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BEHAVIOUR OF DIFFERENT GRADES OF FRESH & HARDENED MAGNETIC WATER CONCRETE CAST WITH WATER SUBJECTED VARYING MAGNETIC FIELD STRENGTHS FOR DIFFERENT EXPOSURE TIMES

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Abstract— This paper presents the effect of magnetic structured water on the properties of different grades of concrete cast with magnetic water of varying magnetic field strengths (0.2 T, 0.4 T, 0.6 T) exposed to 12 hours, 24 hours of magnetic field. Workability, Compressive Strength, Split Tensile Strength of cubes and cylinders cast with magnetic structured water and cured in magnetic water are determined and the test results are compared with the results of normal water concrete. It was found that the workability and strengths of Magnetic Water Concrete (MWC) are more when compared to those of Normal Water Concrete (NWC). The compressive strengths of M25 and M30 grades of Magnetic Water Concrete cast and cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour are found to be 50.89 MPa and 54.77 MPa respectively. They are 4.32% & 3.05% respectively greater than those for cubes of Magnetic Water Concrete cast, cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 12 hour; and they are 10.31% & 5.024% respectively greater than those for cubes of Magnetic Water Concrete cast with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour, cured in normal water; and they are 77.81% & 61.68% respectively greater than those for cubes of Normal Water Concrete cast and cured with normal water. The split tensile strengths of M25 and M30 grades of Magnetic Water Concrete cast and cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hours are found to 8.56 MPa and 8.705 MPa respectively. They are 11.31% & 5.64% respectively greater than those for cylinders of Magnetic Water Concrete cast, cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 12 hour; and they are 6.6% & 4.38% respectively greater than those for cylinders of Magnetic Water Concrete cast with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour, cured in normal water; and they are 52.18% & 34.34% respectively greater than those for cylinders of Normal Water Concrete cast and cured with normal water.

Keywords— Magnetic Structured Water, Magnetic Water Concrete (MWC), Normal Water Concrete (NWC), magnetic field strength, magnetic exposure time, magnetic water curing.

I. INTRODUCTION

A. Magnetic Water Concrete

After passing through a magnetic field of certain strength, water is called magnetic structured water . From previous research works, it is extracted that water molecules are a polar substance, which tends to be attracted to each other by hydrogen bonding and forms clusters. The breakdown of water molecules clusters into small clusters by using magnetic treatment of water, allows easily penetration into cementitious grains which leads to effective hydration. Each cluster contains about 100 water molecules at room temperature. In a magnetic field, magnetic force can break apart water clusters into a single molecules or smaller clusters. The structure of water is aligned in one direction after magnetization, and the molecule sizes change after the bond angle changes, so the viscosity and surface area increases by magnetization, therefore the hydration rate increases, hence improving the activity of water [2, 3, 4, 5, 7, 8]

Using MW in concrete mixtures causes an improvement in workability, and the compressive and splitting tensile strengths of concrete [6, 7]. This processed water if used for mixing as well as curing has more encouraging results [1, 5]. The results of tests showed that magnetic water concrete (MWC), has higher slump values than normal water concrete (NWC). The strengths of the MWC were higher than that of the NWC [2, 8]. Also, the compressive strength of the MWC cured with magnetic structured water was higher than that of the NWC samples and higher than that of the MWC samples cured normally [8].

B. Background of the work

Magnetic water treatment machine was first invented in 1945 at Belgium. Till 1980, this technique was used for the stimulation of plant growth, domestic usage in order to reduce the scale formation in pipes. Later this technology was used in concrete industry during the year of 2000 at Taiwan. Using magnetic structured water has promising potentials in saving water amount used in concrete construction. Magnetic structured water proves to be able to increase the workability and strength of concrete, while maintaining the same water demand.

An experimental program was undertaken which consists of determining the effect of varying magnetic field strengths on the properties of different grades of fresh and hardened MWC.

C. Aims & Objectives

Following are the main aims & objectives of this work:

1) To study the effect of magnetization on water by examining its properties (pH & Hardness).
2) To find the effect of magnetic structured water on workability (Slump) of concrete.
3) To study the effect of using magnetic structured water by determining the compressive strength and split tensile strength for various grades (M25, M30) of concrete cast with magnetic structured water of varying magnetic field strengths (0.2 T, 0.4 T, 0.6 T) exposed to 12 hours, 24 hours of magnetic field.
4) To study the effect of using magnetic structured water by determining the 28 day compressive strength and 28 day split tensile strength for various grades (M25, M30) of concrete cast and cured with magnetic structured water of varying magnetic field strengths (0.2 T, 0.4 T, 0.6 T) exposed to 12 hours, 24 hours of magnetic field.

A comparative study is made between the different grades of MWC. The effect of using magnetic water to cure MWC is observed. Also, the variation of MWC strengths with the variation of magnetic field strengths and magnetic exposure time is recorded.

II. **EXPERIMENTAL WORK**

A. Overview

The present investigation focuses on the investigation of using magnetic structured water for casting and curing concrete of different grades, i.e. M25 & M30. Test variables include the magnetic field strength and magnetic time exposure. Magnets of intensities 0.2 T, 0.4 T, 0.6 T are used & magnetic exposure is done for 12 hours and 24 hours. Slump test is conducted on fresh MWC. The magnetic water concrete is cured using normal water and magnetic structured water & Compressive strength test, Split tensile strength test are conducted on hardened MWC.

B. Materials

1) *Ordinary Portland Cement:* Ordinary Portland Cement 53 grade was used. The procured cement was tested and the properties were found. The standard consistency and specific gravity of cement was found to be 32% and 3.01 respectively. The initial and final setting times were 65 minutes and 490 minutes respectively.
2) *Fine Aggregate:* The fine aggregate (sand) conforming to Zone-2 was used, which was obtained from a nearby river source and tested conforming to the requirements of IS: 383. The specific gravity, fineness modulus were found to be 2.54 and 2.58 respectively.
3) *Coarse aggregate:* The coarse aggregates were obtained from a local source and maximum size of aggregates used was 20mm. The procured coarse aggregates were tested conforming to IS: 383 and the specific gravity, fineness modulus was found to be 2.78 and 6.9 respectively.

4) *Water:* Portable water is used, which is free from chemical substances and suspended particles. This water is then magnetized using magnets of intensities 0.2 T, 0.4 T, 0.6 T. This magnetic structured water is then used for casting and also for curing the concrete.

C. Preparation of magnetic structured water

The water is magnetic structured by placing beakers of water over N+S pole Neodymium magnets for 12 hrs and 24 hrs. Three different magnets of intensities 0.2 T, 0.4 T, 0.6 T are used for magnetizing water, as shown in figure 2.

(a) *(b)* *(c)*

Fig. 1 Neodymium Magnets of varying intensities: (a) 0.2 Tesla (b) 0.4 Tesla (c) 0.6 Tesla

Fig. 2 Beaker placed over the magnets for magnetizing the water

During this process, the magnetic field passes through the water and thus, the water gets magnetized; as shown in figure 3.The magnetic structured water was tested for pH and hardness and the test results were compared with normal water.

TABLE I

PROPERTIES OF MAGNETIC STRUCTURED WATER COMPARED WITH NORMAL WATER

S. No.	**Property**	**Normal Water**	**Magnetic structured water – 12 hr exposure**			**Magnetic structured water – 24 hr exposure**		
			0.2 T	**0.4 T**	**0.6 T**	**0.2 T**	**0.4 T**	**0.6 T**
1	pH	7.3	7.4	7.4	7.5	7.5	7.6	7.6
2	Total Hardness (ppm)	573	420	381	331	396	362	324

D. Mix Proportions

For M25 & M30, the mix proportions used are 1:1.49:2.9 & 1:1.196:2.327 respectively. The water-cement ratios for M25 & M30 are taken as 0.45 & 0.40 respectively.

E. Test variables

The test variables include the magnetic field strength and magnetic exposure time. Magnetic field strength is varied as 0.2 T, 0.4 T and 0.6 T. The magnetic exposure time is 12 hours and 24 hours.

F. Experimental scheme

The experimental program was designed to study

1) Workability (slump) of fresh MWC of M25 & M30 grades.
2) Compressive strengths, split tensile strengths of M25 & M30 grades of MWC cast with magnetic structured water of varying magnetic intensities (0.2 T, 0.4 T, 0.6 T) exposed to 12 hours, 24 hours of magnetic field and cured with normal water for 28 days.
3) Compressive strengths, split tensile strengths of M25 & M30 grades of MWC cast with magnetic structured water of varying magnetic intensities (0.2 T, 0.4 T, 0.6 T) exposed to 12 hours, 24 hours of magnetic field and cured with magnetic structured water for 28 days.

G. Testing

Slump Test (as per IS: 1199-1959) is used to measuring the workability of concrete. Standard slump cone dimensions are 30 cm height, 10 cm diameter at top, 20 cm diameter at bottom. Compression Test on concrete specimens (as per IS:516-1959) is used to determine its compressive strength, using CTM / UTM. Standard cubes of size 150mm are prepared. Tension Test on concrete specimens (as per IS:516-1959) is used to determine its split tensile strength, using CTM / UTM. Standard cylinders of diameter 150 mm, 300mm height are prepared.

All the test results are noted down in a tabular format and the results are discussed by plotting the graphs. The conclusions are thus, drawn.

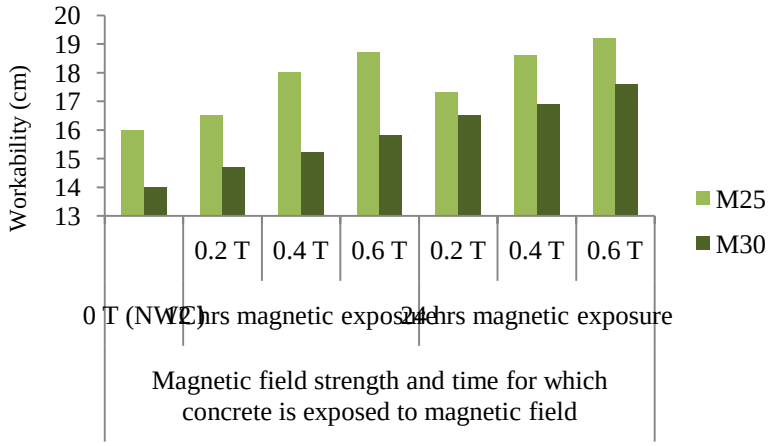
III. **RESULTS & GRAPHS**

A. Test results for fresh NWC & MWC

TABLE II

RESULTS FOR WORKABILITY TEST- SLUMP VALUES (CENTIMETER)

Grade of Concrete	**Fresh NWC**	**Fresh MWC – 12 hr exposure**			**Hardened MWC – 24 hr exposure**		
		0.2 T	**0.4 T**	**0.6 T**	**0.2 T**	**0.4 T**	**0.6 T**
M25	16	16.5	18	18.7	17.3	18.6	19.2
M30	14	14.7	15.2	15.8	16.5	16.9	17.6



B. Test results for hardened NWC & MWC

1) Conventional Concrete (NWC)

TABLE III

RESULTS FOR COMPRESSIVE STRENGTH & SPLIT TENSILE STRENGTH OF NWC CAST AND CURED WITH NORMAL WATER

Grade of Concrete	Average Compressive Strength (MPa)	Average Split Tensile Strength (MPa)
M25	28.62	5.625
M30	33.875	6.48

2) MWC- Use of magnetic structured water for casting concrete and normal water for curing

TABLE IV

RESULTS FOR COMPRESSIVE STRENGTH OF MWC CURED WITH NORMAL WATER

Grade of concrete	Magnetic field strength and time for which concrete is exposed to magnetic field					
	12 hrs magnetic exposure			24 hrs magnetic exposure		
	0.2 T	0.4 T	0.6 T	0.2 T	0.4 T	0.6 T
M25	37.09	41.095	44.27	38.865	42.59	46.135
M30	41.04	46.815	50.125	42.78	48.85	52.15

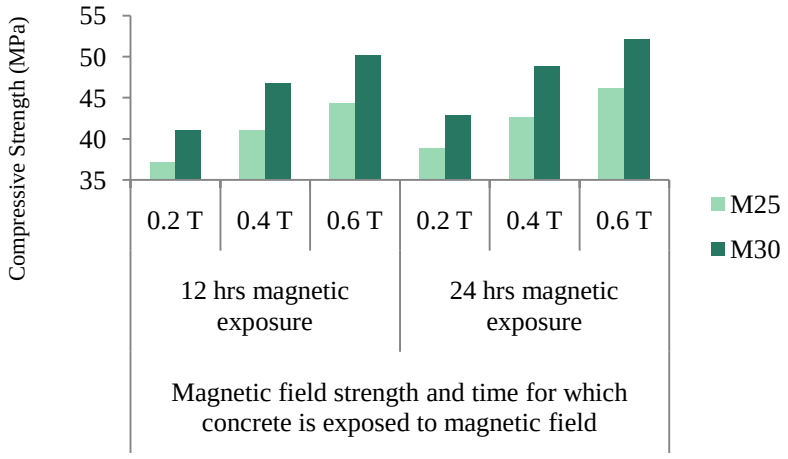
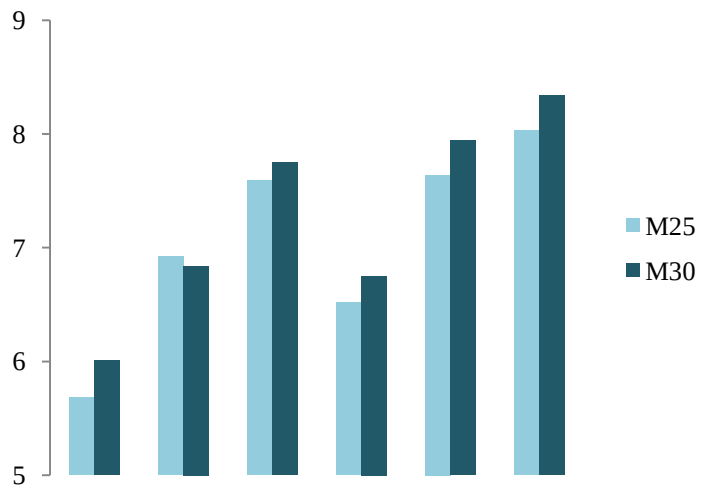


TABLE V

RESULTS FOR SPLIT TENSILE STRENGTH OF MWC CURED WITH NORMAL WATERError! Not a valid link.



3) MWC- Use of magnetic structured water for casting and curing concrete

TABLE VI

RESULTS FOR COMPRESSIVE STRENGTH OF MWC CURED WITH MAGNETIC STRUCTURED WATER

Grade of concrete	**Magnetic field strength and time for which concrete is exposed to magnetic field**					
	12 hrs magnetic exposure			**24 hrs magnetic exposure**		
	0.2 T	**0.4 T**	**0.6 T**	**0.2 T**	**0.4 T**	**0.6 T**
M25	38.44	45.125	48.78	40.49	45.26	50.89
M30	43.01	51.71	53.15	45.71	51.44	54.77

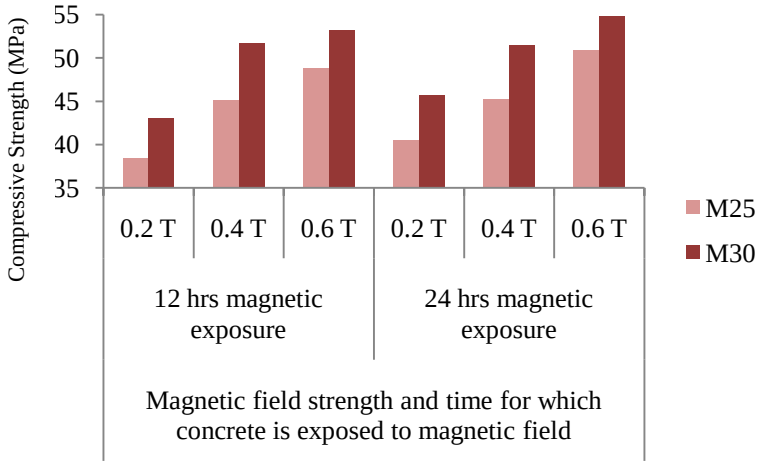
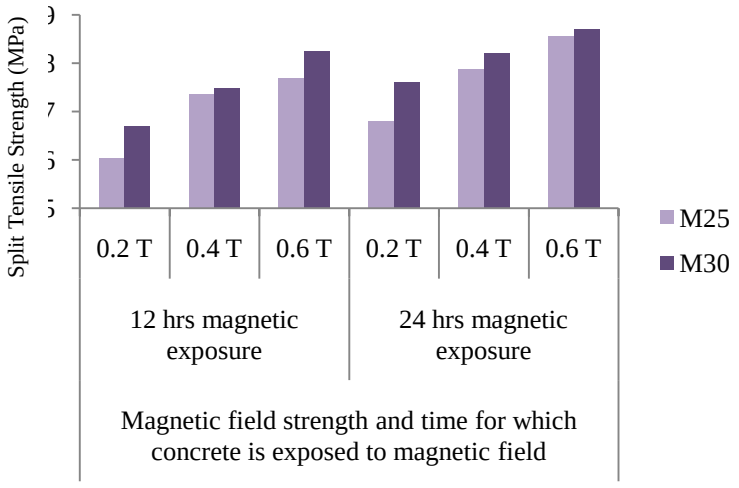


TABLE VII

RESULTS FOR SPLIT TENSILE STRENGTH OF MWC CURED WITH MAGNETIC STRUCTURED WATER

Grade of concrete	**Magnetic field strength and time for which concrete is exposed to magnetic field**					
	12 hrs magnetic exposure			**24 hrs magnetic exposure**		
	0.2 T	**0.4 T**	**0.6 T**	**0.2 T**	**0.4 T**	**0.6 T**
M25	6.04	7.36	7.69	6.8	7.88	8.56
M30	6.69	7.48	8.24	7.61	8.21	8.705



IV. DISCUSSIONS ON TEST RESULTS

- The workability of M25 & M30 grades of concrete prepared with magnetic structured water of intensity 0.6 T exposed to 12 hours of magnetic field were found to be 18.7 cm and 15.8 cm respectively.
- The workability of M25 & M30 grades of concrete prepared with magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field were found to be 19.2 cm and 17.6 cm respectively.
- The average compressive strengths of M25 & M30 Normal Water Concrete were found to be 28.62 MPa and 33.875 MPa respectively.
- The average split tensile strengths of M25 & M30 Normal Water Concrete were found to be 5.625 MPa and 6.48 MPa respectively.
- The optimum compressive strengths of M25 & M30 grades of concrete cast with magnetic structured water of intensity 0.6 T exposed to 12 hours of magnetic field, cured with normal water were found to be 44.27 MPa and 50.125 MPa respectively.
- The optimum compressive strengths of M25 & M30 grades of concrete prepared with magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field, cured with normal water were found to be 46.135 MPa and 52.15 MPa respectively.
- The optimum split tensile strengths of M25 & M30 grades of concrete cast with magnetic structured water of intensity 0.6 T exposed to 12 hours of magnetic field, cured with normal water were found to be 7.59 MPa and 7.75 MPa respectively.
- The optimum split tensile strengths of M25 & M30 grades of concrete cast with magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field, cured with normal water were found to be 8.03 MPa and 8.34 MPa respectively.
- The optimum compressive strengths of M25 & M30 grades of concrete cast and cured with magnetic structured water of intensity 0.6 T exposed to 12 hours of magnetic field were found to be 48.78 MPa and 53.15 MPa respectively.
- The optimum compressive strengths of M25 & M30 grades of concrete cast and cured with magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field were found to be 50.89 MPa and 54.77 MPa respectively.
- The optimum split tensile strengths of M25 & M30 grades of concrete cast and cured with magnetic structured water of intensity 0.6 T exposed to 12 hours of magnetic field were found to be 7.69 MPa and 8.24 MPa respectively.
- The optimum split tensile strengths of M25 & M30 grades of concrete cast and cured with magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field were found to be 8.56 MPa and 8.705 MPa respectively.

V. CONCLUSIONS

The Following are the conclusions by conducting the investigation on the use of magnetic structured water in concrete:

- The pH value remains nearly the same irrespective of magnetizing the water and increasing magnetic field strength or magnetic exposure time. However, by the effecting of magnetizing, the hardness of water is decreased significantly. Further, by increasing the magnetic field strength and magnetic exposure time, the water becomes softer.
- The workability of MWC is greater than NWC. Further, the workability is increased by increasing the magnetic field strength of water and by increasing the magnetic exposure time.
- The highest workability for M25 & M30 grades of MWC (slump values = 19.2 cm, 17.6 cm respectively) are obtained by using magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field.
- The compressive strengths of M25 and M30 Magnetic Water Concrete cast and cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hours are found to be 50.89 MPa and 54.77 MPa respectively. They are 4.32% and 3.05% respectively greater than those for cubes of Magnetic Water Concrete cast, cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 12 hour (48.78 MPa and 53.15 MPa respectively) ; and they are 10.31% and 5.024% respectively greater than those for cubes of Magnetic Water Concrete cast with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour, cured in normal water (46.135 MPa and 52.15 MPa respectively); and they are 77.81% and 61.68% respectively greater than those for cubes of Normal Water Concrete cast and cured with normal water(28.62 MPa and 33.875 MPa respectively).

- The split tensile strengths of M25 and M30 grades of Magnetic Water Concrete cast and cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour are found to be 8.56 MPa and 8.705 MPa respectively. They are 11.31% and 5.64% respectively greater than those for cylinders of Magnetic Water Concrete cast, cured with magnetic structured water of intensity 0.6T with magnetic exposure time of 12 hour (7.69 MPa and 8.24 MPa respectively); and they are 6.6% and 4.38% respectively greater than those for cylinders of Magnetic Water Concrete cast with magnetic structured water of intensity 0.6T with magnetic exposure time of 24 hour, cured in normal water (8.03 MPa and 8.34 MPa respectively); and they are 52.18% and 34.34% respectively greater than those for cylinders of Normal Water Concrete cast and cured with normal water (5.625 MPa and 6.48 MPa respectively).
- By using magnetic structured water of intensity 0.6 T exposed to 24 hours of magnetic field in concrete, it will show higher compressive, split tensile strengths for both M25 & M30 grades of concrete & also, the concrete tends to become workable. Thus, magnetic structured water if used in concrete, can prove to improve the fresh and hardened properties of concrete significantly.

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