MAGNETIC FIELD TREATED WATER INFLUENCE ON STRUCTURAL CONCRETE ELEMENTS: ENVIRONMENTAL ISSUES OF CONCERN

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MAGNETIC FIELD TREATED WATER INFLUENCE ON STRUCTURAL CONCRETE ELEMENTS: ENVIRONMENTAL ISSUES OF CONCERN

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The impact of magnetized water on the strength properties of concrete calls for a holistic appraisal of its effect on the environment of production and use. In this study, the influence of the Magnetic Field Treated Water (MFTW) on the strength of concrete produced under various environments is considered. The work considered three environments of use of magnetized water in concrete with respect to partial replacement of fine aggregate with waste glass; quality of curing medium on mechanical properties of concrete and effect on the mechanical properties of self-compacting concrete. The three scenarios presented involved preparing and testing concrete cubes made with magnetized water, cement, fine (sand and glass) and coarse (granite) aggregates at various levels of combination and environment of curing. The concrete cubes were cured for 7, 14, 28, and 56 days and the strength and other parameters, such as slump and workability, were compared with conventional concrete in normal environment. It was observed that concrete under self-compacting concrete made with MFTW had a 9.1% increase in compressive strength than normal; for concrete made with clay brick powder and MFTW, both the workability and compressive strength was higher than normal. The magnetized water in concrete with waste glass as partial replacement had higher slump value and 24% increase in compressive strength than conventional concrete. MFTW therefore improves strength development of concrete.

Keywords: Waste glass, Curing medium, Compressive strength, Magnetized water, Conventional concrete.

1 INTRODUCTION

Cost considerations, environmental concerns are driving the search for new ways and means of attaining sustainable concrete production and use. The use of magnetic field treated water (MFTW) is one means of utilizing local and accessible material for the development of cost-effective concrete members in the construction of civil works (Matawal and Danladi 2011). In his work, Jamal (2017) described the various types of concrete such as normal, high strength, high performance, air entrained, lightweight, self-compacting and lime Crete concrete depending on the method of production and use. Notwithstanding the type of concrete, water is required in the preparation and curing to attain the necessary or expected strength of the concrete mix. In the case of the production of self-compacting concrete (SCC) for example, the challenge of availability and cost of skilled labor in the construction industry lead to its discovery. This type of concrete is a low flow stress, high deformability, good segregation (prevents separation of particles in the mixture), low viscosity concrete mix, capable of consolidating under own weight. It is widely used in developed countries but in developing countries such as Nigeria, its use especially in constructing pavement is observed to be rare (Busari *et al.* 2017).

Portland cement, fine aggregates such as sharp sand, crushed waste glass and coarse aggregates such as gravel and crushed rocks are usually mixed with (clean) water in predetermined proportions in the preparation of concrete for building elements (Bamigboye *et al.* 2017). The medium that activates the processes necessary for the required bond formation between the cement and constituent aggregates mixture is water, which implies that water is basic in the making of concrete. Research has recently shown that magnetized water can be used in the fields of health, agriculture, construction etc. (Olugbenga 2014). The quality of water employed in concrete production can affect the qualities of such concrete according to Olugbenga (2014). Bellis (2006) reported that several factors influence the performance of concrete, such as water, the binder percentage, the moisture content, the type of aggregate used to make concrete, extra binders and fibres. Production of concrete all through the years especially in developing countries has been traditionally with the utilization of ordinary water. Current effort is to look at alternative source of water such as magnetized water, which is gotten when faucet water is passed through a magnetic field with the purpose of altering its structure or magnetized water (MW) as stated by (Hamza *et al.* 2017). A more specific name however is magnetic field treated water (MFTW) as this helps to clarify that the water in no way has properties associated with magnetism. Magnetic field's magnetic force improves water activity by breaking down the molecules into single or finer form. Diamagnetism of the hydrogen bond results in higher stability under a magnetic field, which is the major factor behind some adjustment in the water properties (Hosoda *et al.* 2004, Alwediyani *et al.* 2015). Concrete can solidify when cast in place and develop high compressive strength, its value depends on its grade, level of workmanship in the casting of concrete process and nature of vibrations which may constitute errors that increase porosity and decrease strength. For a large project requiring great precision, such accumulated errors can create a big problem. This underscores the need for a more flowable concrete mix according to Walraven (2013).

The aim of this study is to assess and compare the development of strength of concrete made with both magnetic field treated water and normal water under varied environmental conditions. The specific objectives being to obtain various mixes using magnetized water and then ordinary water for the same mix design of concrete; to compare the results of the tests for characteristics of the fresh state and compare the strength of the hardened properties of concrete made with normal water and magnetized water with both cured in either of magnetized and normal water and to finally compare the results of the test of the mechanical properties of hardened concrete such as compressive and tensile strength at the ages of 7, 14, 28, and 56 days.

2 MATERIALS AND METHODS

The materials used for this study are ordinary Portland cement (OPC) in line with ASTM C150 (2007). The fine aggregates used were natural sharp river sand obtained from river Ogun, Ogun state, Nigeria, in line with ASTM C33 (2003). The sand is free of silt or any deleterious materials and did not contain particles exceeding 5mm in size. Coarse aggregate with maximum size of 20mm was used in line with ASTMC 136 (2014), the supply was free of dust and other impurities. Figure 1 and 2 shows sample of both coarse and fine aggregates respectively. A brown, liquid, chlorine-free superplasticizer that instantly disperses in water was used to increase the strength, durability and maneuverability of concrete without increasing the demand for water.

Figure 1. Coarse aggregate.

Figure 2. Fine aggregate.

Portable water was used in this study for the production of the concrete control mix. The source of the portal water is municipal water supply from the University laboratory while magnetic water was prepared by passing water from source through a magnetic field. In the process, magnetic water is obtained by connecting a hose from an open tap from which the water flows into the magnetic field produced by the solenoid. The water, which comes out through the other end of the solenoid is then stored in a plastic drum. The magnetic field is generated by passing current of about 32 amps through the field which is made up of a coil (turns) wound round a pipe of 600 mm length and about 100mm diameter. The current is generated from an input of 220 volts which is been step down by a transformer of 150volts. During this time the water passing through the pipe is magnetized. Figure 3 shows the setup of the magnetic device.

Figure 3. Magnetic field simulator.

Tests carried out on the cement include: Initial setting time, final setting time, and consistency test. The grading of aggregates (fine and coarse) into various sizes was determined by sieve analysis. Other tests carried out on the aggregates include; water absorption and specific gravity. The following water hardness tests were carried out on water; calcium, magnesium and calcium carbonate using a spectrophotometer. Other tests include pH of water to show the level of alkalinity or acidity of a sample. For this work, all the itemized tests were carried out to determine the fresh properties of concrete, that is, the slump flow test and the V-funnel test. The

Normal concrete was designed using grade M30 for 42.5N cement grade, that is, 1:1.5:3. Ordinary water and magnetic field treated water was used in mix 1 and mix 2 respectively. The same water/cement ratio of 0.46 at a cement content of 417.15 Kg/m^3 was utilized for all mixes. Compressive strength and tensile strength of concrete after curing for 7 days, 14 days, 28 days, and 56 days were determined with a compression-testing machine. Concrete mix design was established for the various types and mixes using normal and magnetized water.

3 RESULTS AND DISCUSSION

3.1 pH Test

In this test, it was observed that pH value of the MFTW increased from that of ordinary water by 24%, that is, the pH of ordinary water collected for the test was 5.55 while the pH for the water after passing through the magnetic field increased to 6.88. The test was carried to confirm that the ordinary water, which passed through the magnetic field, was actually magnetized.

3.2 Fine and Coarse Aggregates Properties Results

The fineness modulus for fine aggregates shows the value of 2.94, which implies that most of the aggregates are found between 150 µm and 300 µm sieves. The aggregate used is a zone-2 fine aggregate. The value is also between 2.9 and 3.2 and therefore coarse sand as shown in Figure 4. The fineness modulus found for combined or all-in-aggregate samples vary between 3.5 and 6.5 for it to be coarse aggregate. The fineness modulus of the coarse aggregate is determined using the sieve analysis result from the result the fineness modulus value of 6.10 implies that most of the aggregates are found between 10 mm and 20 mm. The maximum size of the coarse aggregates is 20 mm as the fineness modulus value fits between the ranges of 6.1 and 6.9. The values for specific gravity are: sand 2600 kg/m^3, fine crushed glass 2300 kg/m^3, granite coarse 2630 kg/m^3; bulk density is 1680 kg/m^3 and for fineness modulus the result is 6.10.

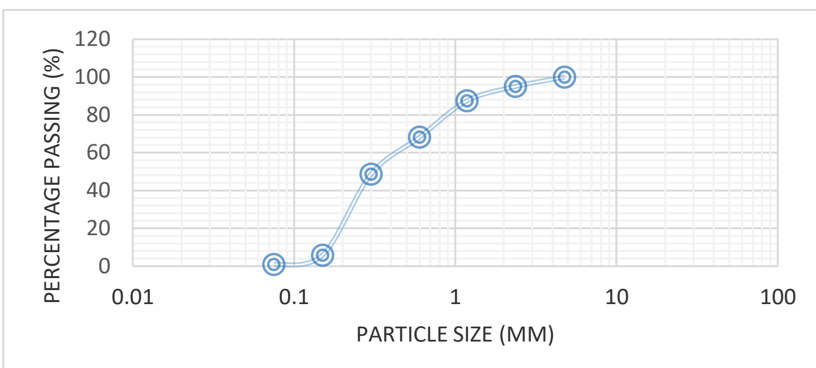

Figure 4. Graph of sieve analysis of fine aggregates.

3.3 Slump Test

The result of the slump test is shown in Table 1 for various types of concrete and environments. From the test result, the general workability of the self-compacting concrete types is higher than those of the normal (consolidated) concrete types. The slump value of MFTW is 29.5mm, which is higher than 18.5mm of NC. Based on the classification of slump given in the standard, both slumps are class S1.

Table 1. Various slump test results (mm).

MIX TYPE	Normal Concrete	Crushed Waste Glass at 15% Replacement	Self-Compacting Concrete	Crushed Brick Dust at 20% Replacement
NC	45	140	18.5	70
MFTW	260	220	29.5	140

NC = Normal Concrete, MFTW = Magnetic Field Treated Water

3.4 Compressive and Split Tensile Strength Tests

The 7, 14, 28, and 56 days compressive and tensile strength of the different concrete mixes were obtained, however only the strength test results for 28 days are shown in Table 2. Generally, the Mix for concrete manufactured and cured in MFTW gave a higher compressive and tensile strength for each curing day than those, which was mixed and cured with ordinary water. The 28 days and 56 days compressive strengths of MFTW are higher than those of Normal concrete by about 10% and 8.32% respectively. For the tensile strength, the increase is 7% of MFTW above that of normal concrete. This implies that at the same cement content and water/cement ratio, magnetized water gives rise to a higher compressive and tensile strength of concrete. The trend of higher compressive and tensile strength values for all curing periods of 7, 14, 28 and 56 days between MFTW and Normal water in concrete for all concrete types, that is, normal concrete, concrete with crushed waste glass at percentages, self-compacting concrete and concrete with brick dust at percentage replacement of fine were observed as indicated in the table.

Table 2. Various compressive and tensile test results (MPa).

MIX TYPE	Normal Concrete		Crushed Waste Glass at 15% Replacement		Self-Compacting Concrete		Crushed Brick Dust at 20% Replacement		Sea Water Cured Environment		HCL Cured Environment	
	C	T	C	T	C	T	C	T	C	T	C	T
NC	32.55	3.27	33.02	3.67	32.55	3.27	25.45	2.94	-	-	-	-
MFTW	36.23	3.50	34.99	3.67	36.23	3.50	30.27	3.09	32.77	2.94	36.51	1.87

NC = Normal Concrete, MFTW = Magnetic Field Treated Water, Compressive Test, Tensile Test

After curing in salt-water, concrete cubes have a darker surface than the reference and magnetized water concrete cubes. When cured in salt water a deposit of salt formed with a whitish appearance all over the cube.

4 CONCLUSIONS

From the above it evident that magnetized water increases the slump of normal concrete by at least 15mm for SCC. Magnetized water reduces the yield stress of SCC and therefore increases the flowability and the rate of flow of SCC. Magnetized water gives rise to a higher compressive strength of normal concrete by about 10% at 28 days. SCC made and cured in MFTW gives a higher strength of about 9.1% than that made and cured in ordinary water. SCC made with ordinary water but cured in MFTW gives little increase in strength when compared to that cured in ordinary water. SCC made and cured in MFTW starts showing significant higher strength (2%) when compared with that made using MFTW but cured in normal water from the 28th day.

SCC made using MFTW gains strength more slowly than its normal concrete counterpart until the 28th day. Study may be carried out by subjecting the concrete made with MFTW to some form of environment conditions such as elevated temperature and presence of pollutants to determine the long-term carrying capacity of elements built with it. The results indicate that the environment of production and use of concrete affects its strength considerably.

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