistance due to abrasion)

Treatment	W_1(kg)	W_2(kg)	W_3(kg)	W_4(kg)
T_0 A	4,000	4,300	3,890	3881
T_0 B	4,000	4,390	3,920	3903
T_1 A	4,120	4,460	3,950	3935
T_1 B	4,170	4,480	3,850	3842
T_2 A	4,100	4,440	3,940	3914
T_2 B	4,060	4,510	3,980	3969
T_3 A	4,010	4,430	3,870	3866
T_3 B	4,000	4,540	3,850	3844

W1 = Initial weight of the block (kg), W_2 = Weight of block after submerged in water (kg)
W_3 = Weight of block after oven-dry (kg), W_4 = Weight of block after scratching (kg)

$$D_{T0} = \frac{3890 - 3881}{4000} \times 100 = 0.225\ \%$$

2.6 Computation of Paired t-test Statistical Analysis for the Impact of the Magnetized Water

A paired t-test statistical analysis was used to determine if the effect of magnetized water was statistically significant on the force at peak, compressive strength and Young's modulus. The mean difference between the two data, standard deviation, standard error and t-test value were determined using Equations (6), (7a) or (7b), (8) and (9), respectively as given by Montgomery (1998). The data used for the computation of the paired t-test presented in Table 2 were obtained from Table 4. The calculated values of the paired t-test and tabulated values were compared to determine if the effect was significant or not significant.

$$\bar{d} = \frac{\sum d}{n} \tag{6}$$

$$\delta = \sqrt{\frac{\sum d^2 - n\left(\bar{d}\right)^2}{n-1}} \qquad (7a)$$

$$\delta = \sqrt{\frac{\sum \left(d - \bar{d}\right)^2}{n-1}} \qquad (7b)$$

$$\delta_{Er} = \frac{\delta}{\sqrt{n}} \qquad (8)$$

$$t_{cal} = \frac{\bar{d}}{\delta_{Er}} \qquad (9)$$

where $\bar{d}$ is the mean of the difference between x_1 and x_2, Σd is the summation of d, n is the number of the observations, δ is the standard deviation, δ_{Er} is the standard error and t_{cal} is the calculated value of the t-test which is compared to the critical or table value of t-test at $\alpha = 0.10$ or 0.05.

Table 2 Data used for the computation of the paired t-test was obtained from Table 4 for the shear stress

T_1	T_0	$d = T_1 - T_0$	d^2
3.929	3.323	0.606	0.367236
2.890	2.177	0.713	0.508369
4.742	2.358	2.384	5.683456
N = 3		**$\sum d = 3.703$**	**$\sum d^2 = 6.559061$**

$$\bar{d} = \frac{3.703}{3} = 1.234 \qquad (6)$$

$$\delta = \sqrt{\frac{6.559061 - 3(1.234)^2}{3-1}} = 0.998 \qquad (7a)$$

$$\delta_{Er} = \frac{0.998}{3} = 0.576 \qquad (8)$$

$$t_{cal} = \frac{1.234}{0.576} = 2.142 \qquad (9)$$

But table value of the t-test at $\alpha \leq 0.10$ and 2 degrees of freedom = 2.920
Similarly, the same method was used to calculate the values of other paired t-test (t_{cal}).

3. RESULTS AND DISCUSSION

The magnetic water tretment device fabricated in this study as shown in Figure 5 could produce magnetized water or magnetically treated water (magnetic water) within 11 – 55 seconds. The results of force at the peak required to break the sandcrete block, the compressive strength (compressive shear stress) and the Young's modulus are presented in Table 3 while the percentage increments of compressive strength, and Young's modulus is presented in Table 4. The durability (resistance to abrasion) and percentage increment of the resistance to removal of particles by abrasion from the sandcrete block is shown in Table 5. The forces that were required to break the sandcrete block were all higher were the blocks produced using magnetized water (T_1, T_2 and T_3) compared to block produced using non-magnetized water (T_0). Similarly, the compressive strength and Young's modulus of the block produced with T_1, T_2 and T_3 were all higher than that of T_0. The magnetized water increased the compressive shear stress of the sandcrete by 7.97 – 18.24%, 17.82 – 39.51% and 44.44 – 107.98% after curing for 7, 14 and 28 days, respectively as shown in Table 5. The result in this study was in agreement with Albahrani (2018) that magnetized water treated for 28 days using static flow method increased the compressive strength of concrete by 26.2% and Kiranmai and Rao (2018) pointed out that magnetized water treated for 24 hours increased the compressive strength of concrete by 38.1% after curing for 7 days. From the results of statistical analysis by paired t-test shown in Tables 6, 7 and 8, treating the water with magnetic field for 33 s was statistically significant for the force at peak, compressive shear stress and Young's modulus at $\alpha \leq 0.10$ but treatingthe water for 11 and 55 s were not statistically significant though they had highest values of compressive strength. The effect of magnetized water when the water was treated for 33 s compared to non-magnetized water (T_2 versus T_0) was significant on the strength properties of the sandcrete block at $\alpha \leq 0.10$ but the effect was not significant at $\alpha \leq 0.05$. The results obtained in this study were in agreement with Podlesny *et al*. (2004) that for effective magnetic treatment, the detention period of water in the magnetic field should be at least 15 s.

The results of durability (resistance to abrasion) and percentage increment are presented in Table 5. The sandcrete block produced using magnetized water had high durability because the loss of weight due to scratching was lower than the weight loss by the sandcete produced using non-magnetized water. The percentage increment of durability of the sandcrete blocks produced using magnetized water that was treated for 11 s (T_1), 33 s (T_2) and 55 s (T_3) compared to non-magnetized water (T_0) were 20.03%, 0.23% and 62.34%, respectively. The effect of magnetized water on the durability (resistance to abrasion) of the sandcrete block was not significant at $\alpha \leq 0.05$ and at $\alpha \leq 0.10$ as shown in Table 9. The sandcrete block produced using magnetized water has high durability and better compressive strength than the block produced using non-magnetized water.

4. CONCLUSION

The magnetized water was produced by allowing water to flow through a combination of magnetic flux densities of 997 G from a speaker magnet and neodymium magnet with magnetic flux 1.3×10^4 G (1.3 T) along a single pvc pipe for 11 – 55 s using the developed magnetic treatment device. Magnetized water is an environmentally friendly, a non-chemical method, very simple and cheap for producing sandcrete block and can not pollute the enviroment. Sandcrete block produced using magnetized water had a higher compressive strength and it was increased by 44.44 - 107.93% after curing for 28 days when the water was allowed to flow for 11 – 55 s in the magnetic field.

Table 3 Force at peak, compressive strength (stress) at peak and Young's modulus

Curing (days)	Force at peak to break the sandcrete block (N)				Stress at peak (N/mm^2)				Young's modulus (N/mm^2)			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
7	75,090	90,367	88,077	82,527	3.323	3.929	3.829	3.588	103.008	179.730	146.000	168.330
14	50,000	66,460	58,998	69,587	2.177	2.890	2.565	3.036	79.781	110.899	91.210	94.036
28	54,240	109,063	78,230	112,780	2.358	4.742	3.406	4.903	76.590	122.161	109.740	137.112

T_0 = Non- magnetized water, T_1 = Magnetized water treated for 11 s, T_2 = Magnetized water treated for 33 s, T_3 = Magnetized water treated for 55 s

Table 4 Compressive strength (stress) and Young's modulus of sandcrete block

Curing (days)	Percentage increment of shear Stress at peak of the sandcrete block (%)				Percentage increment of Young's modulus of the sandcrete block (%)			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
7	-	18.24	15.23	7.97	-	74.48	41.74	63.41
14	-	32.75	17.82	39.51	-	39.01	14.33	17.87
28	-	101.10s	44.44	107.93	-	59.50	43.28	79.02

T_0, T_1, T_2, T_3 were defined in Table 3

Table 5 Durability test and percentage increment of the resistance to abrasion

Treatment	Durability of the sandcrete block (%) x 10^{-2}			Mean (%) x 10^{-2}	Percentage increment (%)
T_0	32.50	24.38	8.13	21.67	-
T_1	27.80	12.08	12.12	17.33	20.03
T_2	45.25	7.97	11.65	21.62	0.23
T_3	12.49	5.00	7.00	8.16	62.34

T_0, T_1, T_2, T_3 were defined in Table 3

Table 6 Paired t-test of peak force to break the sandcrete block

Treatments	Degree of freedom	Calculated value of t-test	Table value of t-test at $\alpha \leq 0.10$	Table value of t-test at $\alpha \leq 0.05$
T_1 versus T_0	2	2.221^{NS}	2.920	4.303
T_2 versus T_0	2	3.419^{S}	2.920	4.303
T_3 versus T_0	2	1.850^{NS}	2.920	4.303

S = Significant, NS = Not significant, The t-test value significant at $\alpha \leq 0.10$ for T_2 versus T_0 but all not significant at $\alpha \leq 0.05$

T_0, T_1, T_2, T_3 were defined in Table 3

Table 7 Paired t-test of the compressive stress of the sandcrete block

Treatments	Degree of freedom	Calculated value of t-test	Table value of t-test at $\alpha \leq 0.10$	Table value of t-test at $\alpha \leq 0.05$
T_1 versus T_0	2	2.142^{NS}	2.920	4.303
T_2 versus T_0	2	3.164^{S}	2.920	4.303
T_3 versus T_0	2	1.791^{NS}	2.920	4.303

S = Significant, NS = Not significant, The t-test value significant at $\alpha \leq 0.10$ for T_2 versus T_0 but all not significant at $\alpha \leq 0.05$, T_0, T_1, T_2, T_3 were defined in Table 3

Table 8 Paired t-test on the Young's modulus of sandcrete block

Treatments	Degree of freedom	Calculated value of t-test	Table value of t-test at $\alpha \leq 0.05$	Table value of t-test at $\alpha \leq 0.10$
T_1 versus T_0	2	3.847^{S}	2.920	1.886
T_2 versus T_0	2	3.131^{S}	2.920	1.886
T_3 versus T_0	2	2.869^{NS*}	2.920	1.886

S = Significant, NS = Not significant, The t-test values significant at $\alpha \leq 0.10$ for T_1 versus T_0 and T_2 versus T_0 were significant at at$\alpha \leq 0.05$ and at $\alpha \leq 0.10$ but T_3 versus T_0 only significant at $\alpha \leq 0.10$. T_0, T_1, T_2, T_3 were defined in Table 3

Table 9 Paired t-test on the durability of the sandcrete block

Treatments	Degree of freedom	Calculated value of t-test	Table value of t-test at $\alpha \leq 0.10$	Table value of t-test at $\alpha \leq 0.05$
T_0 versus T_1	2	0.922^{NS}	2.920	4.303
T_0 versus T_2	2	0.001^{NS}	2.920	4.303
T_0 versus T_3	2	2.184^{NS}	2.920	4.303
T_1 versus T_3	2	0.540^{NS}	2.920	4.303

NS = Not significant, the effect were not significant at $\alpha \leq 0.05$ and at $\alpha \leq 0.10$, T_0, T_1, T_2, T_3 were defined in Table 3.

REFERENCES

Aladjadjiyan, A. (2000). The use of physical methods for plant growing stimulation in Bulgaria. *Journal of Central European Agriculture,* 8 (3): 369-380.

Albahrani, H. S. (2018). Improvement of mechanical properties of concrete using magnetic water with different ages of magnetism. *Journal of Engineering and Applied Science*, 13 (24): 10384-10387.

Anosike, M. N. and Oyebade, A. A. (2012). Sandcrete blocks and quality management in Nigeria building industry, Journal of Engineering, Project, and Production management, 2 (1): 37-46.

ASTM C994 (2012). Standard test method for abrasion resistance of concrete or mortar surfaces by the rotating-cutter method: *ASTM International, West Conshohocken*: 1-5.

Awoyera, P. O., Alfa, J., Odetoyan, A. and Akinwumi, I. I. (2021). Building collapse in Nigeria during recent years – Causes, effects and way forward. *IOP Conference Series: Materials Science and Engineering,* 1-9. doi:10.1088/1757-899X/1036/1/012021

Babu, C. (2010). Use of magnetic water and polymer in agriculture. *TropicalResearch*, ID 08-806-001.

David, S. O. (2019). Effects of magnetized water compressive strenfth and flexural of concrete block. *B.Eng Thesis submitted to the Department of Agricultural and Biosystems Engineering*, Faculty of Engineering and Technology, University of Ilorin, Ilorin, Nigeria.

Ejieji, C. J. and Adeniran, K. A. (2009). Effect of water and fertilizer stress on the yield, fresh and dry matter production of grain amaranth. *Australian Journal of Agricultural Engineering*, 1 (1):

18-24.

Karam, H. and Al-Shamali, O. (2013). Effect of Using Magnetized Water on Concrete Properties, *Third International Conference on Sustainable Constructional Materials and Technologies* held at Kyoto Research Park, Kyoto, Japan on 18th – 22nd August, 2013.

Kiranmai, Y. and Rao, K. N. S. (2018). Strength Permeation and Nano Studies on Fly Ash Based Magnetic Water Concrete. *International Journal of Scientific Engineering and Technology Research,* 7 (6): 1088-1093.

Malathy, R, Karuppasamy, N. and Baranidharan, S. (2017). Effect of magnetic water on mixing and curing of M25 grade concrete. *International Journal of Chem Tech Research*, 10 (11): 131-139.

Montgomery, D. C., Runger, G. C., Hubele, N. F. (1998). Engineering statistics. *John Wiley and Sons, Inc, New York*: 135-248.

Nilson, A. H. (1987). High-Strength Concrete, an Overview of Cornell Research, *Proceedings Symposium on Utilization of High-Strength concrete, Stavanger, Norway*, 27-38.

Odeyemi, S. O., Akinpelu, M. A., Atoyebi, O. D and Orire, K. J. (2018). Quality assessment of sandcrete blocks produced in Adeta, Kwara State, Nigeria. Nigerian Journal of Technology (NIJOTECH), 37 (1): 53-59.

Othman, F, Sohaili, J, and Fausia, Z. (2009). Influence of magnetic treatment on the improvement of landfill leachate treatment, *International Journal of Environment and Waste Management*, 4 (3-4): 433-444.

Patil, S. V. and Pathak, N. J. (2016). The experimental study on compressive strength of concrete using AR glass fibers and partial replacement of cement with GGBS with effect of magneticwater. *International Journal of Engineering Technology, Management and Applied Sciences*, 4 (8): 21-29.

Podlesny, J., Pietruszewski, S. and Podleoena, A. (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. *International Agrophysics*, 18: 65-71.

Reddy, S. B., Ghorpade, V. G. and Rao, H. S. (2014). Influence of Magnetic Water on Strength Properties of Concrete. *Indian Journal of Science and Technology*,7 (1): 14–18.

Shynier, A, Abed, M., Fouad, Z., Kazim, A., Isse, R., Reheem, N., Chaloob, A., Mohammad, H., Jamal, N., Jasim, H., Sadeeq, J. and Salim, A. (2012). Improving some of mechanical properties of concrete by magnetic water technology. *Proceedings of 5th Jordanian International Civil Engineering Conference (JICEC5)* 17th – 19th January, 2012 held at Landmark Hotel Amman (5 stars), Amman, Jordan: 1-11.

Wordu, H. and Kanu, C. M. (2021). Residential building collapse in Nigeria: incidence, causes, effects, solution and implication for technical education, International Journal of Innovative Education Research, 9 (2):153-162.

Yusuf, K. O. and Ogunlela, A. O. (2015). Impact of magnetic treatment of water on growth and yield of tomato. *Journal of Notulae Scientia Biologicae*, 7 (3): 345-348.

Yusuf, K. O. and Ogunlela, A. O. (2016). Effect of magnetically treated water on the quality of tomato. *Kathmandu University Journal of Science, Engineering and Technology*, 12 (2): 29-33.

Yusuf, K. O. and Ogunlela, A. O. (2017). Effects of magnetized water on the vegetative growth and yield of tomato. *Agricultural Engineering International: CIGR Journal*, 19 (1): 1-8.

Yusuf, K. O., Akepenpuu, T. D., David, S. O. and Olueayemi, C. H. (2021). Impact of magnetically treated water on compressive and flexural strength of concrete, *Nigerian Journal of Technological Development*, 18 (3): 251-257.