Performance Evaluation of Magnetic Field Treated Water on Conventional Concrete

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Abstract— This Dissertation presents that when water is magnetised, it exhibits structural changes which increases the specific surface area of water. When this magnetised water is used in concrete instead of normal water, it is found that the compressive strength increases considerably. The additional strength attained by the use of magnetised water is used to address the need for reducing cement usage in concrete. In this attempt to reduce the usage of cement, fly ash which has immense potential to be used in construction industry, can be used to replace cement in concrete to a considerable extent. Based on the experimental results obtained by conducting tests on fresh concrete i.e. workability & compaction factor test, and test on hardened concrete i.e. compressive strength, flexural strength, split tensile strength for various grades of concrete i.e.M15, M20, M25, M30, M40 are achieved.

Key words: Magnetic water, Magnetic water concrete, Normal water concrete, Compressive Strength, flexural strength, split tensile strength

I. INTRODUCTION

Concrete is a manmade rock in required size and shape unlike other materials of construction and as such can vary to a very great extent in its quality, properties and performance owing to the use of natural expect cement . To make the properties of concrete some research has been done in the following chapters.

II. RESEARCH METHODOLOGY

Water has long been neglected in research studies related to the construction industry. Various standards have been established for the quality of water to be used in construction. Most of them stipulate that potable water is fit to be used in construction. Unlike coarse aggregates, water is not inert. Water is very important for the hydration of cement. When the specific surface area of cement is increased, it improves the extent of hydration. Therefore, attempts have been made to increase the specific surface area of water and the effects of increased surface area are studied on the workability and compressive strength of concrete. Magnetising the water is found to be helpful in increasing the specific surface area of water, thereby increasing the rate of hydration. An experimental program was undertaken which consists of testing of various grades of concrete ie M15,M25,M20,M30,M40 respectively and also on water sample. The properties of fresh and hardened concrete specimens were also compared after that. In order to make sure the increase in workability of concrete Fresh concrete was tested for Slump as well as Compaction Factor. The hardened concrete tests consisted of testing 150 mm x150mm cubes to know the compressive strength of concrete at the age of 3days, 7days and 28 days.

A. Objective of Dissertation

Following are the main objectives of this research work:

1) To prove that underground water, used water (hard water) can be used for concreting by giving magnetic treatment.
2) To find the solution to effective use of ground water available.
3) To find the effect of magnetically treated ground water of different grades on compressive strength & workability (Slump & Compacting Factor) of concrete
4) To study the effects of magnetic treatment on properties of water.
5) To find the compressive strength, flexural strength and split tensile test for various grades of conventional concrete.

The objective of this research is tried to achieve through the study the various literature survey and by performing the actual experiment.

B. Scope of Dissertation

The scope of the research is limited to study of effect of magnetic treatment on grades of concrete ie.M15, M20, M25, M30, M40 respectively

To find out the effect of magnetic treatment on properties of water the testing of water sample was done before & after the treatment. There are many properties which can be taken into account, but due to limitations of time the scope was limited to following tests:

1) Determination of hardness of water (TDS)
2) Determination of pH of water
3) Determination of turbidity of water

To find out the effect of magnetically treated water on workability of concrete only following two tests were taken into account:

1) Slump Cone Test
2) Compacting Factor

Tests to determine properties of hardened concrete following test were conducted:-

1) Compressive Strength.
2) Split Tensile Strength.
3) Flexural Strength.

The results were recorded for 3 days, 7 days and 28 days.

III. EXPERIMENTAL METHODOLOGY

Water is the least expensive but most important component of concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid, etc. In general, the water which is fit for drinking should be used for making concrete too.

A. Preparation of Magnetic Water

1) Setting up of Instrument

The preparation of magnetized water was the main aim behind setting up of instrument. It took a lots of efforts to

find out the way to magnetize the water. I have gone through several research papers related to magnetization of water and came to the conclusion that water is diamagnetic substance but when water comes under the influence of high magnetic field of strength around 12000 gauss, it can be magnetized. Thus it was decided to recirculate the water used for casting and curing through magnetic field for three hour each day until concrete samples have achieved sufficient strength for curing period of 28 days.

In this regard I also took help from various industrialist people to find the most economical way to prepare magnetic water. And at last Mr. Girish Chandane of M/S Autofill Systems- Kharghar, Navi Mumbai helped me to design the machine as per the requirement. He has designed two instruments for the experiment work. The detailed specifications of machines that have been used for experimental work.

2) Preparation of MW

For the preparation of magnetic water the instrument was set up as shown if figure fitted the inlet of electromagnet instrument is attached to the outlet of water pump and the outlet of electromagnet to the inlet of permanent magnet instrument. Both the magnets are attached in series to each other as per the manual. The inlet of water motor and outlet of permanent magnet instrument is made to receive and collect water in the same water tank respectively. This process of recirculation of water through magnetic instrument was done for the minimum duration of one hour each day. The magnetic water prepared for curing purpose was also used at the time of preparation of concrete mix.

3) Generation magnetic field in Magnetic Water Conditioner (MWC)

Magnetic Water Conditioner is a device which is used to treat water under the influence of magnetic field. The MWC device used in this experimental investigation was made up of two parts as follows :-

1) Permanent Magnet Instrument
2) Electromagnetic Instrument
3) The two parts are attached in series to each other the functions of each parts are as explained below,

a) Permanent Magnet Instrument

The magnetic field of a permanent magnet results from the mutual alignment of the very small magnetic fields produced by each of the atoms in the magnet. These atomic-level magnetic fields result mostly from the spin and orbital movements of electrons. While many substances undergo alignment of the atomic-level fields in response to an applied magnetic field, only ferromagnetic materials retain the atomic-level alignment when the applied field is removed. Thus, all permanent magnets are composed of ferromagnetic materials. The most commonly used ferromagnetic elements are iron, cobalt, and nickel.

In this instrument, an arrangement was made such that the magnetic field of around 12000 Gauss was used. This high power magnet is fitted in cylindrical pipe with half inches diameter inlet and outlet facility.

b) Electromagnetic Instrument

The electromagnet is constructed from many coils of wire wrapped around a central iron core. The magnetic field is present only when electrical current is passed through the wire coils.

The machine simply works based on the electromagnetic induction principle which was introduced by Michael Faraday in 1832. This law states that when a AC current pass through a long straight conductor a magnetising force, H and a static magnetic field, B is developed around the wire. If the wire is then wound into a coil, the magnetic field is greatly intensified producing a static magnetic field around itself forming the shape of a bar magnet giving a distinct North and South pole. The magnetic flux developed around the coil being proportional to the amount of current flowing in the coils windings as shown. If additional layers of wire are wound upon the same coil with the same current flowing, the static magnetic field strength will be increased and therefore, the magnetic field strength of a coil is determined by the *ampere turns* of the coil with the more turns of wire within the coil the greater will be the strength of the static magnetic field around it. The line of magnetic fields which is generated from the coil.

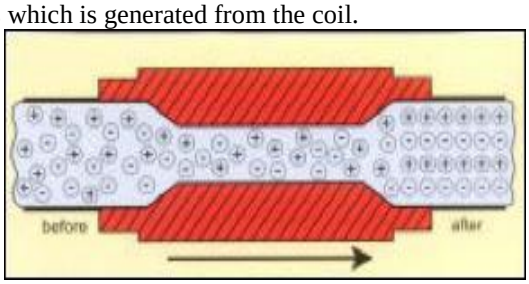

Fig. 1: Electromagnetic Instrument

c) Configuration of Ionic Particles In a magnetic conditioner

The application of a magnetic field to natural water can enhance degassing by 25-30%, caused by local dehydration of surface micro bubble films and a decrease in pressure in the centre of vortices resulting in an increase in free gas bubbles that can then be released into the open air . This degassing increases permeability in soil, resulting in an increase in irrigation efficiency.

When a magnetic field is applied to water the molecular structure becomes more stable and the ability to form hydrogen bonds is enhanced. Magnetizing water can increase the number of hydrogen bonds by 0.34%. In the same study, the researchers verified results of decreased surface tension and increased viscosity with the application of a magnetic field on water.

d) Magnetization of Water & Effect of magnetic treatment on water molecules

Magnetic water or liquids can be made in several ways. Water can be magnetized as it moves through the water pipe or by applying a magnet to a container of liquid. If water is treated while moving through the pipe it will be fully magnetized as it comes out of the pipe. If a large container of still water is treated with magnets it will require several hours to become full magnetize. As the whole layers of water or all the molecules of water require time to come in contact with magnetic field.

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. Proposed 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. The activation of water treatment using magnetic field depends on three conditions.

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

IV. SYSTEM MODELLING

A. Test on Cement

The cement used in this experimental work is "Ultratech Cement 53 Grade ordinary Portland Cement". All properties of cement are tested by referring IS 1489 (
The test results are presented in the table

B. Physical Properties of Coarse Aggregate

Sr. No	**Property**	**Results**
1.	Particle Shape, Size	Angular, 12.5mm down
2.	Fineness Modulus of 12.5mm aggregates	7.79
3.	Specific Gravity	2.70
4.	Water absorption	1.03%
5.	Bulk density of 12.5mm aggregates	1603 Kg/ mm^3
6.	Surface moisture	Nil

Table 1:

C. Sieve Analysis of Fine Aggregate

Sr. No.	Sieve size	Weight retained (gm)	Cumulative wt. Retained	% Cumulative wt. Set	% Passing
01	4.75mm	33.00	33.00	3.3	96.70
02	2.36mm	128.00	161.00	16.10	83.90
03	1.18 mm	223.00	384.00	38.40	61.60
04	600mm	324.00	708.00	70.80	29.20
05	300mm	185.00	893.00	89.30	10.70
06	150mm	98.00	991.00	99.10	00.90
07	Pan	--	--		--

Fineness Modulus = 3.17

Table 2:

D. Sieve Analysis of 12.5 mm Coarse Aggregates

Sr. No.	Sieve size	Weight retained (gm)	Cumulative wt. Retained	% Cumulative wt. Retained	Remark
01	40mm	NIL	NIL	NIL	-
02	20mm	400	400	80	-
03	10mm	4590	4990	99.8	-
04	4.75mm	10.00	5000	100.0	-
05	2.36mm	-	-	100	-
06	1.18mm	-	--	100	-
07	600micron	-	--	100	-
08	300micron	-	--	100	-
09	150micron	-	--	100	-
10	Residue	0	0	0	-
	Total			779.8	-

Fineness modulus =779.8 / 100 = 7.79

Table 3:

E. Test on Water

To find out the effect of magnetic treatment on properties of water the testing of water sample was done before & after the treatment. There are many properties which can be taken into account, but due to limitations of time the scope was limited to following tests:

1) Determination of hardness of water (TDS)
2) Determination of pH of water
3) Determination of turbidity of water

F. Determination of Hardness of Water Samples (TDS) (IS: 3025-2002)

Water Sample	Normal Water			Magnetically Treated Water			Decrease in Hardness
	X	Y	TDS	X	Y	TDS	Percent
	ml	ml	mg/lit	ml	ml	mg/lit	(%)
1, TDS 60	0.8	5.7	59.682	0.7	4.8	49.938	16.32
2, TDS 350	0.9	29.3	345.912	1.1	25.4	295.974	14.43
3, TDS 750	0.7	62.3	750.288	1	48.6	579.768	22.73
4, TDS 1000	1	82.7	995.106	0.9	64.3	772.212	22.40

Table 4:

G. Determination of ph of Water Samples

Water Sample	Temperature °C	Normal Water	Magnetically Treated Water	Increase in pH Percent (%)
1, TDS 60	27	7.4	7.63	3.11
2, TDS 350	27	7.26	7.86	8.26
3, TDS 750	27	7.46	8.03	7.64
4, TDS 1000	27	7.78	8.46	8.74

Table 5:

H. Determination of Turbidity of Water Samples

Water Sample °C	Temperature of Sample	Normal Water	Magneticallly Treated Water	Decrease in Turbidity Percent (%)
1, TDS 60	27	2.3	2.3	0
2, TDS 350	27	4.6	4.2	8.70

3, TDS 750	27	8.2	7.6	7.32
4, TDS 1000	27	13.8	10.4	24.64

Table 6:

I. Determination of Slump of Water Samples

Sr No.	Hardness (TDS) mg/l	Slump For Normal Water	Slump For Magnetically Treated Water	Increase In Slump
1	TDS 60	1.6 cm	6.5 cm	1.9 cm
2	TDS 350	3.9 cm	5.8 cm	1.9 cm
3	TDS 750	2.8 cm	4.3 cm	1.5 cm
4	TDS 1000	1.5 cm	2.4 cm	0.9 cm

Table 7:

J. Determination of Compacting Factor of Water Samples

Water Sample	Compacting factor for Normal Water	Compacting factor for Magnetically Treated Water	Increase in Compacting Factor
1, TDS 60	94.40%	96.00%	1.60%
2, TDS 350	93.50%	95.08%	1.58%
3, TDS 750	91.20%	94.44%	3.24%
4, TDS 1000	89.76%	93.70%	3.94%

Table 8:

V. PERFORMANCE ANALYSIS

A. Mix Design of Concrete

DOE method of mix designed was used for mix design of M15,M20,M25,M30,M40 grade of concrete. The quantity of ingredient materials and mix proportions as per design is as under.

B. Details of Test Specimens for Tests on Hardened Concrete

The specimen used was cubes, beams specimens and cylinder specimens specially prepared to measure bond strength. Dimensions of each test specimen are as under:

- Cube: 150mmx150mmx150mm
- Beam: 100mmx100mmx500mm
- Cylinder: 150mmx300mm
- Beam specimens were used to determine flexural strength.
- Cubes of 150mm size were used to find the compressive strength.
- Cylindrical specimen were used for split tension test

C. Testing of Specimens

Workability of wet concrete is determined by slump cone test and bulk density is calculated by taking weight of concrete cylinder in wet state.

Compressive strength of cubes are determined at 3 days,7 days and 28 days using Universal testing machine (UTM) of capacity 2000 KN. Split tensile test, flexure test are carried out on universal testing machine of 40 tones capacity.

D. Compressive Strength Test on Cube

A cube compression test performed on standard cubes of size 150 x 150 x 150mm after 3 days,7 days and 28 days of immersed in magnetic water & normal water of curing specimens.

The compressive strength of specimen was calculated by the following formula:

$$F_{cu} = P_c/A$$

Where, P_c = Failure load in compression, KN

A = Loaded area of cube, mm^2

E. Flexural Test on Plain Concrete

Standard beams of size 150 x 150 x 500mm were supported symmetrically over a span of 600mm and subjected two points loading till failure of the specimen. The deflection at the centre of the beam is measured with sensitive dial gauge on UTM.

The flexural strength was determined by the formula

$$f_f = P_f L / bd^2$$

Where,

f_f = Flexural strength, MPa

P_f = Central point through two point loading system,KN

L = Span of beam, mm

b = Width of beam, mm

d = Depth of beam, mm

F. Split Tensile Test on Cylinder

The split tensile test is well known indirect test used to determine the tensile strength of concrete. Due to difficulties involved in conducting the direct tension test, a number of indirect methods have been developed to determine the tensile strength of concrete. In these tests, in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses induced in the specimen.

The tensile strength at which failure occurs is the tensile strength of concrete. In this investigation, the test is carried out on cylinder by splitting along its middle plane parallel to the edges by applying the compressive load to opposite edges. The arrangement for the test is shown in photo with the pattern of failure. The split tensile strength of cylinder is calculated by the following formula.

$$f_t = 2P /\pi LD$$

Where, f_t = Tensile strength,

P = Load at failure,

L = Length of cylinder, mm,

D = Diameter of cylinder, mm

G. Physical Properties of Fresh Concrete

Grade	Water cement ratio	Wet Density Kg/m^3
M15	0.45	2438
M20	0.45	2497
M25	0.45	2492
M30	0.45	2521
M40	0.45	2588

Table 9:

H. Final Mix Design

CONTENT	M15	M20	M25	M30	M40

Cement	155	210	230	250	310
Flyash	125	130	120	140	140
Water	160	152	150	148	165
Washed Sand	360	347	445	425	400
Artificial Sand	540	521	445	425	450
20mm	740	805	750	800	800
10mm	355	330	350	330	320
Admixture	2.7	2.38	2.45	2.73	2.73
Total	2438	2497	2492	2521	2588

Table 10:

VI. RESULTS

A. *Graph for Normal Water Compression Test Result*

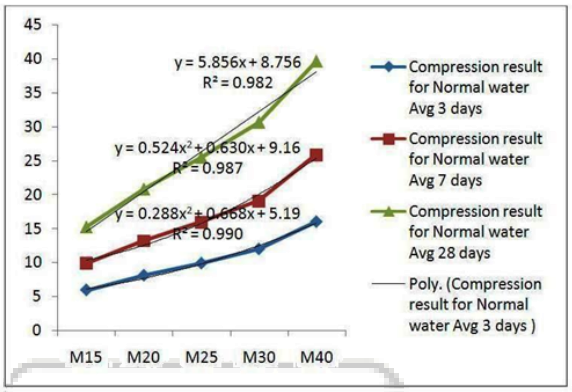

Fig. 2:

B. *Graph for Magnetic Water Compression Test Result*

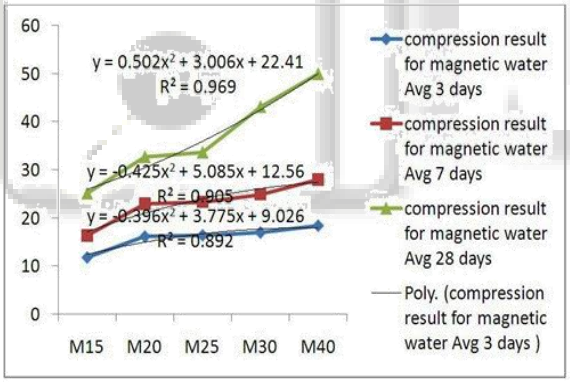

Fig. 3:

C. *Graph for Flexural Test Normal Water Result*

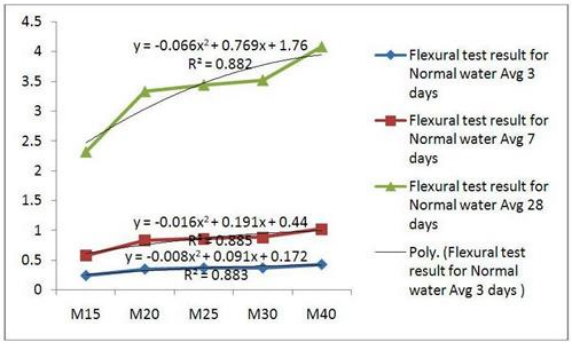

Fig. 4:

D. *Graph for Flexural Test Magnetic Water Result*

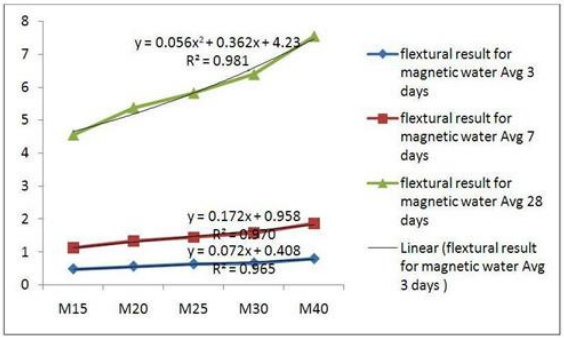

Fig. 5:

E. *Graph For Split Tensile Test Normal Water Result*

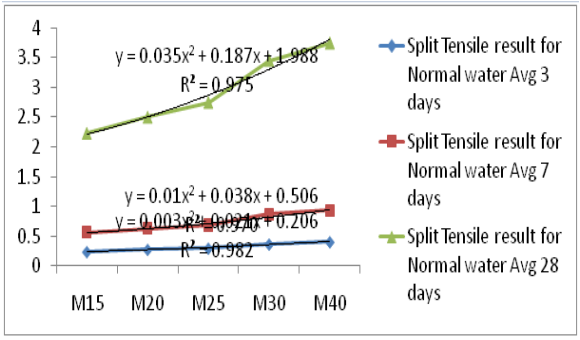

Fig. 6:

F. *Graph for Split Tensile Test Magnetic Water Result*

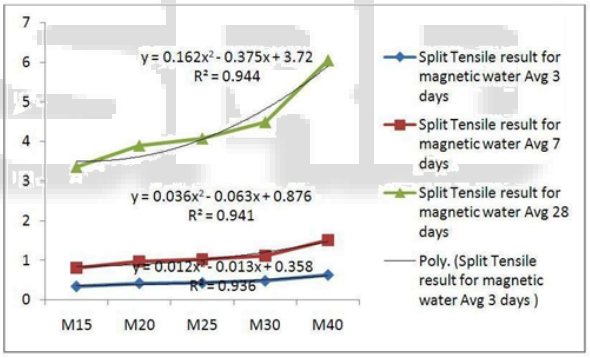

Fig. 7:

VII. CONCLUSION

Workability of concrete is improved after use of magnetically treated water.Here are some of conclusions and observations for the results obtained.

1) Improvement in workability is more for water having less TDS concentration
2) Improvement in compressive strength is more for water having high TDS concentration
3) Increase in mean & characteristic compressive strength is more, when both casting & curing is done by using magnetically treated water
4) Curing in magnetically treated water is more effective than that of casting by using magnetically treated water.
5) Increase in compressive strength of concrete prepared by purified water is 12 % to 14 %, which is same as literature. But in case of ground water magnetic treatment improves characteristic strength of concrete by about 30 to 49%.

6) It is advisable to use magnetic water for casting and curing of concrete in construction industry.
7) The underground water that is brackish in nature can also me made soft by using magnetic treatment and can be made suitable for construction purpose.

ACKNOWLEDGEMENT

I am pleased to acknowledge my thankfulness to Dr. A.P. Wadekar my guide, for his innovative and invaluable suggestions in completing this work. I am thankful to him for his gracious encouragement and very valued constructive guidance in reviewing results of this work. It would not have been possible to complete this work without his guidance and persistent persuasion.

I would like to express my sincere thanks to Prof. Rahul D. Pandit my Co-Guide, Dept of Civil Engineering for extending valuable source of information during the course of these studies.

I offer profound gratitude towards Honorable Principal Dr. A.P. Wadekar, People's Education Society's, P.E.S. COLLEGE OF ENGINEERING AURANGABAD for providing me all the excellent academic facilities required to complete this work.

Last but not least, I am thankful to all my friends' family members for time to time support, encouragement, help and motivation.

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