Journal of Engineering and Applied Sciences 13 (24): 10384-10387, 2018
ISSN: 1816-949X

Improvement of Mechanical Properties of Concrete Using Magnetic Water with Different Ages of Magnetism

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Abstract: This investigation deals with the effect of using magnetic water on some mechanical properties of concrete like compressive, tensile and flexural strength of concrete and also, the effect of magnetic water on fresh concrete like slump value. The results show that when using magnetic water instead of tap water, it gives higher values of all mechanical properties and more fluidity performance (higher workability) of concrete and that is good property to make concrete need less energy in construction such as less vibration of compaction and workable concrete can enter dense reinforcement without problems and without any formation of voids or air cavities that lead to less strength and durability, therefore, that behavior of magnetic water can make construction in less cost and higher durability comparing with tap water. Results show that compressive strength for 28 days magnetic water had compressive strength of (36.51 MPa) comparing to ordinary concrete using tap water that had (28.94 MPa) compressive strength and the increment here is about 26.2%. And also, increasing the period of magnetism leads to increase the value of compressive strength gradually. The flexural and tensile strength also increased when using magnetic water and workability also improved in this investigation. Microscopic photos of magnetic and tap water in addition to environmental characteristic tests of these two types of water clarified that the suspended particulates in magnetic water begin to split and arrange. This state of magnetic water help it to fill the voids inside dry mixture of concrete better than tap water and work to improve its mechanical properties. This result can give a quick digital test for water magnetism in the field help the users to choose the optimal discharge of water, retention time inside magnetic field and the necessary power of magnets.

Key words: Magnetic water, concrete properties, workability, turbidity microscope photo, construction, tensile, compressive, flexural

INTRODUCTION

Magnetic power has entered in many applications of industry, agriculture and health care. It could be used to improve the characteristics of products physically without changing their chemical compounds.

The using of magnetic water started first in irrigation and fields of agriculture and plant growth, the use of Magnetic Water (MW) showed various benefits that can improve water absorption by plants and plant growth, there are three main reasons that cause the treatment in soil, first, magnetism can remove excess soluble salts, second, lowering PH value of layers of soil and finally dissolving slightly soluble components such as phosphates, carbonates and sulfates (Ali *et al*., 2014; Hilal *et al*., 2013).

The magnetic field plays a major role in finding successful solutions for environmental problems. It was used to treat samples of water taken from lake Eastern Jeddah in Saudi Arabia. The physical, chemical and microbiological properties of these samples were improved after retaining in magnetic field for about 30 days (Mohammed *et al*., 2010).

Magnetic water has an ability on reducing water hardness until 51% depending on the factors of magnetic field intensity, situation of magnets set up, amount of water entrance and concentration of water hardness. Electronic microscope pictures (Fig. 1) showed the reducing in particles size of calcium carbonate and increasing in their number after treating by magnet (Banejad and Abdosalehi, 2009).

The use of MW in concrete construction leads to more improvements in mechanical properties for concrete such as compressive strength, some researchers found that the use of magnetic water improve the compressive, tensile and flexural strengths comparing to ordinary water with same mixes and also, increase fluidity or workability of concrete (Su *et al*., 2000; Malathy *et al*., 2017; Bharath *et al*., 2016; Reddy *et al*., 2014; Faris *et al*., 2014; Manjupria and Malathy, 2016).

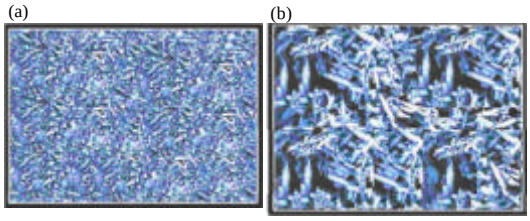

Fig. 1: a, b) Crystals of calcium carbonates before and after magnetic treatment (Banejad and Abdosalehi, 2009)

MATERIALS AND METHODS

Experimental program: Magnetic water was prepared by keeping the tap water in magnetic field for different periods 1, 3, 7, 14 and 28 days, the magnetic field was activated by fixing two different magnet poles (North and South) on a plastic bottle with capacity equals 2.25 L (Fig. 2). Ordinary Portland cement was depended in all mixes, tap water was used as reference mixes and coarse aggregate was entered in mixes with maximum size aggregate of 16 mm according to the Indian standard specifications IS-383 2013 (Anonymous, 1970), the grading of coarse aggregate is shown in Table 1. The fine aggregate (sand) was confirmed to the same Indian standard and matched zone 2 where Table 2 is showing the grading of fine aggregate that is used in this study.

Mixes: Mixture rates (1:1.5:3.0) (cement: sand: gravel) were used in all mixes.

Specimens, molds and testing procedure: Three specimens for each mix were prepared for testing and taking the average value, molds (100*100*100) mm were used to cast concrete for compressive strength test. Tensile strength tests were done by using, cylinders with 100 mm diameter and 200 mm high and using splitting tensile method (indirect test). For flexural test, beams with dimension (100*100*400) mm were used to find flexural strength according to British Standards (BS 1881) (Anonymous, 1983) and the type of test was third point loading. The specimens were cured in ordinary tap water after 24 h of mixing and tested for 28 days age (Fig. 3a-c).

Mixing procedure: The dry cement, sand and gravel were mixed together, so as to be homogeneous dry mixture. Water with water/cement ratio equals 0.50 was added to the dry mixture and moved together to form concrete mixture, then it was casted in cubic iron molds in three layers and compacted each layer with steel rod after that, they were leaved to harden for 24 h and sunk them in water for 27 days to prepare them for compressive and other strength tests where these tests were done after 28 days of curing.

Fig. 2: Magnetic water preparing

Table 1: Sieve analysis of coarse aggregates used in study

Sieve size (mm)	Passing by weight (%)	IS Indian standards limits
40	100	100
20	100	100
16	98.3	90-100
12.5	-	-
10	66.8	30-70
4.75	6.9 0	0-10
2.36	-	-

Table 2: Sieve analysis of fine aggregates used in study

Sieve size	Passing by weight (%)	I.S Indian standards limits for fine aggregates (Zone 2) (%)
10 (mm)	100	100
4.75 (mm)	100	90-100
2.36 (mm)	82.6	75-100
1.18 (mm)	77.5	55-90
600 (μ)	48.9	35-59
300 (μ)	21.1	8-30
150 (μ)	3.9	0-10

Slump test procedure: Slump test was done by an iron cone with upper circular diameter of 10 cm lower circular diameter of 20 cm and height of 30 cm. The fresh concrete was put with three layers and compacted with 25 strikes by steel rod for each layer, the final upper surface had been made smooth and horizontal before the cone was raised up by hand and put it beside concrete to test the slump in centimeter directly (Fig. 3d).

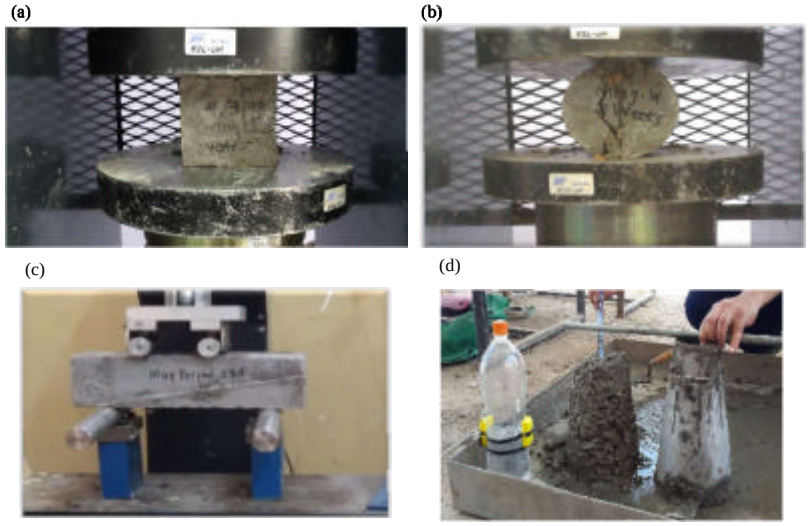

Fig. 3: Concrete tests; a) Compressive test; b) Tensile test; c) Flexural test and d) Slump test

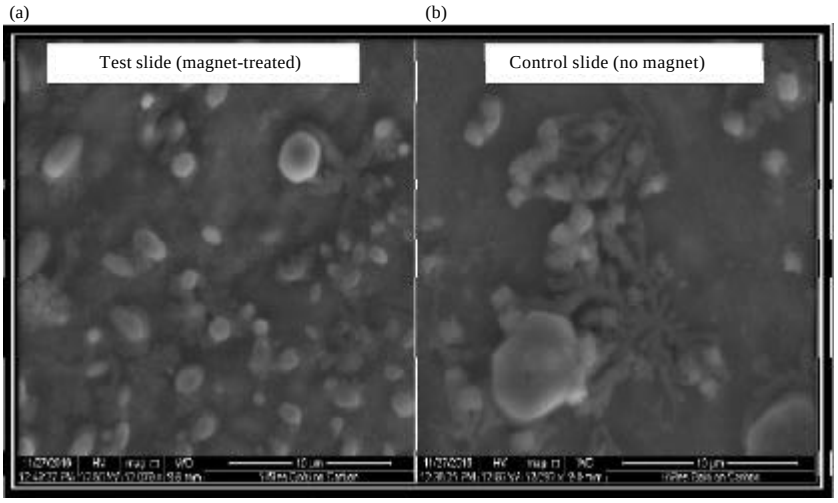

Fig. 4: a, b) Microscopic photos of magnetic and tap water

RESULTS AND DISCUSSION

Table 3 shows all mixes of concrete that were used in this study, their mechanical properties and slump values. It can be seen that the compressive strength of concrete increases from 28.9-36.51 MPa by using magnetic water (for 28 days magnetism), the increment here is about 26.2% and also from Table 3, it can be shown that the increasing of magnetism period leads to gradual increase in compressive strength and the slump of mix or workability of mixes improved also from 7.5-10.5 cm with increment equals 40%.

For tensile strength test, the tensile strength also, improved from 4.3-6.95 MPa (61.6% increment) and this is a very good increment. And also flexural strength improved by using magnetic water, the flexural strength of concrete increases from 5.3-7.5 MPa (the increment here is about 41.5 %) and also this is high increment.

These increments in mechanical properties can be attributed to the effect of magnetic field on mixing water. This field works to reduce the size of particulates and dissolved solids in the liquid, it makes them laminar and fine. Figure 4 clarifies the difference between particulate sizes of two photos of magnetic and tap water which were taken by electronic microscope.

Table 4 illustrates the difference between tap and magnetic water via the environmental characteristics of water. It is seen a little reduce in Total Dissolved Solids (TDS) and Electrical Conductivity (EC) for magnetic water comparison with tap water, these changes are

Table 3: Mechanical properties and their increments (%) of different magnetic concrete mixes comparing with the reference mix

Mix types	Compressive strength (MPa)	Tensile strength (MPa)	Flexural strength (MPa)	Slump value (cm)
Reference mix1: 1.5:3, w/c = 0.5, tap water	28.94	4.30	5.30	7.5
Same mix with 1 day magnetism	29.12, 1%	4.50, 5%	5.52, 4%	7.7, 3%
Same mix with 3 days magnetism	29.73, 3%	0.3, 17%	5.90, 11%	8.0, 7%
Same mix with 7 days magnetism	30.34, 5%	5.80, 35%	6.16, 16%	8.6, 15%
Same mix with 14 days magnetism	32.40, 12%	6.65, 55%	6.70, 26%	9.3, 24%
Same mix with 28 days magnetism	36.51, 26%	6.95, 62%	7.50, 42%	10.5, 40%

Table 4: Environmental characteristics of tap and magnetic water

Parameters	Unit	Tap water	Magnetic water
TDS	Mg/L	785	771
EC (22°C)	µS/cm	1302	1290
Turbidity	NTU	8.04	16.5

insignificant to do the clear improvement in mechanical properties of concrete. Also, it is seen an increment in turbidity for magnetic water from 8.04-16.5 NTU (about 51%) because of the magnetic field effect on water which works on dividing the suspended and dissolved particles in water (increase their number and reduce their size) this reducing in particulate size improve the ability of water to mix the solid mixture of concrete and make it stronger with more workability.

CONCLUSION

It is concluded from this research that magnetic field affects on suspended particles in water, makes them smaller and tidier than themselves in normal water before magnetism process. This changes in water properties help water to pass through voids of dry mixture of cement, sand and course aggregates to produce more homogenous mix of concrete which is more workable and when it gets solid, it will have more strength comparison with the same mixture except using normal water. However, it can be used turbidity test as a quick digital indicator to know that normal water transforms to magnetic water, also it can determine optimal period of magnetism and optimal magnetic field from this test in the field quickly.

ACKNOWLEDGEMENT

Many thanks and appreciates for honest assistance of lecturer Qusay Abdul Hameed. His help was very useful and necessary to carry out this study. Also I'd like to thank my students for help me doing the concrete tests in addition to the great assistance of the concrete laboratory staff in Faculty of Engineering and the staff of Electronic Microscope Unit in Faculty of Science.

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