Improving Some of Mechanical Properties of Concrete by Magnetic Water Technology

Ali Shynier, Mezher Abed[1], Zainab Fouad, Akeel Kazim, Raed Isse, Nihad Reheem, Ali Chaloob, Hazim Mohammad, Nather Jamal, Hayder Jasim, Jaafar Sadeq & Ali Salim.
Ministry of Science and Technology - Baghdad – Iraq
e-mail: mizher_57@yahoo.com
or mizher.abed@gmail.com

1- Abstract

In this research, the compressive strength and workability of the concrete by using magnetized water، have improved certain percentages depending on the process of the formation of this concrete.

The experiments comprise the preparation of standard cubes from this concrete according to the standard ratios of ingredients and mixed with magnetized water, which was prepared by passing tap water through the devices of different magnetic strength in terms of (4000, 6000, 9250) Gauss. Then the factors affecting on some physical and mechanical properties were studied, and developed some methods to be tested and verified. To complete the scope of the present experimental results, the study was necessitated the preparation of similar cubes using ordinary tap water.

Several experiments were conducted to determine the velocity of water through the magnetic field, which gave the highest value for the compressive strength, where it was up to 0.8 m / sec.

It was also appeared from the tests for compressive strength of more than 63 cubic concrete mixed with magnetic water that there is an increase ranging between (10-22%) compared to the results of the control cubes, Where the highest increase up to 22% at the magnetic intensity equal to (9250) gauss.

Investigations of the slump test have shown best softness and good workability to the mix concrete in the range between (6.25-7) cm. It is compatible with a number of international standards, for this, the percentage of water to cement (w/c) was determined, regardless of the quality of water used.

Key words: magnetic water, concrete, magnetic field, compressive strength, slump.

[1] Corresponding author: senior civil engineer.

2-Introduction

One of the most recent important technologies to enhance concrete workability and compressive strength is using magnetized water instead of normal water within concrete mixes [1]. This technology changes the main effective aspects of water with no change to other components of concrete mix [2]. Water effective properties could be well controlled within flowrate velocity, magnetic field strength and exposure time [3]. This technology has increased compressive strength up to 20% and more which make it very important within concrete production and uses [4]. The homogenous and workable concrete that mixes with magnetic water gave further property of maintaining equipments from hardening process through transportation of fresh concrete [5]. Using magnetized water in the concrete mix is the best in terms of higher density and lower porosity with no additives needs [6].

The implementation of magnetized water technology in concrete mix had increased rapidly on the eighties and nineties decades due to the development of magnetic devices and its physical water effluents at concrete properties. The importance of mechanical properties of this concrete mix have been dispersed in many fields of civil and military construction like airports and jetties [7].

Most researchers concentrate their attention on producing economical concrete with higher strength using new philosophies of design methods, through modern technique, like using water which has magnetically treated. When ordinary water flows through magnetic field, the water physical properties are changed therefore, the number of molecules in water clusters will decreased to 6 or 5 molecules which causing decrease in surface tension and increase the percentage of molecules contribution of hydration process [1,3].

when water treated in a magnetic field is added to concrete. In a magnetic field water molecules will loose their attractive-repulsive forces and become oriented on a magnetic pole or electric charge. “Neutralized” molecules of water are much more easily attracted to numerous electrostatic fields naturally contained by cement grains. Hydration of cement is faster and more complete than with untreated water **[4,7].**

2-1 Fundamentals of Concrete

Concrete is basically a mixture of two components: aggregates and paste. The paste, comprised of portland cement and water, binds the aggregates (usually sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of the chemical reaction of the cement and water. Supplementary cementations materials and chemical admixtures may also be included in the paste. The binding quality of portland cement paste is due to the chemical reaction between the cement and water, called hydration. Almost any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water for making concrete. Therefore, the strength at any particular age is both a function of the original water cement ratio and the degree to which the cement has hydrated. Hydration needs a specific quantity of water, where the water used in the concrete mixing is always much more than that required. The addition water used to increase the elasticity of concrete and fill all mold corners and the areas surrounding the reinforcing bars. Effects of mix water impurities can be found in setting time and concrete strength, for example high chloride content in mixing water is mainly due to the possible adverse effect of chloride ions on the corrosion of reinforcing steel or pre-stressing strands. Therefore, tests should be done to ensure that impurities in the mixing water do not adversely shorten or extend the setting time of the cement and conformable to acceptable criteria for used water in concrete [6].

2-2 Magnetized water

When fluid conductor (such as water) moving in one direction across a perpendicular magnetic field produces current around the same conductor, which creates a drift force perpendicular to the inductive magnetic field and also parallel to the direction of the fluid. This deflating electrical will occur positive pole through the fluid conductor fig. (1) [8].

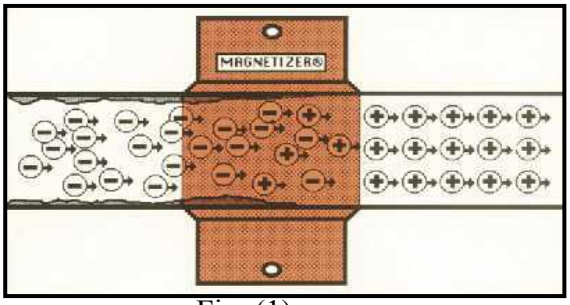

Fig. (1)
effect of magnetic field on water polarization.

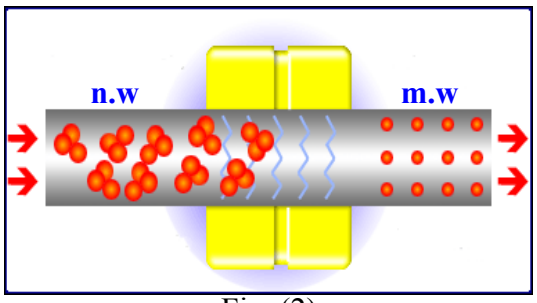

Fig. (2)
difference between magnetized and normal water molecules

Magnetic field will decreasing the random contribute bonds specially in the molecule groups nuclides points, which form the precipitate layer. Thus, will making the minerals suspended in water without deposit. The molecule groups of magnetic water differ from molecule groups of ordinary water in having lower degree of consolidation, and the molecules volume is more uniform fig. (2) [9].

Magnetic field effect on hydrogen bonds between water molecules and found some exchange which happened in the properties of water such as light absorption, surface tension and pH [10].

The activation of water treatment using magnetic field depends on three conditions [11]:

- Magnetic flux density.
- Duration of exposing water to magnetized field (velocity of water current).
- The amount of exposing water to the field.

2-3 Hydration of cement

When cement and water are mixed, the hydration process begins and the concrete will gain strength and durability with time. Hydration process is driven by three elements water, temperature and the availability of unhydrated cement. In the hydration process, water is chemically combined with cement. When triple calcium silicates (Ca_3SiO_5) of cement comes in contact with water , it forms ($Ca_3SiO_5OH_3$), Calcium Silicate Hydrate with the release of ($Ca(OH)_2$) (Calcium hydroxide) from the surface of grains as the equation (1) flow [12].

$$2Ca_3SiO_5 + 6H_2O \longrightarrow Ca_3SiO_5OH_3 + 3\ Ca(OH)_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Rapid evolution of heat during this period (≈ 5 minutes). Then hydrolysis slows down (dormant period) and this stage is responsible for the plastic state of cement (2- 4 hours). Then (Ca_3SiO_5) again reacts. Nuclei forms and hydration products in equation (1) begins to crystallize from solution (Acceleration period). ($Ca(OH)_2$) crystallises from solution & ($Ca_3SiO_5OH_3$) develops at the surface of the (Ca_3SiO_5) grains ,developing a coating (4 -8 hours). Rate of reaction slows down as the coating of the (Ca_3SiO_5) hydrate layer flow through the barrier to reach the unhydrated (Ca_3SiO_5). Water reaches unhydrated (Ca_3SiO_5)through capillary action fig. (3).

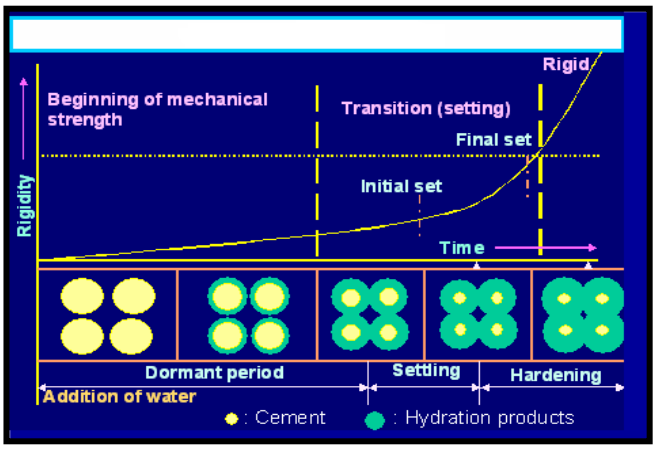

Fig. (3) hydration of cement

Concrete is a mixture of cement and aggregates. When cement touches by water it will form paste which coats the surface of the fine and coarse aggregates. This paste hardens through hydration process to form concrete and its properties depends upon many factors, including the quality and proportions of the ingredients and the curing environment. The most important indicator of the above properties is the ratio of the water used to the amount of cement. The major properties of Concrete which are influenced by water are workability, porosity / permeability and strength. Factors Influencing compressive Strength characteristics of cement, characteristics and proportions of aggregates, water / cement ratio, degree of compaction, efficiency of curing and temperature during the curing period [13, 14].

High strength and high performance concretes have became the most interesting topic in the area of concrete development since 1980s, and it is now possible to have structures that are built with concrete having compressive strength over 100 MPa. Therefore, the study of this research have been concentrated to the major characteristics of concrete like workability and compressive strength by using magnetic water with varies magnetic strength instead of normal water in concrete mixture.

The aim of this research is to improve compressive strength and workability without any admixtures to the concrete mix.

3- Literature review

Much researches in recent years has been devoted to establish the fundamental and engineering properties of high-strength concrete, as well as the engineering characteristics of structural members made with the material [15,16].

Increasing the compressive strength of concrete is an aim which most researchers are looking for, using various methods to do so, as the use admixtures in a concrete mixture. New techniques design or changing the ratio of material that component the concrete mixture to increase concrete strength [17,18]. In the other hand, many researchers where used their experiments to the manner and manufacturing conditions that determine the concrete properties, such as Su & Wu (2003) [7]. They discussed the break down of water molecules clusters into small clusters by using magnetic treatment of water which allow easily penetrate into cementatous grains and that leads to effective hydration which gave improvement of concrete durability.

The study of Wang & Zhao's (2008) [19] shows the improvement of cement dough characteristics that made with magnetic water. Also magnetic treatment had gave positive results in compressive strength and porosity of concrete rock.

Su & Wu (2000) [20] show that the compressive strength and workability of concrete containing fly ash and prepared with magnetic water increases by (9-19)%, (10-23)% respectively more than that prepared with normal water also he was found that magnetic water had increasing the rheology, amount of slump and concrete hydration.

Weilin et al (1992) [21] had got increasing in cement dough durability when he had treated it magnetically, also he had observed improvement in other properties of cement dough such as compressive strength 54%, tension strength 39%, adhesion of dough 20% and decreasing in initial and final setting time about 39%, 31% respectively.

4- experimental work

4-1 materials

4-1-1 Cement: the cement used in this work was ordinary Portland cement (O.P.C) type Taslojah (UCC), it conforms to the Iraqi Specifications No.5, (1984).

4-1-2 Fine aggregate (sand): sand was red sand from Ukhaydir region, its grading was within Iraqi Specifications No.45, (1980), and measured bulk specific gravity was 2.63 and fineness modulus of 2.75. The weights of the fine aggregate are based on material in the saturated surface dry condition, in which, as the description implies, the fine aggregate is fully saturated but has no water on the exterior of the particles.

4-1-3 Coarse aggregate (gravel): Natural crushed gravel had been used and its grading was within Iraqi Specifications No.45, (1980).The bulk specific gravity based on material in the saturated surface dry condition was 2.6, and fineness modulus of 3.

4-1-4 water: drinking water from El-jadriyah water supply is used in the research for both magnetic and normal water case, it conforms to the Iraqi Specifications No.1703, (1992). The system described in the fig. (4) have been used to magnetized water. In the beginning opens the valve that connects to the network of piped city water to feed water to the tube which is part of a device magnet fig. (5) and here there are two valves, one before and another after this device. The water will flow through the magnetic field after opening the valves down to the tank collecting water which is used immediately in the concrete mix, and if we need to change the velocity of water flow through the magnetic field is controlled by the valve before the magnetic device, which makes the water flowing through the magnetic field as the velocity selected, which is read from the flow rate measurement type (Ratometer).

Fig. (5) magnetic device

Fig. (4) (1. Feeding valve, 2. Control Valve, 3. Magnetic device, 4. Valve, 5. flowrate measurement, 6. Magnetized water container.)

4-2 magnetic devices

Design and manufacturing three magnetic devices, which have magnetic strength (4000, 6000, 9250) gauss, three stages for each one as shown in fig. (5).

4-3 Mixing procedure

It is customary to define the proportions of a concrete mix in terms of the total weight or volume of each component needed to make up 1 m3 of wet concrete, mix proportion (1:1.75:2.75) have been used to determine the cement, sand and gravel respectively in all specimens that describes in table (1). The symbol CS is the specimens of concrete had prepared with normal water which represent the control group. While the symbols (M1V1-M3V2) are point to specimens had prepared with magnetized water different in magnetic strength and flowrate. In all specimens that had used in this research, the density of cement is 1400Kg/m^3, slump test (6.25-7)cm and flowrate velocity through magnetic field had been (0.6-0.8)m/s.

Table (1) details of specimens

symbol	Magnetic field strength (gauss)	Flowrate velocity (m/s)	Slump (cm)	Water/cement ratio (W/C)
CS	-----	-----	6.25-7	0.53
M1V1	4000	0.6	6.25-7	0.5
M1V2	4000	0.8	6.25-7	0.5
M2V1	6000	0.6	6.25-7	0.49
M2V2	6000	0.8	6.25-7	0.49
M3V1	9250	0.6	6.25-7	0.46
M3V2	9250	0.8	6.25-7	0.46

4-4 slump test

The standard cone fig. (6) had been used for slump of concrete mix. The slump is a good measure of the total water content in the mix. The slump of each groups of concrete mixes was carried out according to **BS** 1881: part 2 (1970).

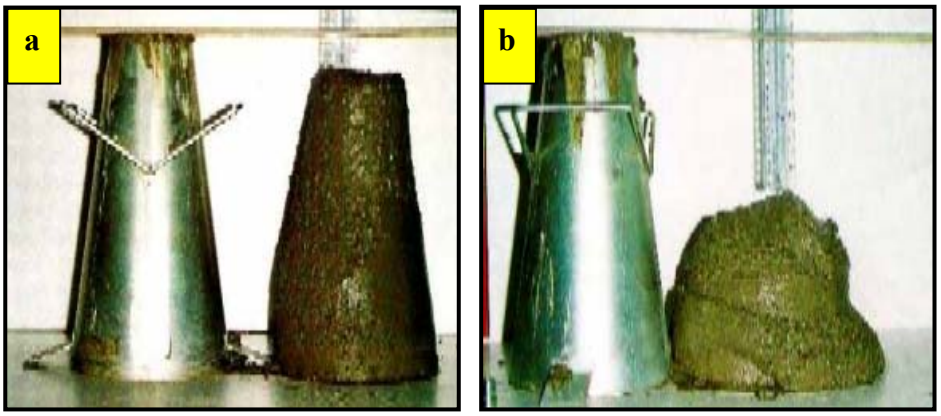

Fig. (6) describe the slump test (a) before magnetic, (b) after magnetic.

4-5 compressive strength test

All the samples were standard cubic specimens (150*150*150mm) fig. (7) in accordance with BS, and tested immediately after removing from water, compressive strength of each group of concrete was carried out according to Iraqi Specifications No.45, (1980) by using compressive strength apparatus (Viatest Cyber-Tronic) type (QPC-3000). The compressive strength was taken as the average value of three specimens in age of 7days, 14days and 28days. Thereby, 250 cube had prepared for all ages to determine this factor.

Fig. (7) describe the standard specimens cube

5- results

This research had investigated the two important factors that effect on concrete characteristics:

1. Effect of flowrate velocity through magnetic field on compressive strength.
2. Effect of magnetic field strength on compressive strength and slump of concrete, when flowrate velocity is constant.

5-1 Effect of flowrate velocity through magnetic field on compressive strength.

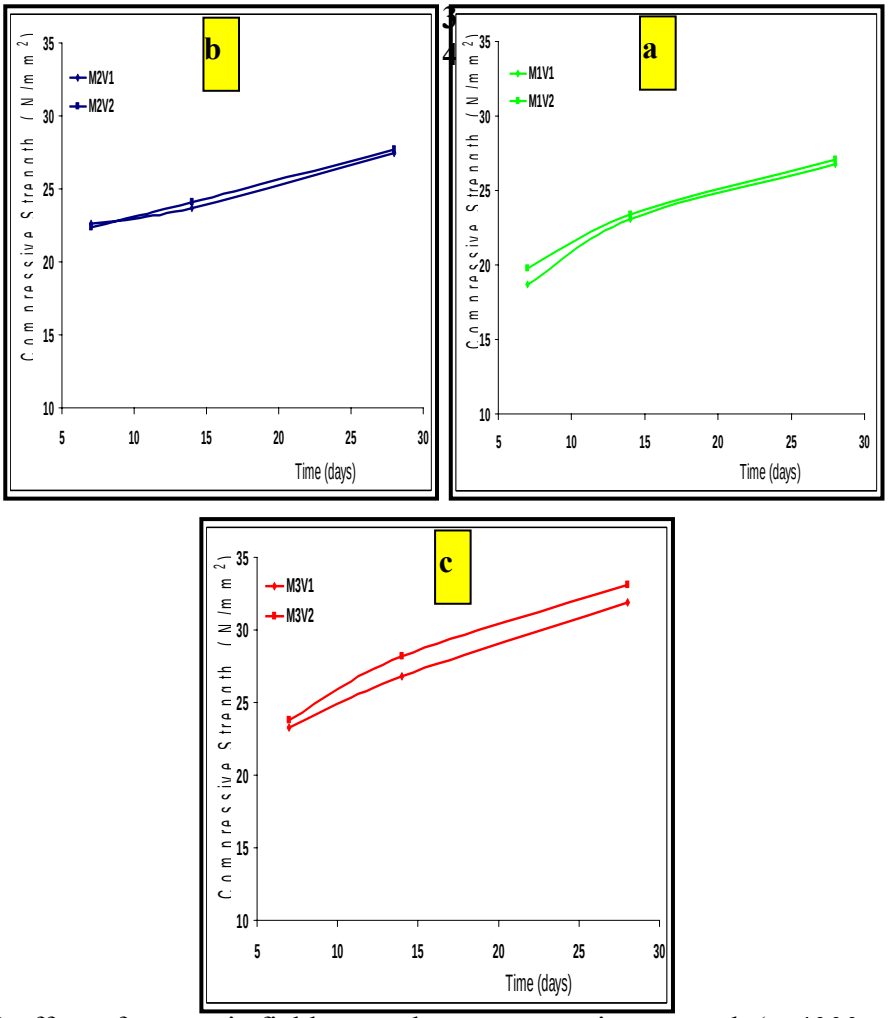

Fig. (8) effect of magnetic field strength on compressive strength (a. 4000gauss, b. 6000gauss, c. 9250gauss)

5-2 Effect of magnetic field strength

5-2-1 On compressive strength

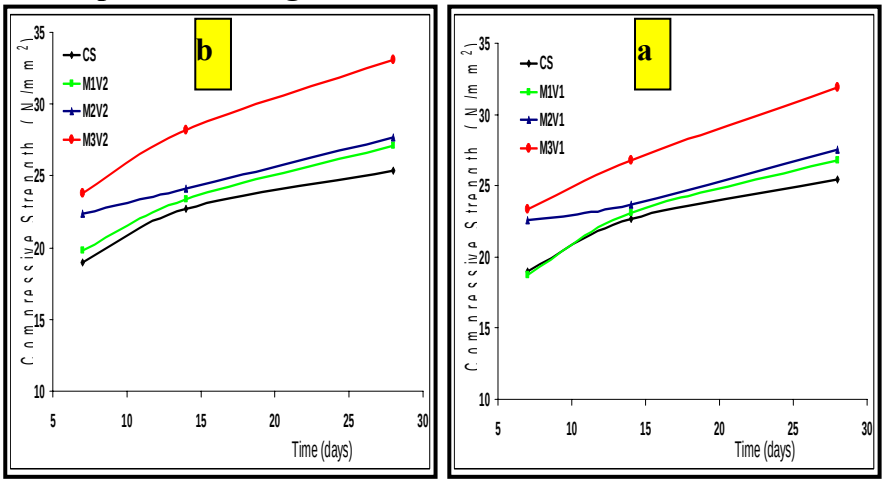

Fig. (9) Effect of flowrate velocity on compressive strength (a. 0.6m/s, b. 0.8m/s)

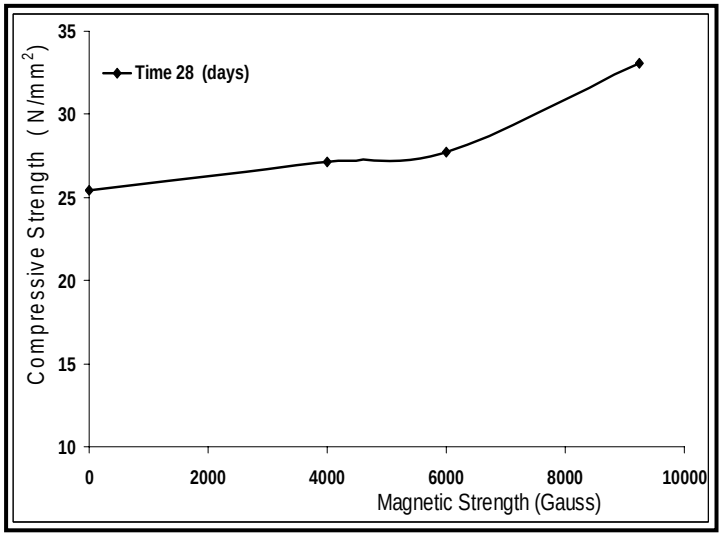

Fig. (10) effect of magnetic field strength on compressive strength in age 28 days

5-2-2 On slump of concrete.

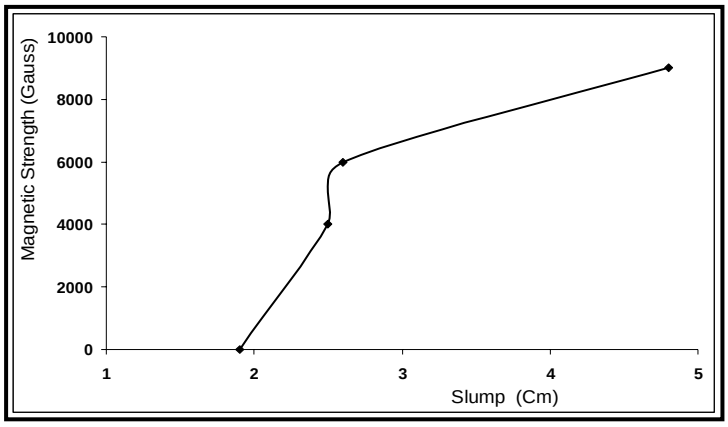

Fig. (11) effect of magnetic field strength on the slump

6- Discussion

The results show that the concrete specimens prepared with magnetic water (M1V1, M1V2, M2V1, M2V2, M3V1, M3V2), has a compressive strength and workability (slump) higher than that of the mix with normal water (CS) specially at the mix (M3V2), although the same mix proportions are used for all mixes and that agree with (S. Niko) [3], whom using magnetized water in concrete mix and get increasing in compressive strength about 24%.

6-1 Effect of flowrate velocity through magnetic field on compressive strength.

Fig. (8) (a,b,c) show that compressive strength proportional with increasing flowrate velocity through magnetic field, the higher increasing had occur at velocity 0.8m/s and field strength 9250gauss.

Fig. (9) (b) show that using water which magnetized in field strength (4000, 6000 & 9250gauss) in concrete mix will achieve increasing in compressive strength about (10-22)% and this agree with (S. M. Ahmed) [5] who was found that the higher increasing had been achieved at velocity about 0.7m/s through magnetic field.

The increasing in compressive strength with increasing the flowrate velocity results from the Lorentz Force which means that an ionized fluid moving in one direction across a perpendicular magnetic field produces an electric current (Faraday Current), proportional to the Lorentz Force. This current creates a dynamic force which acts on the flowing minerals, separating those which are dominantly positive from those which are dominantly negative. Lorentz Force generates the electric potential of the Faraday Current as long as there is a potential capacity to absorb its energy. When the density and length of magnetic field are considered to be constant, the producing potential will be proportional with flowrate velocity which represent the only variable characteristic. Also water flows across perpendicular magnetic field causes magnetic resonance for water molecules proportional within applied field and that will causing break down the large water clusters to small clusters. This property will show clearly in cement hydration process to be form daub layer on the surface of triple calcium silicate (Ca_3Sio_5) which represent one of cement compounds, so the final resulting from this stage will be form wet calcium silicate ($Ca_3Sio_5OH_3$). Because of the hydration reactions will occurs through the osmosis property of water, so the small clusters of magnetized water will be efficient to diffuse and osmosis through the dry cement molecule and that leads to improving the workability of fresh concrete and consequently increasing the compressive strength of concrete rock.

6-2 Effect of magnetic field

6-2-1 on compressive strength

Water is a highly unusual material, and its physical properties are out of line with those of similar structure. The molecular structure is not linear but V- shaped or angular-shaped with an H-O-H angle of slightly less than 105°. It is the unique structure which accounts for water's physical properties.

The figures (9) & (10) shows the increasing in compressive strength with magnetic field and we can interpret that, when ordinary water flows vertically through the magnetic field, the water molecules undergo nuclear magnetic resonance whereby the hydrogen and oxygen nuclear resonate with the magnetic field, causing the magnetic field lines to split off some of the hydrogen bonds in the larger water clusters forming smaller water clusters. These smaller water cluster will increase the rate of diffusion, penetration and its solvent which will enhance the workability of the concrete mix in the fresh state and increase concrete compressive strength in the hardening state.

6.2.2 On slump test

we can interpret the increasing of slump of concrete made with magnetized water as shown in fig (11) that the phenomenon of magnetically activated water, produces a lot of the same polarity as the ingredients of concrete mix, and a lot more of the smaller water clusters. These can cause better dispersion of fine cement particulates. Hence, lumps of cement particulates are broken down and provide maximum surface contact area. This has two effects on fresh concrete:

6.2.2.1 Broken down cement particles provide a "ball bearing" effect on the concrete mix, hence improving the workability and slump better in fresh state measurements (mm) .

6.2.2.2 Broken down cement particles have maximum contact surface area with water for maximum cement hydration process to take place and therefore the concrete compressive strength is higher in the hardened state.

Fig. (11) show the increasing in slump of concrete made with magnetized water and that agree with (Zhiwei, Hou) [22], who was used magnetic field (5000gauss) and he had get increasing in slump about 25% compared with normal water.

7- Conclusions

From the obtained results, it may be concluded that application of magnetic field leads to:

8-1 Reducing water/cement ratio therefore, increasing compressive strength of concrete rock.

8-2 Improving workability by increasing slump of mixture.

8-3 Eliminates the use of any known admixtures and supplementary materials.

8-4 Number of pores is lower and different types of pores are fewer, i.e, ordered porosity.

8-5 Pumpable concrete mix flow with slump at 2.5"-3".

8- References

[1] Craig Andrew McMahon, 2009 “Investigation of the quality of water treated by Magnetic fields” In fulfillment of the requirements of Courses ENG4111 and 4112 Research Project Towards the degree of Bachelor of Engineering (Environmental), University of Southern Queensland, Faculty of Engineering and Surveying, Australia.

[2] H. Afshin, M. Gholizadeh, and N. Khorshidi, 2010 “Improving Mechanical Properties of High Strength Concrete by Magnetic Water Technology” Transaction A: Civil Engineering. Vol. 17, No.1, pp. 74-79.

[3] H. Safaye Nikoo, 2007 “The Study of Velocity and Frequency of Passing Water through a Magnetic Field and its Effect on The Compressive and Tensile Strength of Concrete ” 3rd International Conference on Concrete & Development, CD07-001, pp. 987-998.

[4] An- Tai Ma, 2007 “Effect of Magnetic Water on Engineering Properties of Self-Compacting Concrete with Waste Catalyst” A thesis submitted to Institute of Construction Engineering, National Yunlin University of Science & Technology in Partial Fulfillment of the Requirements for Degree of Master of Design in Construction Engineering, Taiwan, Republic of China.

[5] Saddam, M. Ahmed, 2009 “Effect of Magnetic Water on Engineering Properties of Concrete” Al-Rafidain Engineering, Vol.17, No.1, pp.71-82.

[6] H. Arabshahi, 2010 “The Effect of Magnetic Water on Strength Parameters of Concrete” An International Journal of Chemistry, Vol.1 (1), pp. 30-35.

[7] Nan Su, Wu Y. H. and Mar C. Y., 2003 “Effect of Magnetic Field Treated Water on Mortar and Concrete Containing Fly Ash”, *Cement and Concrete Composites*, Volume 25, Issue 7, pp. 681-688.
[8] Willits, 2009 "Hard Water Magnetic Water Conditioning" CA95490, Catalog, pp. 66, Copyright 2009© Drip works, Everliner
[9] L. A. Huchler, P. E. Mar, 2002 “Non-Chemical Water Treatment System: Histories, Principles and Literature Review” International Water Conference, IWC-02-45, Pittsburgh, PA.
[10] J. E. Starmer, 1996 “Magnetic Treatment of Swimming Pool Water for Enhanced Chemical Oxidation and Disinfecting”, M.Sc., Thesis, Cranfield University, School of Water Sciences, United Kingdom.
[11] K. J. Kronenberg, 1985 “Experimental Evidence for Effects of Magnetic Fields on Moving Water” (IEEE) Conference transactions: IEEE Transactions on Magnetic, Vol. Mag-21, No. 5, pp. 2059-2061.
[12] S. Bishnoi, 2008 “Vector Modeling of Hydrating Cement Microstructure and Kinetics” Thesis No. 4093, M. Eng. in Civil Engineering, University of Tokyo, Japan.
[13] Alex. Rusinoff, 1998 “Composition for Protecting the Body of Concrete, a Process for Preparing and the Method for the Protection of the Body of Concrete” US. Patent, No. 5728428.
[14] A. M. Neville, 1993 “Properties of Concrete” Longman, Third Edition, UK.
[15] M. P. Collins, D. Kuchma, 1999 “How Safe are our Large, Lightly Reinforced Concrete Beams, Slabs, and Footing”. *ACI Materials Journal*, Vol. 96, No.4, pp. 482-490.
[16] A. H., Nilson, 1987 “High-Strength Concrete, an Overview of Cornell Research” Proceedings of Symposium on Utilization of High-Strength concrete, Stavanger, Norway, pp. 27-38.
[17] T. Ohigashi, 1984 “Fracture energy of glass fiber reinforced cement composites: Method of determination” Advanced Cement Based Materials", Volume 14, Issue 3, pp. 349-359.
[18] M. N. Gopalan and M. N. Haque, 1989 “Mix Design for Optimal Strength Development of Fly Ash Concrete” *Cement and Concrete Research,* Volume 19, pp. 634-641.
[19] L. Wang, S. Zhao, 2008 “Laboratory Studies on the Properties of Cement-Based Materials With Magnetic Water” *Indian Concrete Journal*, Vol. 82, No. 9, pp. 17-27.
[20] Su N., Wu Y. H.; Mar C. Y, 2000 “Effect of Magnetic Water on the Engineering Properties of Concrete Containing Granulated Blast-Furnace Slag” Cement and Concrete Research, Vol. 30, No. 4, pp. 599-605.
[21] S. Weilin, L. Yun, H. Hanzhao and L. Quingwang, 1992 “Effects of Magnetic Treatment on Properties of Cement Slurry” *Society of Petroleum Engineers of AIME, (Paper) SPE*
[22] Z. Hou, 1997 “Method and Apparatus for Producing Increased Strength Concrete” European Patent Application, Hong Kong.