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An Experimental Study on the Use of Magnetized Water in Concrete with M Sand as Fine Aggregate

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Abstract: Water plays an important role in the concrete preparation. It plays an important role in workability and strength of concrete. A new technology known as magnetized water is used to increase the workability and strength of concrete. The magnetized water technology initiated in Russia and China for agricultural and other medical values and now it extends its application in construction industry. Magnetic water has been used in different fields like health care, dairy production, agriculture and oil industries. In this study, the effect of magnetized water on workability, strength and quality of M20 grade concrete with M sand as fine aggregate was studied. Magnetized water is prepared by passing the normal tap water through a magnetic field. When water passes through the magnetic field some of the physical properties of water changes. The water clusters are broken due to magnetic field and which will increase the water activity.
In this study magnetized water used for both mixing and curing. Different tests were conducted on four mixes. The results obtained shows that workability is higher for mix with magnetized water. The compressive strength is higher for the mix which used magnetized water for both mixing and curing.

Keywords: Magnetized water, water activity, compressive strength

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I. INTRODUCTION

Concrete is a composite material which composed of coarse aggregate bonded together with cement paste that hardens over time. When aggregate is mixed with dry Portland cement and water the mixture forms a fluid slurry which can be easily poured and moulded into shape. The cement reacts chemically with the water and other ingredients and form a hard matrix which binds the materials together. Sometimes additives like pozzolans or superplasticizers are added in the mixture to improve the physical properties of the finished material.

Water is the key ingredient in concrete for the different process including hydration process, proper curing etc. When water mixed with cement which forms a paste which binds the aggregate. Water causes the hardening of concrete by the process known as hydration. Water consumption is increasing as the population and human needs increases. Water consumption in agricultural sector is around 70% and in industrial sector it is 20%. In concrete production there is more than one billion tonnes of water consumed each year.

One of the recent technologies used to enhance the compressive strength and workability of concrete is using magnetized water instead of normal water in concrete mixes. This new technology has increased the compressive strength. Using magnetized water in concrete is best in terms of lower porosity and higher density. There is a rapid increase in the implementation of magnetized water technology on the eighties and nineties decades. This is due to the development of magnetic devices and their influences in concrete properties. Importance of the mechanical properties of magnetized water concrete have been used in many fields of civil, military construction, like airports and jetties. Most researchers concentrate to produce economical concrete with higher strength by using new philosophies of design methods, like using water which is magnetically treated. When normal water flows through magnetic field, some of the physical properties of water are changed. Also the number of molecules in the water clusters will decreased to 6 or 5 molecules which will cause decrease in surfacetension and an increase in the percentage of molecules contribute for the hydration process. In magnetic treated water, molecules will lose their attractive and repulsive forces and then oriented on a magnetic pole or electric charge. Neutralized molecules of water are more easily attracted to numerous electrostatic fields which naturallycontained by cement grains. Hydration of cement is faster and more complete with magnetically treated water.

II. MAGNETIZED WATER

When water passes through a magnetic flux it is known as magnetized water. The level of magnetization is controlled by the method used and water purity. The structure of water is aligned in one direction after magnetization, and the molecule sizes change after the bond angle changes, therefore viscosity and surface area increases by magnetization, hence the hydration rate increases. The effect of a static magnetic field on liquid water, and suggested that stronger hydrogen bonds which lead to a higher viscosity was formed due to the broken hydrogen bonds after magnetization. Fig. 1(a) illustrates water molecules arrangement in normal temperature. Water molecules tend to form clusters with hydrogen bonds, while these clusters are broken due to the magnetic field when applied as shown in Fig. 1(b), hence increasing the water activity. Due to the smaller size of magnetized water molecules, the water layer surrounding the cement is thinner than normal water molecules, therefore less water demand which has positive effect of hardened concrete properties. [1]

Figure 1: (a) Water molecules before magnetic treatment; (b) Water Molecules after magnetic treatment [1]

The estimated improvement to the concrete strength is 10 %, saving 5 % of the cement dosage in addition to improving other characteristics. Where the structure of anysubstance appreciably determines its physical, chemical and thermo-physical properties (Fig. 2). [5]

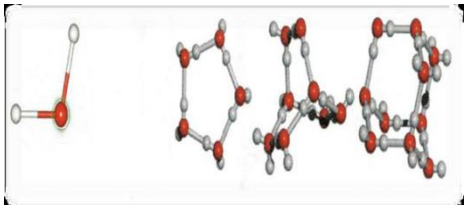

Figure 2: Structure of water[8]

The process of magnetizing water does change its mechanical properties. As seen in Fig. 3 it only changes the trajectory of the charged particles movement, and not its energy. [5]When water is magnetized, it becomes anti-magnetized and inhibits the mineral in concrete from bonding, which causes the minerals of the concrete and additive to repel each other.

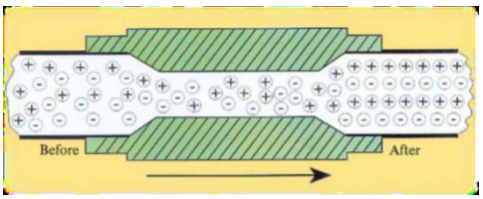

Figure 3: Trajectory of charged particles movement, before and after the magnetizing process[6]

This fact plays a major role in mixing, forming, and curing stages which all contribute in producing better concrete. All that will contribute in producing a high-quality concrete which can overcome its lack of ability to resist deterioration. [5]

III. OBJECTIVE AND METHODOLOGY

The main research objectives of the work are,

1. To establish the procedure for producing the magnetic water (MW)
2. To understand the magnetic water concrete (MWC) and its characteristics in terms of workability and strength aspects.
3. To compare the compressive strength, split tensile strength and flexural behaviour of Normal water concrete (NWC) and Magnetized water concrete (MWC) for M20 grade of concrete mix.
4. To conduct the ultrasonic pulse velocity test on the concrete and check the quality of concrete

The project methodology includes the study of the materials used for project. Design of M20 concrete is done by using the observations from the test results. The establishment of magnetizing unit is done to make the magnetized water for the study.

IV. EXPERIMENTAL WORK

Materials: The materials used in this experiments were cement, coarse aggregate, fine aggregate and magnetized water.

Cement: The cement used for preparing the concrete mix for this study is 53 grade Ordinary Portland Cement (OPC) (Maha cement) with specific gravity 3.15. The physical properties of cement were found by conducting tests.

Table 1: Physical properties of cement

Properties	Values
Specific gravity	3.15
Consistency	31%
Initial setting time	122 minutes
Final setting time	329 minutes
Fineness	1%

Coarse aggregate: The size of coarse aggregate used for this study is greater than 4.75 mm.Mainly size of 20mm and below are used as a coarse aggregate.

Table 2: Physical properties of coarse aggregate

Properties	Values
Fineness	3.89
Specific gravity	3.128
Water absorption	2%

Fine aggregate: River sand is mainly preferred for fine aggregate. Due to the lack of availability of river sand has led to the use of artificial sands. In this study M sand is used as fine aggregate.

Table 3: Physical properties of coarse aggregate

Properties	Values
Fineness	2.98
Specific gravity	2.82
Zone	II

Magnetized water: In this project a large amount of magnetized water is required for mixing and curing. Therefore, a magnetizing unit or instrument is established for the production of magnetized water. This system consists of a motor pump, magnetic field and pipes.

In this device the strong magnets are placed on the top and bottom of a PVC pipe to create a magnetic field. Magnets are placed in such a way that to form a magnetic field with north and south pole. The length of the device is around 600mm. the diameter of the magnets which are used are of 10cm. The PVC pipes are placed in the middle of the two sets of magnets. Motor pump is used to recirculate the water through the magnetic field. 0.5 HP motor pump is used for the experiment.

The magnetized water is prepared by recirculating the water in the tank through the magnetic field which is prepared. The recirculation of the water is done by using the motor pump. The circulation of water is done for 3 to 4 hours alternately. The magnetized water is used for mixing and curing.

Figure 4: Water magnetizer for magnetized water

pH of the water is find out by using pH meter. The pH obtained for normal water is 6.71 and for magnetized water is 8.1. The change in pH shows the magnetization of water.

Mix proportion: The mix is designed by using the data from the material tests. The mix proportion for M20 concrete designed as per provisions in IS 10262-2009.The mix proportion is given in table 4.

Table 4: Mix proportion of M20 concrete

Water	Cement	Fine aggregate	Coarse aggregate
197 L	394 kg	726.544 kg	1314.88 kg
0.5	1	1.84	3.33

Specimen preparation: For the experimental study cubes of size 150x150x150 mm is used for compression test and for UPV test. Cylinder of 150x300 mm used for split tensile test and beam with 100x100x500 mm size used for flexural strength test. The specimens are prepared and cured in normal and magnetized water. 4 mixes are used in the study they are,

NMNC- Normal water Mixing and Normal water Curing
NMMC- Normal water Mixing and Magnetized water curing
MMNC- Magnetized water Mixing and Normal water Curing
MMMC- Magnetized water Mixing and Magnetized water Curing

V. RESULTS AND DISCUSSIONS

5.1 Workability

The fresh state properties of concrete are find out by using slump cone test and the obtained value is compared by the IS code provisions.

Table 5: Slump values and workability of concrete

Mix	Slump value (mm)	Workability
Conventional concrete	90	Medium workable
Magnetized water concrete	120	Highly workable

From the observations it is found that slump value of magnetized water concrete is higher than that of conventional concrete and also the magnetized water concrete is highly workable when compared with conventional concrete. It shows that magnetized water enhances the workability of concrete. The increase in the slump value is due to the increase in viscosity and increase in the surface area of the mix when magnetized water is used.

5.2 Compressive strength test

The compressive strength test is conducted on samples at 7 and 28 days of curing. This test is done as per IS: 516-1959. The graphical representation of the results is shown in the figure. The graph is plot between compressive strength vs time in days.

The results show a significant increase in the compressive strength for the mix with magnetized water used for mixing and curing.There is a slight increase in strength for 7 days of curing but for 28 days curing a noticeable increase can be seen. An increase of 58.72% can be observed in the compressive strengths of concrete cubes made and cured in magnetic water when compared with the conventional concrete.

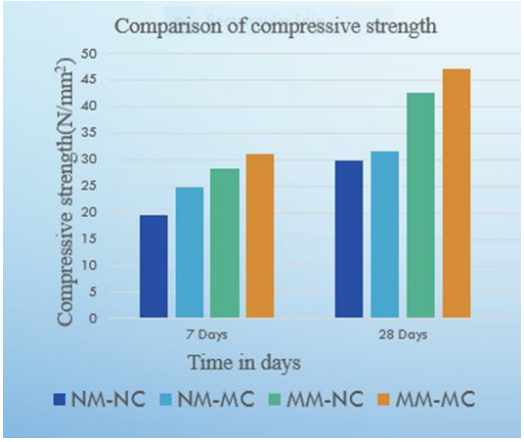

Figure 5: Comparison of compressive strength

The increase in the strength is due to more hydration of cement in the magnetized water concrete. Due to the increase in hydration it fills up the pores in the concrete.

5.3 Split tensile strength test

In this test cylinder of 150mm diameter × 300mm length is used for testing. The split tensile strength test is conducted on samples at 7 and 28 days of curing.The graphical representation of the results shown in figure below.

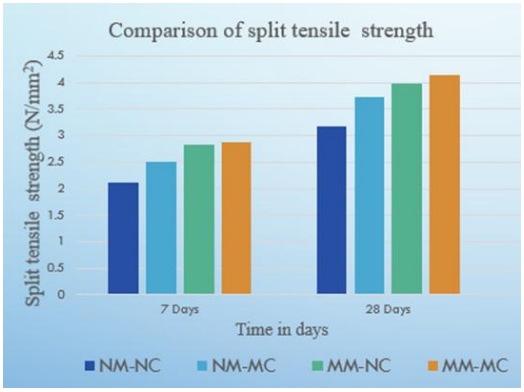

Figure 6: Comparison of split tensile strength

Results it shows that the split tensile strength is higher for the specimen which is mixed and cured in magnetized water.There is a 30% increase in 28 days split tensile strength for specimen with both mixing and curing is done by magnetized water when compared with the normal water concrete.

5.4 Flexural strength test

The flexure test is done on a beam of 100mm×100mm×500mm size prism loaded at the centre of the span.From the test results it shows that the flexural strength is higher for the specimen with magnetized water used for mixing and normal water used for curing. The optimum strength obtained for 28 days is 8.5 N/mm2. The specimen which is mixed and cured in magnetized water have strength of 7.5 N/mm2.

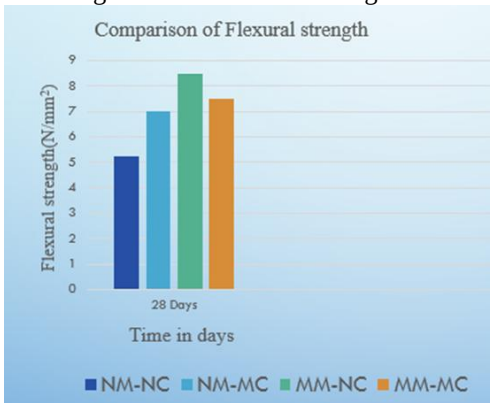

Figure 7: Comparison of flexural strength

From the graphical representation it can easily identified that the higher strength is for the magnetized water mixed and normal water cured specimen.

5.5 Ultrasonic Pulse Velocity (UPV) test

Ultrasonic pulse velocity test is a non-destructive test. This non-destructive test is used to determine the quality of the concrete specimen. The results obtained from the tests are shown below in the tables. Table 6.5 shows the general condition as per IS:1311(Part 1)-1992.

Table 6: General condition as per IS: 1311 (Part I)-1992

Velocity (m/s)	General condition
Above 4500	Excellent
3500-4500	Good
3000-3500	Medium
Below 3000	Poor

Table 7: UPV results for 7 days

Mix	7 Days			
	Direct transmission		Semi direct transmission	
	Time (µs)	Velocity (m/s)	Time (µs)	Velocity (m/s)
NM-NC	29.9	5017	18.9	7925
NM-MC	29.5	5085	16.6	7937
MM-NC	29.3	5147	16.4	8467
MM-MC	28.2	5267	15.8	9036

Table 7 shows the result obtained for the specimen of 7 days curing and table 8 shows results for 28 days curing. From the results the velocity is increasing when magnetized water is used. The velocity is higher for specimen which use magnetized water either for mixing or curing in case of direct and semi direct transmission. When velocity is higher it shows good quality and continuity of the specimen.

Table 8: UPV results for 28 days

Mix	28 Days			
	Direct transmission		Semi direct transmission	
	Time (µs)	Velocity (m/s)	Time (µs)	Velocity (m/s)
NM-NC	29.1	5155	27.4	6474
NM-MC	28.4	5282	17.3	8671
MM-NC	27.6	5435	15.2	9868
MM-MC	26.4	5348	18.2	8126

As per IS:1131(part I) -1992, if the velocity is higher than 4500m/s then the specimen is in excellent condition. Hence from the result it shows that the velocities are greater than 4500m/s for all the specimen. Therefore, all specimens used for the experiments are excellent in condition.

V. CONCLUSION

1. From the literature review, normal water can easily replace with magnetized water in which strength of the concrete increases with magnetic water
2. Material properties were tested and results are obtained
3. The mix design is done as per the IS provisions by using m sand as the fine aggregate
4. The use of magnetic water increased the workability of concrete
5. The magnetic water mix concrete show higher compressive, split tensile and flexural strength rather than normal compacting concrete.
6. The specimen with magnetized water used for mixing and curing shows an increase of compressive strength by 50% at 28 days of curing
7. Use of magnetized water in concrete mixing showed an increase in its split tensile strength at the end of 28 days. And the optimum value is obtained by the specimen with both mixing and curing done in magnetized water
8. The maximum flexural strength is obtained for the specimen with magnetized water used for mixing and

normal water used for curing

9. The UPV test results shows that the quality of magnetized concrete is higher than that of conventional concrete

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