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EFFECT OF MAGNETIC TREATMENT TECHNOLOGY ON THE (WORKABILITY AND COMPRESSIVE STRENGTH) OF HIGH-STRENGTH CONCRETE

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ABSTRACT

A sustainable approach to improving the properties of high-strength concrete is essential for the construction industry due to its excellent properties, such as high compressive strength, reduced dead load of the concrete structure, reduced construction cost, and environmental friendliness. The aim of the present work is to use a new technique (fresh concrete mixture treatment with magnetic field) to enhance the properties of HSC. The magnetic method is considered one of the techniques that develop mechanical characteristics of concrete, either by utilizing magnetic water to mixture the concrete mixture or by magnetizing the mixture itself. This research studied the influence of a magnetic field on characteristics of high-strength concrete. The experimental work was done in two lines; one was magnetizing fresh, high-strength concrete by passing the concrete mixtures through four devices. The first three devices contain (3, 4, and 5) magnetic units, respectively. Each magnetic unit has 3000 gauss intensity. The last device was a tube without any magnetic units. The second line was exactly the same as line one, just for one thing: the mixing water was magnetic water instead of tap water. When the mixtures are subjected to a magnetic field, The slump and compressive strength did not improve significantly and the values were variable. The highest increase in slump was achieved 4.7%for the magnetized mixture with the device equipped with 4 units (F3). The compressive strength of the mixture passing during the pipe equipped with 5 magnetic units (F4) was increased by percentage 7%at 28 days. As soon as magnetic water was utilized in place of ordinary water, the slump value was increased to 19% from the reference mix.

KEYWORDS

High strength concrete, Magnetic water, Magnetic treatment, Fly ashes, Magnetic time.

1. INTRODUCTION

High-strength concrete has gradually advanced over years. Concrete with 34 MPa was regarded as excellent strength as early as 1950. In the 1960s, 62 MPa concrete was considered high-strength. According to (ACI363 R-10, 2010) concrete with a compressive strength of 55 MPa or higher is considered high-strength concrete (HSC). HSC is made up of cement, cementitious material, aggregate, water, and superplasticizers. When these contents are proportionate and thoroughly blended, compressive strength can approach 140 MPa or somewhat higher (Calderon,2014). HSC production requires high-quality raw materials with an optimum mixing ratio. Aside from that, decreasing the water to binder ratio (W/B) and applying a superplasticizer are most essential aspects in achieving high strength (Rashid,et al,2009). Due to population expansion, there is a need to reduce potable water use. Magnetic cure technology was employed to alter molecular construction of water, resulting in significant water savings, particularly in concrete manufacturing (Sabapathy,et al,2019). Adding the magnetic water in the concrete mixing process can improve the workability and the compressive strength of the concrete, and by decreasing the cement content by a proportion of 28 per cent, it can perhaps decrease the pollution of the environment (Afshin, 2010). The compressive strength of magnetic water concrete increased as increasing strength of magnetic water. Raising magnetic strength implies raising water by which cement is treated so as to enhance the efficacy of the cement mix in concrete. (Al-Maliki et al., 2020). It was found that magnetic water increases the efficiency of the properties of fresh concrete when conducting slump tests, the compression factor,vee bee tested on concrete samples. The slump and compression factor increased by a percentage (58%,35%) respectively and decreased vee bee in seconds (Divya, 2020). There are many research studies on the effective use of magnetic fields in concrete mixtures. Magnetic water enhances the fluidity of cement paste and enhances the cement hydration, which increases the rate at which cement hardens and the bonding time (Li-jiu,.and Shan, 2008). Interaction of cement paste with three magnetic intensities (25.37, 22.22, 9.07 Gauss) was studied, and it was obtained that microscopic environment of cement pastes would variation in the aspects of the form and amount of CSH, where the amount of CSH would rise with growing magnetic intensity (Soto, 2015). It has been found that to make concrete, the utilization of magnetized water lowers the water content and enhances compressive strength by 15 percent. Environmental problems can be addressed to a large extent when magnetic water is used to treat wastewater in industries using a magnetic field, and the product can be used in concrete, and the strength is like normal water (Prakash, 2019). The preparation of concrete components with magnetized water enhances their weight density and compression force (Xiao and Xing, 2013).

The compressive force of the concrete improved with increased magnetic strength on a mixture of water, and the improvement occurred at a young age. It was found that the compressive strength at a late age was similar to that with no magnetic water (Su and Wu, 2003), and this was made out by the conclusion that led to the compressive strength. Faris,et al, 2014 used magnetic water that magnetized with 0.9T intensity at concrete with 40 MPa as a reducing water agent instead of super plasticizer. The result shows compressive strength enhanced by 12% and tensile strength enhanced by 8.9% in comparison with normal concrete (Ramalingam, 2022). Contrary to what most studies have concluded about the positive influence of magnetized water on the characteristics of concrete, there is a study that concluded that treating concrete with magnetic water led to a decrease in the compressive strength by percentage (26%) of concrete at intensity(0.4Tesla) (Abdel-Raouf, and Abou-Zeid,2009). Another study done on concrete with steel fibers (1% by volume) and exposed to magnetic field (0.5 Tesla) led to improved compressive and flexural strength in 16% and 18%, respectively (Hajforoush,2020). The magnetic field effective on cement paste was studied. They found there was an increase in initial and final sitting time and an increase in compressive strength (Sevim, 2023). Magnetic water can reduce the ability of concrete to absorb water. One of the studies shows that concrete with magnetic water had 0.05% absorption ratio, while concrete with normal water had 1.6% absorption ratio (T.Muradidhara, 2023). A study was conducted on effect of magnetic water on bonding strength between magnetic water concrete and reinforcement steal with different diameters the result shows that magnetic water led to increase bonding strength due to high liquidity and decrease porous content (Barham, 2020). A closer look at water's molecules will help you understand how it affects strength. Water's molecular structure consists of two hydrogen atoms and one oxygen atom joined by a covalent bond at an angle of 105°. Because \oxygen atoms are negative and hydrogen atoms are positive, they are attracted to one another and form enormous accumulative groups. To disrupt these accumulative chemical collections, extensive study has been conducted on the impact of magnetic fields on water (Ahmed, 2009). When water permits during a magnetic field, link's angle narrows, and water particles are organized in one route Fig.1 & 2.

Moreover, the magnetic field practical to water could decrease the connection of hydrogen bonds so the big molecular water collections break into minor collections, maybe $2H_2O$ or even $1H_2O$ (Reddy,2014). The physical properties of water changed after its exposure to the magnetic field, reducing both boiling temperature and specific heat and increasing the amount of evaporation. Each of these variations is hinged on the consequence of magnetization that entails the intensity of the magnetic field (Wang,2018) and (Toledo,2008). In addition, the

magnetic field also influences PH, the amount of ions, and the solubility of salts in water by raising PH and lowering the salt,s although the influence of the magnetic field on PH and the amount of ions reduces the corrosion average (Manjupriya, and Malathy, 2016).

Many of previous researches studied influence of magnetized water on characteristics of concrete. In this research, two approaches have been taken. The first was magnetizing fresh concrete and making a comparison with other mixtures that had been treated by magnetizing mixing water and choosing the better option of treatment. The second was magnetizing fresh concrete, which was already mixed with magnetic water to enhance magnetic treatment.

(a) (b)

Fig. 1. Influence of magnetic field on water particle, (a) water particle, (b) water molecular after subjected to magnetic Field (Ghazy,2021)

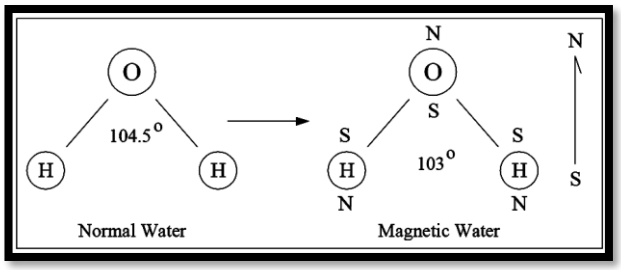

Fig. 2. Water molecule binding angle before and after magnetic treatment (Ghazy,2021)

2. EXPERIMANTAL WORK

Two lines are used to conduct the experiment. The first was to check the material specifications of cement, sand and gravel and associate it with those specifications needed in Iraq and second was to treat high strength concrete with a magnetic field.

2.1. Material characteristics

2.1.1. Cement and Cementite's materials.

OPC from the AL-MASS establishment was utilized in this study. It was with Iraqi Specification No. 5/1984. Also, 20% of cement weight was changed by Class C fly ash, which in relation to ASTM C618. The chemical properties for both cement and fly ash are listed in Table 1.

Table 1 Chemical properties and limits of Iraqi specification for cement and fly ash.

Items	Cement	Fly ash	Limits of Iraqi Specification
SiO_2	20.88	33.483	-
Al_2O_3	4.06	11.887	-
Fe_2O_3	5.40	19.337	-
CaO	62.41	24.231	-
MgO	1.6	0.268	≤5%
SO_3	1.19	0.530	≤2.8%

2.1.2. Aggregate

Fine aggregate from Al-Ukhaider (a region in Iraq) was used. It was identical to Iraqi specifications and within zone 3 limits. Local crushed gravel with a maximum size of 14 mm was used in this research. The gravel was identical to Iraqi specifications, and very of the tested physical characteristics were itemized in Table 2 and sieve grading for both fine and coarse aggregate in Fig.3.

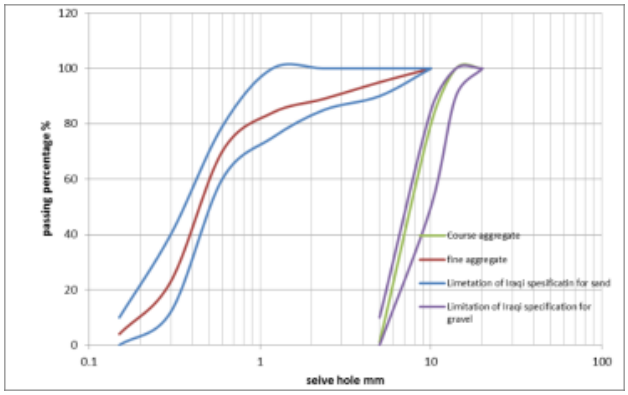

Fig.3 Sieve analysis for aggregate and the limits of Iraqi specification.

Table 1 SO_3 content and some physical properties of sand and gravel.

Item	Sand	Gravel
`SO_3	0.2%	0.02%
Finesses modulus	2.76	-
Water absorption	0.64 %	1.03 %
Bulk density	1689 kg/m^3	1568 kg/m^3
Specific gravity	2.680	2.587
Clay content	2 %	0.2 %

2.1.3. Super plasticizer

High performance concrete super plasticizer (Master Genium 54) is used to give high workability without segregation or bleeding besides improving the surface finish. Its typical properties were listed in Table 3.

Table 3 Properties of super plasticizer.

Form	Whitish to straw coloured liquid
Relative density	1.07
Ph	5-8

2.1.4. Water

Tap water was utilized in very concrete mixtures and treatment.

2.1.5. Magnetic water.

The tap water was magnetized in 20 minutes, i.e., by passage during a magnetic tool as revealed in Fig.3. Instrument is a pipe whose diameter is 25 mm and is covered by the magnet with a strength of (guess) (12000). Its properties was listed in Table 4.

Fig.4. Magnetic water device and the way of magnetizing tap water.

Table 4 some of the manufacturing properties of smart magnetic water device.

Length	600 mm
Diameter	75 mm
Weight	4 kg
Magnetic force	12000 Gauss
Softener electronic	30 dbi
Salt fraction rate	2000-8000 T
Power supply	12 vdc

2.2. Mix proportions

To create high-strength concrete (fc′=70 MPa), the method introduced by (Alonzo,1993) (with small proportion correction on water content dependent on water content and aggregate absorption) is used after an experiment by trial and error until the target compressive strength is achieved. Table 5 shows the mix design proportions employed in this study by weight. Fly ash replaced 20% of the cement weight. The W/binder ratio was 0.24, with a super plasticizer of 1.3% from cementations martials.

Table 5 Mixture percentage for high strength concrete.

Cement kg/m3	Fly-ash kg/m3	Sand kg/m3	Gravel kg/m3	Water kg/m3	S.P kg/m3
533.36	133.34	450.8	1102.8	159	8.67

2.3. Magnetic mechanical device

In this study, three magnetic mechanical procedures were used, every one comprising two pipes, one with a 6-inch diameter and another pipe with a 4 inch. Between these pipes, there are magnetic units, everyone with 3000 gauss intensity, spread along the pipe at a constant distance. There were three procedures comprising 3 , 4 , and 5 units, correspondingly, as revealed in Figs 5 and 6.

Fig.5. magnetic devices

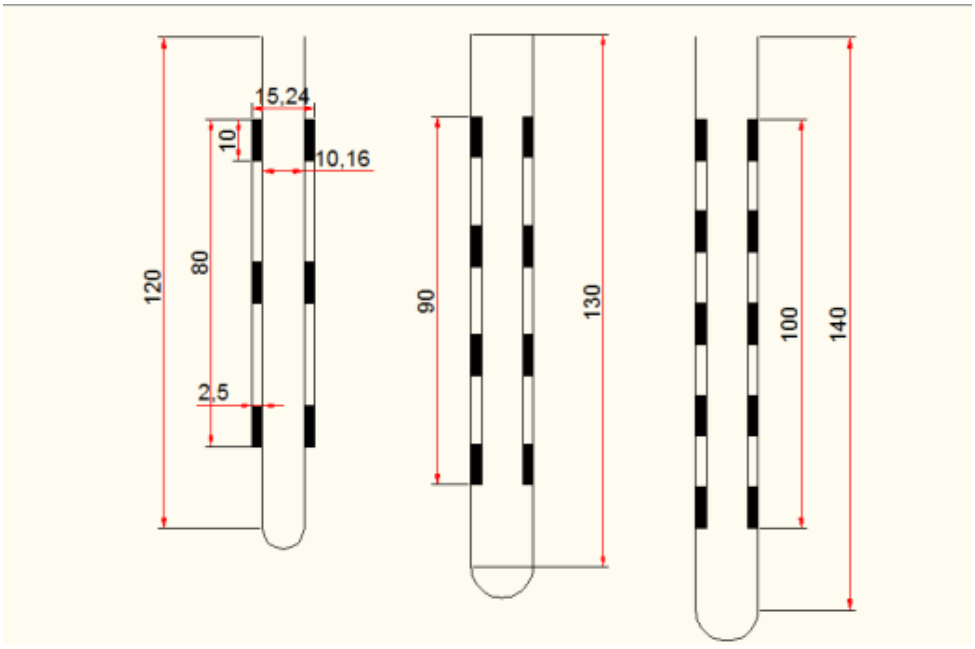

Fig.6 Magnetic devices and the distribution of magnetic units along tubes ' length.

3. PROCEDURE OF WORK

3.1. Samples' preparation.

In this study, three concrete combinations with a compressive strength of 70 MPa were used. The two mixtures (H1 and F1) were combined with ordinary water, whereas the mix (W1) was varied with magnetic water. The mixes were magnetically treated. The combination was (H1) for 5 minutes, (F1) for 10 minutes, and (W1) for 10 minutes. The cure approach was the same for all three combinations. Each mixture was sent through the device's tube without magnetic units to serve as reference combination, while other mixes were passed during pipes with magnetic units (3, 4, and 5 units). The slump was measured, and 6 cubes (10*10*10) cm in size were poured for each treatment case to conduct compressive strength testing.

4. RESULTS AND DISCUSSION

Workability and compressive strength were measured to all tested mixtures. The tested mixtures were a signed with name as listed in Table 6.

Table 6 description of mixtures' names.

NO. of set.	Mixtures name	Type of mixing water	No. of magnetic units effect the mixture	Period of magnetizing
Set 1	H1	Tap water	0	5 minutes
	H2		3	
	H3		4	
	H4		5	
Set 2	F1	Tap water	0	10 minutes
	F2		3	
	F3		4	
	F4		5	
Set 3	W1	Magnetic water	0	10 minutes
	W2		3	
	W3		4	
	W4		5	

4.1. Workability

A slump test was prepared for every mixture revealed before. It was tested on reference mixture at first and on additional mixtures that were subjected to a magnetic field. Test results showed a variation in the slump of the magnetic mixtures. For set1 the slump increased by the percentage (4.3%) For magnetized mixture with 4 units H3 while it decreased by the percentage (4.3%) For magnetized mixture with 5 units (H4). The slump remained constant for magnetized mixture with 3 units (H2). For set2The slump decreased for magnetic mixtures with 3 and 5 units (F2,F4) by the percentage (9.5%,4.7%) respectively and increased by the percentage (4.7%) of the mixture(F3). For set3 the slump did not change for magnetic mixtures with 3 and 4 units (W2, W3) and decreased by the percentage (4%) magnetic mixtures with 3 and 5 units

(W4). (Table 7 listed slump value for very combinations). The combination that travels during a pipe with four magnetic units improves workability the most. When using magnetic water instead of tap water, the drop increased to 19% related to reference mix, Because of the influence of magnetic field on the groups of water molecules, which makes them more dispersed from each other, this causes an increase in the participation of a larger number of water molecules in the cement hydration reaction, which leads to the dispersion of cement molecules within the concrete mixture in a complex form of molecules, and the reaction occurs on surface of cement molecules, which forms a smooth layer of reaction produces on the cement molecules that prevents water molecules from penetrating the mass of the material (Faris,et al,2014), (Gholizadeh, and Arabshahi, 2011).

Table 7 Slump values for all concrete mixes

Set. No.	Mixture Name	Slump (cm)
Set 1	H1	23
	H2	23
	H3	24
	H4	22
Set 2	F1	21
	F2	19
	F3	22
	F4	20
Set 3	W1	25
	W2	25
	W3	25
	W4	24

4.2. Compressive strength.

Table 8 listed compressive strength for all sets. For set 1, when the magnetizing period was 5 minutes, the compressive strength was slightly higher by 5% in comparison with the reference mixture. This increment is done when the concrete is magnetized by a device with 4 magnetic units(H3) at 28days. For set 2, the increment was 7% for the mixture passed through the device with 5 magnetic(F4) at 28 days. For set 3, the compressive strength rose to 9.8%For the mixture varied with magnetized water compared to mixture varied with tap water, and it decreased when exposed this mixture to a magnetic device, regardless of the number of magnetic units, The lowest percentage of decrease was (2.6%,2.2%) at (7,8) days respectively for the mixture passed through the device with 4 magnetic unitsThis is consistent with researchers (Abdel-Raouf, and Abou-Zeid,2009)(Su and Wu,2003). The reason for this reduction or affection may be due to the high quantities of cement and lower water content (the water content is low), which didn't let the concrete components be affected by the magnetic device. Abdel-Magid et al, 2017 also concluded in her study that as the amount of water became larger and cement reduced, the effect

of magnetic water on the cement granules became greater. Fig.7 indicates failure manner of high-strength cubes.

Fig. 7. Compressive strength test and failure mode of specimens

Table 8 Compressive strength for all mixes.

Set No.	Mixture name	Compressive strength Mpa	
		7-days	28-days
Set 1	H1	74	83
	H2	71	85
	H3	75	87
	H4	72	80
Set 2	F1	71	81
	F2	72	83
	F3	72	81
	F4	72	87
Set 3	W1	76	89
	W2	70	79
	W3	74	87
	W4	69	80

5. CONCLUSIONS

Magnetization of fresh concrete mix did not significantly improve concrete slump regardless of the type of mixing water(tap or magnetic water).

1. There is a minor development in CS (7%) at 28 days For magnetized mixture with device equipped with magnetic 5units for 10 minutes.

2. When utilizing magnetic water in its place of tap water in mixing concrete, the slump increased by 19% and the compressive strength increased by 9.8% at 28 days.

3. Increasing magnetic mixing time from 5 to 10 minutes did not appreciably increase slump or compressive strength.

4. After conducting research, it was not recommended to use magnetic technique on high-strength mixtures with 20% fly ash replacement and a water-to-binder ratio of 0.24 W/B due to the minor increase in slump and compressive strength, which could be overlooked given the cost and effort.

5. Fly ash effects late ages, while magnetic treatment effects earlier ages. New research was done in the same manner but using silica fume instead of fly ashes to better understand the magnetic behavior. Mainly, there was some recommendation for future studies.

6. Study of the effect of fly ash content in concrete mixture exposed to magnetic field.

7. Study The effect water over binder ratio(W\binder) and magnetic field intensity on fresh concrete mix.

8. Conducting a study that includes the effect of magnetization of fresh concrete mix on the properties of other types of concrete such as self-compacting concrete and fiber-reinforced concrete.

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