

Magnetic Field-Treated Water: A Comprehensive Experimental Analysis of Its Influence on the Properties of M20 Concrete

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Abstract: The pursuit of enhancing the compressive strength of concrete has driven researchers to explore various methodologies, such as incorporating fiber reinforcement and utilizing specific admixtures like super plasticizers to achieve high-strength concrete. However, the associated costs of these methods often outweigh their benefits, prompting a shift toward the development of economical yet high-strength concrete through innovative design philosophies and modern techniques. One such technique gaining attention is the use of magnetic water (MW) in concrete production. This technology involves passing water through a magnetic field, inducing changes in its physical properties. Notably, the reduction in water cluster molecules from 13 to 5 or 6, accompanied by a decrease in bond angle within the water molecular structure, results in an increased surface area of water in a unit volume. This phenomenon enhances the hydration of cement, consequently improving the compressive strength, flexural strength, and splitting tensile strengths of concrete. Furthermore, the utilization of magnetized water in concrete mixtures exhibits the potential to reduce the required cement content for achieving specified compressive strength values. This paper presents an experimental investigation into the effects of magnetized water on concrete properties, shedding light on its potential as a cost-effective and efficient strategy for enhancing concrete strength.

Introduction

Concrete is the most widely used man-made building material on the planet. Concrete structures have been built since the discovery of Ordinary Portland cement (OPC) in the midst of the nineteenth century. The reaction of OPC with water results in hydration products, which glue the reacting cement particles together to form a hardened cement paste. When cement and water are mixed with sand, the resulting product is called mortar. If the mixture also contains coarse aggregate, the resulting product is called concrete. Right from the invention of the concrete, the concrete has undergone many changes to suite the requirements in the construction sites. Many additives and admixtures are being added to change the physical form of concrete and also concrete without cement, aggregates is under use. One essential thing for the word concrete to gain strength is hydration or some other reactions by usage of water for mixing the ingredients, so water is very essential for the hydration process to take place in the concrete made with OPC.

The most important challenge for concrete technologists is to improve the properties of concrete. To improve the workability of concrete at less water content are the aims which most researchers are looking for using various methods. If Magnetic water is used the workability can be improved and more strength can be achieved with less water content and further reduction in cost. The magnetic water treatment machine contains a powerful magnet which is the source of production of magnetic energy. This powerful magnet is fixed in a small tube with such high technology that can create a magnetic field reaching a high rate of about 3000 Gauss.

Magnetically treated water (MTW) is water which has been passed through a magnetic field prior to use. Water plays an important role in the production of cement concrete as it governs hydration of cement, workability, microstructure, strength and over all durability of concrete. Hydration of cement is exothermic reaction, therefore proper curing is required to achieve durability and strength. Durability of concrete is one of the most important properties of sustainable concrete. Curing plays a major role in developing micro structure and pore structure of concrete, which ultimately governs its important properties

Objectives

1. To study the literature on behavior of magnetized water concrete.
2. To study the behavior of various ingredient of concrete.
3. To study the physical properties of magnetic Water.
4. To prepare concrete of M20 grade.
5. To study behavior of fresh and hardened concrete.
6. To investigate comparative study of magnetized water concrete and normal water concrete with respect to strength.
7. To examine the effect of MW on the compressive strength, split tensile strength and flexural strength of M20 grade concrete.

Magnetized Water (MW) and Its Applications

Magnetized water doesn't mean that the magnetic strength is acquired by water but when water is subjected /exposed to a magnetic field it exhibits changes in its certain properties. Since water has certain unique anomalous properties this may result in many variations of macroscopic properties. Water is often perceived to be ordinary fluid yet this is the most studied material on the earth. Generally water is transparent and treated to be homogenous consisting of just two hydrogen atoms bonded to a single oxygen atom. But at nano level water is not homogeneous, water exists in clusters of molecules and this cluster size depends on the temperature, pressure and forces existing around the water. These clusters of molecules are held by hydrogen bond and vanderwaal's forces. When water is exposed to the magnetic or electric fields these clusters break down changing certain properties of water.

These variations changes the structure of water and this structured water has many benefits and used in different applications as listed below:

1. Magnetic treatment of saline irrigation water is used as an effective method for soil desalinization
2. The magnetic water is used to increase crop yield, this induced growth in is attributed to an increase in photosynthetic pigments, where the magnetic water increases the cell metabolism and mitosis.
3. The application of a magnetic water on seeds increases the germination and a percentage increase in the germinated seeds.
4. Dairy cows that drink magnetized water have shown an increase in milk production with the same quantity and quality of milk fat as present in cows drinking ordinary water.
5. On consuming magnetic water poultry have showed an increase in egg production due to increase of improved digestion and nitrogen retention in them.
6. As this Magnetized structured water carries more oxygen and other essential minerals in to the human blood/organs alter rates of cellular, enzymatic or organic processes, thus magnetic water is used to cure/treat ill effects or diseases in human body.

Magnetic Water

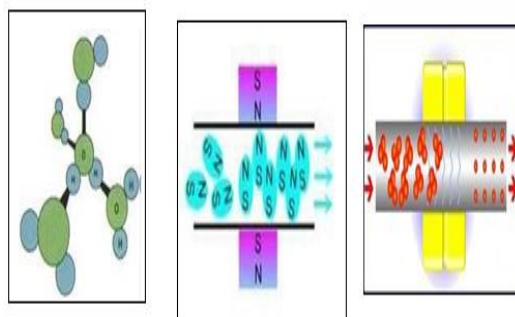
This topic presents the basic concepts of Magnets and Magnetism, basic structure of water molecule, effects of magnetic field on water structure and Magnetic water concrete.

Magnet and Magnetism

Motion of a charged particle produces the magnetic fields like electrons flowing in a wire producing the magnetic field surrounding the wire. The magnetic fields generated by moving electrons are used in many engineering applications like automobiles and machines. Magnets are of two types hard and soft, materials which are magnetic with no applied magnetic field are known as hard magnets and they have an important remnant magnetization in a zero applied magnetic field. Magnetite is an example for such magnet. The second type of magnet is not permanent magnet but is attracted to hard magnets but lose their magnetization rapidly when the magnetic field is removed. Metallic iron is an example for a soft magnet. Generally the strength of a magnet measured as its magnetic flux density in units of Gauss. The earth's magnetic field is on the order of 0.5 Gauss.

Molecular Structure of Magnetic Water

A substance is said to be magnetized when its constituent atoms or basic structural components can be arranged in a definite course by the impact of an external magnetic field. Structural groups of water. In fluids, this alignment can only happen to molecules that possess an odd number of electrons. Water (H_2O), contains 10 electrons so it is not attracted to or oriented by a magnetic field. Indeed, water like most atoms is diamagnetic; it is really repulsed by a magnetic field. Shows water molecules which comprises of one oxygen atom and two hydrogen atoms bonded as an isolated triangle with bond angle of 104.5° . Generally, when water is subjected to a magnetic field, the water molecules will arrange in one direction. This mode of arrangement is caused by relaxation bonds and then the bond angle decreases to less than 104.5° , leading to a decrease in the consolidation degree between water molecules. In other words, larger water clusters are cut and broken by external magnetic field to form smaller water clusters or even double water molecules (H_2O) two or single water molecule (H_2O). The bond angle decreases from 104.5° to 103° because magnetic field deflects the bond pairs and squeezes the bond pairs to be closer together.



Compressive strength of concrete with and without MW in N/mm^2 at 28days

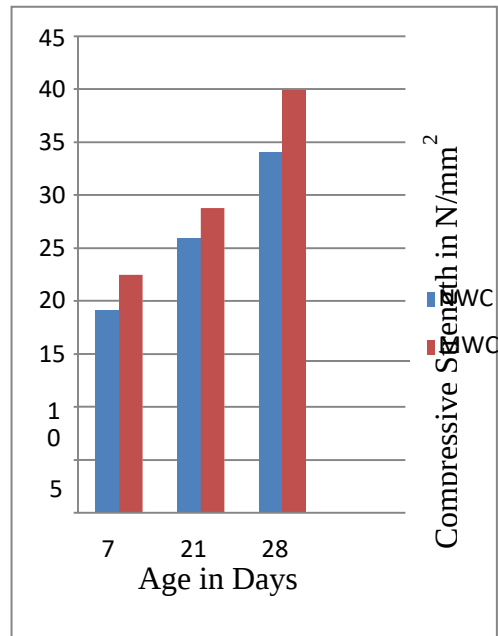
Figure Mechanism of magnetic water, Water Cluster Orientation, Breakage of Cluster

Results and Discussion

Table 1 Compressive strength of NWC and MWC in N/mm^2 (M20)

Sr. No.	Age	NWC	Avg of NWC	MWC (N+S)	Avg of MWC
1	7 days	17.77	19.10	23.11	22.44
		20.66		22.22	
		18.88		22	
2	21 days	25.34	25.84	28.32	28.74
		27.66		27.85	
		24.54		30.05	

3	28 days	35.55	34.07	39.25	39.87
		34.66		41.52	
		32.00		38.85	



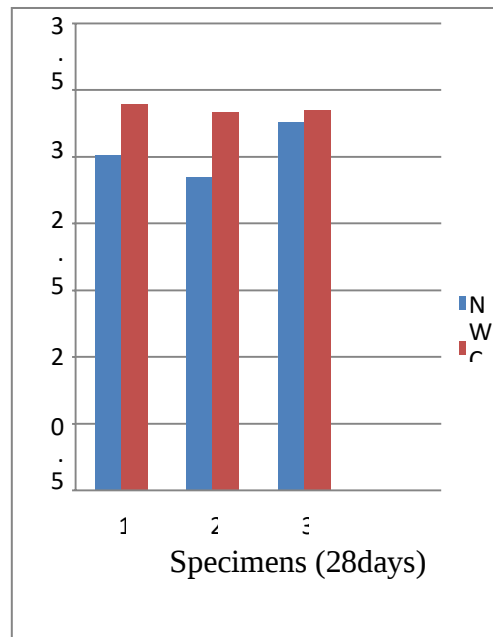
Testing of cubes

Table 2 Splitting Tensile Strength of NWC and MWC in N/mm^2 (M20)

Sr. No.	Age	NWC	Avg. of NWC	MWC (N+S)	Avg. of MWC
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1	28	2.51	2.54	2.89	2.86
2	28	2.35		2.83	
3	28	2.76		2.85	

Compressive Strength in N/mm²



Split tensile strength of concrete with and without MW in N/mm² at 28days

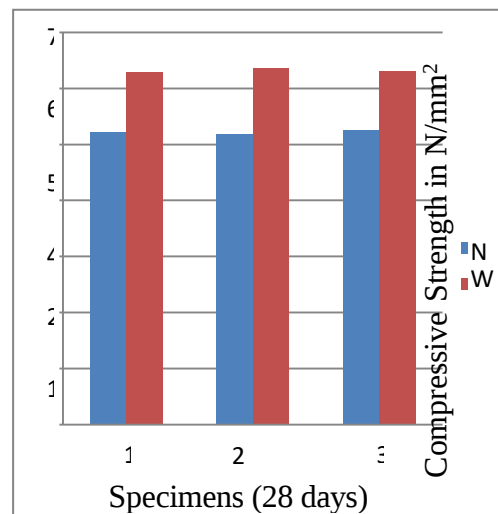


Testing of cylinders

Table 3 Flexural Strength of NWC and MWC in N/mm² (M20)

Sr. No.	Age (Days)	NWC	Avg. of NWC	MWC (N+S)	Avg. of MWC
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1	28	5.21	5.21	6.29	6.32
2	28	5.18		6.35	
3	28	5.24		6.31	



Flexural strength of concrete with and without MW in N/mm^2 at 28 days



Testing of beams

Carbonation Test



Figure PH of concrete

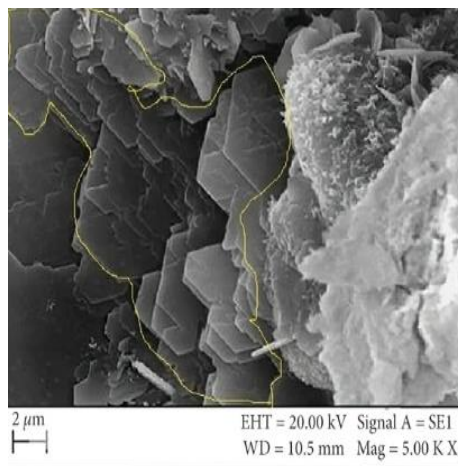
Carbonation test of concrete with and without MW in PH

Sr.No	Type of Concrete	PH	Remark
1	NWC	09	<9 Carbonated Zone
2	MWC	10	

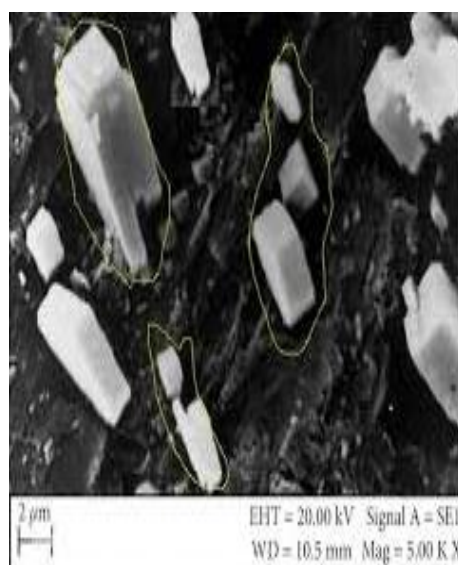
Scanning Electron microscope Images

Morphology of mono sulphate, hydrate, C–S–H gel, and ettringite in the cement mantel of magnetized water incorporated concrete found analogous to those mixed with normal water. In contrast, calcium hydrate crystals containing unique hexagonal plates have been seen in pastes made using normal water. Molecules present in normal water tend to conglomerate the particles and form clusters. Production of larger C. H. plates may be due to the reaction of cement with the formed clusters.

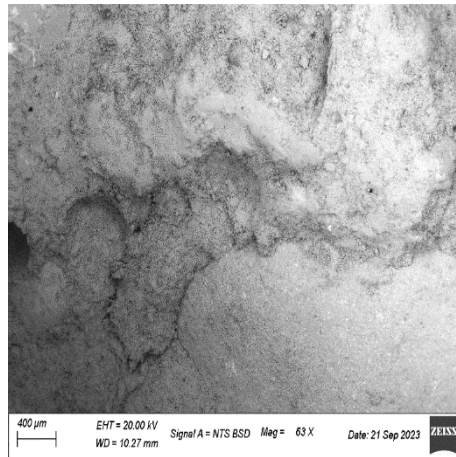
Figure displays a micrograph of C. H. crystals created in concrete using normal water, whereas Figure shows a micrograph of C. H. crystals prepared in magnetic water. This occurs as a result of smaller water molecules in magnetic water reacting with cement. This might explain why the mechanical characteristics of concrete mixed with magnetic water are better than those of concrete mixed with normal water.



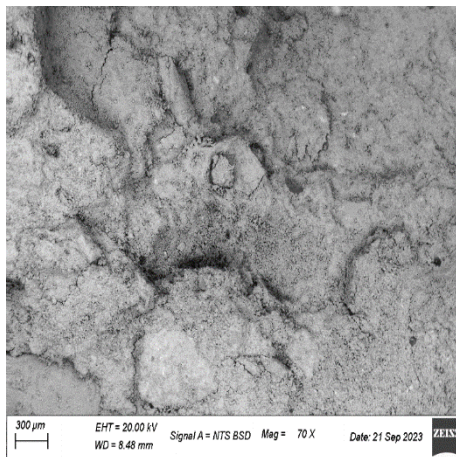
Scanning Electron micrograph Images of Normal water concrete, Ca(OH)_2 crystals.



Scanning Electron micrograph Images of Magnetic water concrete Ca(OH)_2 crystals.



Scanning Electron micrograph Images Magnetic water concrete



Scanning Electron micrograph Images Magnetic water concrete

Conclusion

From the experimental results reported in this project, the following conclusions are drawn:

By passing water through a magnetic field, some of its properties like,

- PH of MW is changed slightly basic to slightly acidic.
- It was observed that of MW alkalinity is increased 16.36%.
- Hardness was reduced by 6.02%.
- Similarly reduced turbidity of MW by 4.76%.

As a result of such physical changes, the number of molecules in the water cluster decrease from 13 to 5 or 6, which causes a decrease in the bond angle in water molecular structure and increases the surface area of water in unit volume and which enhances the hydration of cement.

Using magnetised water in concrete mixtures causes an improvement in the compressive strength, Splitting Tensile Strength and Flexural Strength of concrete.

- It was observed that with the addition of MW the compressive strength of concrete is increased by 17.5% at 7 days, 11.22% at 21 days and 17.02% at 28 days.
- The split tensile strength increase is about 12.60% in MWC at 28 days.
- Similarly the flexural strength increase is about 21.31% at 28 days.

- Carbonation not occurred on MWC having PH 10 at 28 days.

Limitations of study

- This technology is still at evolving stage, more and more research data are required to convince the professionals about the benefits of using magnetized water in concrete production.
- Magnetized water can't hold its properties for a longer period after the removal of magnetic field i.e. about 12 hours; therefore use of stored magnetized water is difficult at this stage

References

- [1] T. Alkhrissat, "Investigation of the effect of magnetic water and polyethylene fiber insertion in concrete mix", Journal of Composite Science, (2023).
- [2] S.Bedke,O.S.Bhondve,S.S.Bhondve,A.P.Bodke,R.Vaidya, "Magnetic water in construction", International Research Journal of Engineering and Technology, vol.09, (2022).
- [3] R.Dharmaraj, G.K.ArunvivekA.Karthick,V.Mohanavel,B.Perumal,S.Rajkuma, "Investigation of mechanical and durability properties of concrete mixed with water exposed to a magnetic field", Advances in Civil Engineering, (2021).
- [4] A.Mugale,S.Kate,P Kumbhar, K.Mete, "Effect of Admixtures on Water Uses in a Concrete: A Review" International Journal of Innovative Research in Science, Engineering and Technology, vol.09, (2020).
- [5] S.Venkatesh,V.R.Prasath kumar, P.Jagannathan, "An experimental study on the effect of magnetized water on mechanical properties of concrete", International Conference on Advances in Mechanical Engineering, (2020).
- [6] V.B.Doddagoudara,K.B.Poornima,C.Bellad,P.Sunagar,B.Shivakumara, "Effect of different types of water on compressive strength of concrete", International Research Journal of Engineering and Technology, vol.6, (2019).
- [7] S.Ashtekar, G.C.Jawlkar, "Effect of magnetic water on workability of concrete" International Journal of Management, Technology and Engineering, vol.8, 2018.
- [8] R.Sumathi, K.Sindhuja, "Influence of Magnetized Water on Strength Parameters of Concrete", International Journal of Innovative Research in Technology, vol.4, (2018).
- [9] Y.Wang,H.Wei,Z.Li, "Effect of magnetic field on the physical properties of water", Results in Physics, vol.8, (2017).
- [10] S.D.Bafna,N.J.Pathak, "Experimental investigation to enhance compressive strength of concrete blended with plastic waste using magnetized water", International Research Journal of Engineering and Technology, vol.4, (2017).
- [11] A. Jain, A. Laad, "Effect of magnetic water on properties of concrete", International Journal of Engineering Science and Computing, (2017).
- [12] R. Malathy, N Karuppaswamy, S.Baranidharan, "Effect of magnetic water on mixing and curing of M25 gradeconcrete", International Journal of Chemtech Research, vol.11, (2017), PP 131-139.
- [13] S.Pednekar, N.J.Pathak, "Experimental investigation of properties of concrete cast in magnetized water", International Journal of Science Technology and Engineering, vol.3, (2017).
- [14] P.Parthiban,M.Rajalingam,"Comparative study on strength enhancement of concrete using magnetic and normal water", International Journal of New Technology andResearch, vol.2, (2016), PP 65-68.
- [15] T.Manjupriya,R.Malathy,"Experimental investigation on strength and shrinkage properties of concrete mixed with magnetically treated water", International Journal of Engineering and Advanced Research Technology, vol.2, (2016).

- [16] P.Ubale, R. D.Pandit, A.P.Wadekar, “Performance evaluation of magnetic field treated water on convectional concrete containing fly ash”, International Journal Of Science Technology And Management, vol.5, (2016).
- [17] V.S.S. Kaushik, V.R.N.V.D.Pavan, A.D.Prasad, “Influence of magnetized water on strength parameters of concrete”, International Journal for Research and Development in Technology, vol.3, (2015), PP 26-29.
- [18] T.R.Nikhil,S.M.Gopinath,R.Sushma,B.C.Santhappa, “Impact of water quality on strength properties of concrete”, Indian Journal of Applied Research, vol.04, (2014).
- [19] B.S.Reddy,V.Ghorpade,H.S.Rao, “Influence of magnetic water on strength properties of concrete” Indian Journal of Science And Technology, vol.7 (1), (2014), PP 14-18.
- [20] G.N.Kumar,J.Shamil, “Experimental studies on durability of magnetic water concrete”, International Journal of Science and Research, vol.5, (2013).
- [21] F.M.Wegian, “Effect of seawater for mixing and curing on structural concrete” The IES Journal Part A: Civil and Structural Engineering, vol. 3, (2010), PP 234-243.
- [22] S.M.Ahmed “Effect of magnetic water on engineering properties of concrete”, Al-Refidain Engineering, vol.17, (2009).