Experimental Investigation on Strength and Shrinkage Properties of Concrete Mixed with Magnetically Treated Water

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***Abstract*— The most important challenge for concrete construction is to improve the performance of concrete. Till now potable water is used for mixing different ingredients of concrete. This paper finds new technology called magnetic water technology has been used in making concrete. As per this technology, by passing water through a magnetic field, some of its physical properties tends to change and, as a result of such changes, the cluster size in water molecules breaks down due to decrease in the bond angle between the hydrogen atoms, which causes decrease in the hardness of water, with an improvement in the workability and strength of concrete when compared to use of potable water in concrete. It also has an advantage that the quantity of cement content in concrete mix can be reduced when the magnetized water is used in concrete. Some of the most beneficial claimed water applications from magnetically treated water include improvement in scale reduction in pipes and enhanced crop yields with reduced water usage. Strength tests conducted on this magnetic water concrete showed encouraging results and one can easily replace normal water with magnetic water for mixing of concrete. Drying shrinkage properties has been studied and that results are compared with specimen mixed with potable water.**

Keywords: Magnetic water technology, magnetized water, workability, strength, drying shrinkage.

I. INTRODUCTION

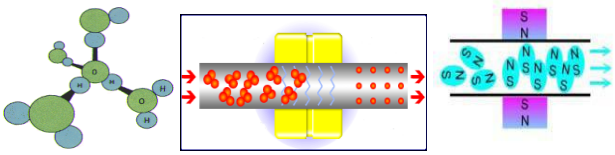
In general, adding chemicals and admixtures while mixing concrete is practiced to alter the properties of concrete to obtain a concrete with desired property. In many cases, these are added to get concrete with increased strength. The chemicals that are required for increasing the strength will be rarely available in rural areas and it will cost more in case of large projects. Magnetic water treatment is a proposed method of reducing the effects of hard water, as an alternative to water softening. This softening intensity is based on the magnitude of flux induced. In this study, the process of preparing the magnetized water by using the equipment called PERMAG (N406) with the magnetic field intensity of 0.9 Tesla. The usage of magnetic water for the preparation of concrete would increase strength of the concrete and also there will be higher workability for the same water cement ratio. The study is to replace the normal water with magnetically treated water by which quantity of cement used in any concrete mix is reduced.

II. BACKGROUND

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. The effect of magnetic water on the engineering properties of concrete containing granulated blast – furnace slag which results in increased in the compressive strength of concrete up to 23% and the reason for improving the characteristics of concrete by the directional arrangement of the molecular structure after the treatment of water. The magnetic field treated water could save the cement dosage up to 5% and also decrease in the bleeding of concrete and improve the resistance to freezing [1]. The production of magnetized water has an ability to reduce the hardness of water and increase in efficiency of flow of water [2]. The use of magnetized water in concrete for mixing and curing, showed encouraging results in the properties of concrete. The use of this water in concrete has high density and water absorption is less when compared to normal water concrete by which the usage of cement content in concrete can be reduced without affecting the other properties of concrete [3]. The concrete made with magnetic water (magnetic concrete) has higher slump values than those of control concrete up to 45% [4]. The fresh concrete made with MW has higher slump value up to 35% at the magnetic intensity of 9000 Gauss [5]. The increasing of slump of concrete made with MW 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 [6]. A substance is said to be magnetized when its constituent molecules or structural elements can be aligned in a definite direction by the influence of an external magnetic field [7]. The process of magnetizing water does change its mechanical properties. It can only changes the trajectory of the charged particles movement, and not its energy [8]. The drying shrinkage of concrete with various kinds of aggregates increased with the increase of the Specific Surface Area (SSA) of the aggregate and suggest that the SSA determined by using H_2O is an effective index for evaluating the influence of the aggregate type on the drying shrinkage properties of concrete [9].

III. MECHANISM & WORKING PRINCIPLE OF PERMAG (N406)

PERMAG is entirely made up of strong rare earth magnets called Neodymium (N406). Magnetic fields are produced by the motion of the charged particles. The magnetic fields generated by moving electrons are used in inducing magnetic field in water. The magnetic field is present only when electrical current is passed through the wire coils or by using permanent magnet along the flow of water.



A **B** **C**

Mechanism of magnetic water: A. Water Cluster; B. Breakage of cluster; C. Orientation.

It works with the principle of MHD (Magneto Hydro Dynamics) creating a strong perpendicular magnetic field to the direction of water flow. The decrease in the cluster size of the water molecule causes decreases in the water surface tension. The minerals continue to remain in the water, the altered physical state prevents the minerals from exhibiting hardness, thus the water becomes soft.

IV. RESEARCH SIGNIFICANCE

The main objective is to improve the workability and strength of concrete by using magnetized water and also to reduce the quality of cement content in the concrete mix. This technology has been used in many countries for the purpose of irrigation and domestic use. But in concrete industry, this technique has not yet been initiated till in many areas. So, the main significance of this study is to determine the benefits of usage of magnetized water in the concrete mix.

V. EXPERIMENTAL INVESTIGATION ON CONCRETE

A. Materials

The materials involved in this study - cement (PPC), Coarse Aggregate, Fine aggregate, Potable water and Magnetized water. The properties of the materials are tested and tabulated.

Table 1: Physical Properties of Ingredients

S. No.	Property	Values
1.	Specific gravity of C.A	2.70
2.	Crushing value of C.A	25%
3.	Impact value of C.A	20%
4.	Specific gravity of F.A	2.58
5.	Fineness modulus of F.A	2.70 (Zone II)
6.	Specific gravity of cement	3.15

B. Chemical Composition

Table 2 : Physical Properties of Ingredients

Parameter (ppm)	Potable Water	Magnetized Water
Magnesium	290	195
Calcium	220	135
Total Dissolved Solids	1800	1650
Total Hardness	512	380
pH	8.18	9.17

C. Mix Design

In the present investigation work the effect of magnetized water on workability and strength properties on M_{20} grade of concrete is carried out. The Indian standard mix design procedure is adopted (i.e., IS: 10262-2009) in the present investigation to arrive the mix proportions for M_{20} grade of concrete. The mix design of M_{20} grade concrete is given table 3.

Table 3: Trial mix proportions for 1m^3 of concrete

Material	Cement	Sand	20mm Aggregates	W/C
Kg/m^3	372	700	1146	0.5

VI. RESULTS AND DISCUSSION

A. Workability

Slump test is the most commonly used method of measuring consistency of concrete. Slump test as per IS: 1199 - 1959 is followed. The workability test has been taken for different w/c ratios by using both Normal water and Magnetized water.

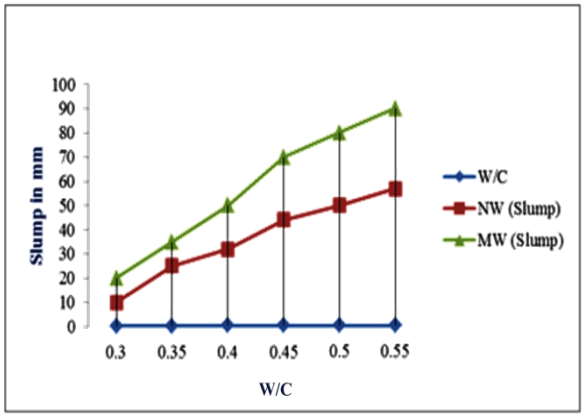


Fig. 1 Slump Flow for M_{20} grade of Concrete with different W/C ratios (using NW & MW)

Fig 1 shows that the workability is improved when using MW (Magnetized Water) in concrete. Using NW in concrete, medium slump (50 mm) is achieved in 0.5 w/c ratio, but in MW the medium slump is achieved in 0.4 w/c ratio. Hence, the cement content can be reduced up to 9.9% while using MW in concrete.

B. Compressive Strength of Concrete

The important property of concrete is its strength in compression. Compression test is the most common test conducted on hardened concrete property, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. Cubes of size

150mm×150mm×150mm were casted and the specimen was made to cure after 28 days it is test under compression testing machine. The Compressive Strength of concrete cube was determined based on IS: 516 – 1959.

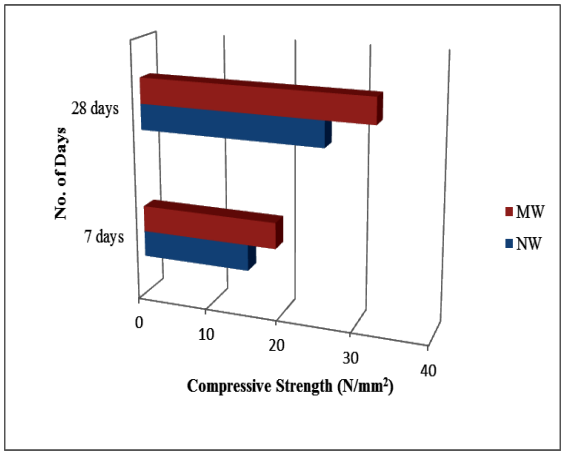


Fig 2 Compressive Strength development in NWC and MWC

Fig 2 shows the Compressive Strength development in Normal Water and Magnetized water concrete. It is observed that the addition of magnetic water showed that significant increase in compressive strength by around 20.88% at 7 days of concrete and 25.85% at 28 days when compared to potable water. At 28 days strength, the target strength can be achieved even before in magnetized water, hence the cement content can be reduced up to 11% to achieve the target strength of concrete and also formwork can be removed at earlier and the cost is reduced.

C. Split Tensile Strength

. The splitting tensile strength results of M_{20} grades of concrete at the age of 28 days were observed. The tensile strength of concrete was determined based on IS : 5816 -1970. The splitting tensile strength at the age of 28 days is plotted in the form of graph and shown in fig 3.

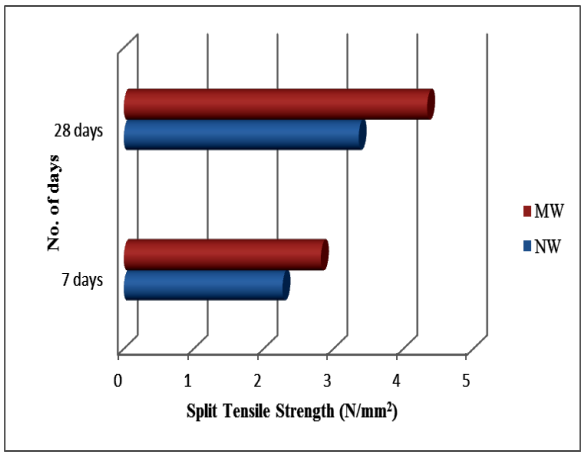


Fig 3 Splitting tensile strength at 7 & 28 days

It is seen that the splitting tensile strength for M_{20} concrete was gradually increased up to 24.52 % at the age of 7 days and 29.26% increased at the age of 28 days. Hence, the strength of the concrete is increased when magnetized water used in concrete so that the cement content can be reduced up to 11% to achieve the target strength of the concrete.

D. Flexural Strengthening of RC beams

D (I) Load carrying capacity

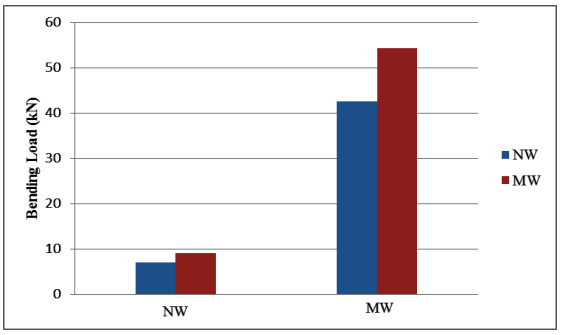


Fig 4 First Crack load and Ultimate load

The first crack load and ultimate load details are shown in Fig 4. It was observed that the performance of concrete with magnetized water in terms of first crack load and ultimate load were higher than the control beam. The improvement in strength of Magnetized water beam is about 53.45 kN (27.58 %) when compared to control beam at breaking point load.

D (II) Load Vs Deflection Behaviour of Control beam

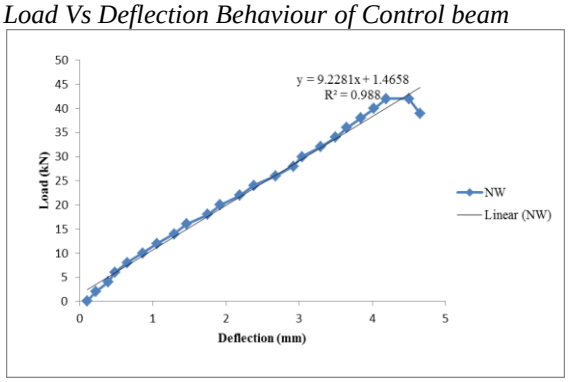


Fig 5 Load deflection behavior of Control Beam for M_{20} grade concrete

RCC beam is tested on the two point loading and the values of the deflection are noted for each 2kN interval. From the fig 5, it clearly shows that the load is increased up to 42.6 kN and then it decreases. Thus the ultimate load is 42.6 kN for control beam.

Load Vs Deflection behavior of Magnetized Beam

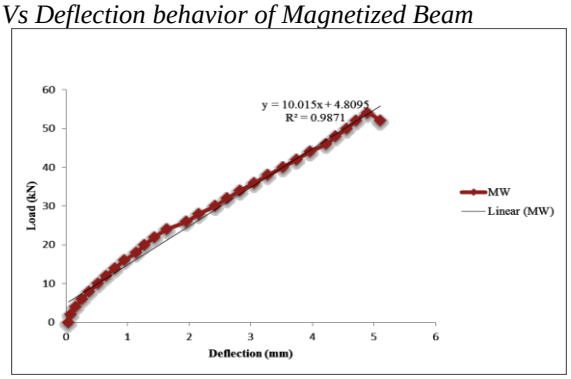


Fig 6 Load deflection behavior of Magnetized Beam for M_{20} grade concrete

From the fig 6, it clearly shows that the load is increased up to 53.45 kN and then it decreases. Thus the ultimate load is 53.45 kN for magnetized beam. Strength properties are found higher in concrete with magnetized water and the same is reflected in beam also. Concrete with magnetized water developed a well compacted structure, which results in withstanding higher loads.

D(III) Toughness Indices

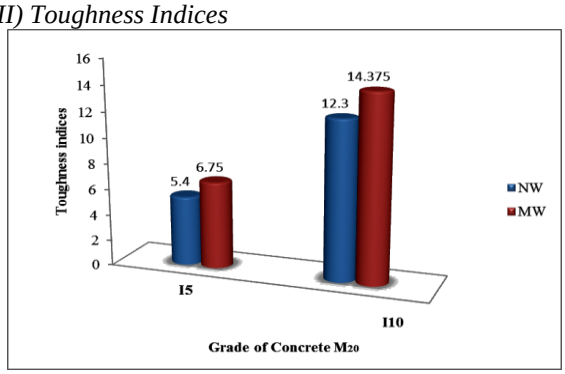


Fig 7 Toughness Indices of M_{20} grade RC beam

The toughness indices I_5 and I_{10} are calculated respectively as the ratios of the area of the load – deflection curve up to the deflections of 3 and 5.5 times the first crack deflection divided by the area of the load – deflection curve up to first crack deflection. The toughness indices values of M_{20} grade of RC beam were calculated and are shown in fig 7.

- $I_5 = \frac{\text{Area of load – deflection curve up to 3 times the first crack deflection}}{\text{Area of load – deflection curve up to the first crack deflection}}$

- $I_{10} = \frac{\text{Area of load – deflection curve up to 5.5 times the first crack deflection}}{\text{Area of load – deflection curve up to the first crack deflection}}$

D(IV)Ductility Characteristics

Ductility is one of the most important parameters to be considered in the design of structures subjected to inelastic deformations due to various loading conditions such as wind, seismic or impact loading. Ductility is defined as the ability of a member to undergo inelastic deformations beyond the yield deformation without significant loss in load carrying capacity. The ductility of a flexural member can be obtained from load-deflection curve. The ratio of ultimate deflection to the deflection at first yield is known as ductility factor (μ). The ductility factor was calculated for M_{20} grade of RC beam and the result are given in Fig 8. Ductility factor, μ

$$\mu = \frac{\text{Ultimate deflection}}{\text{Deflection at first yield}} = \frac{\delta_u}{\delta_y}$$

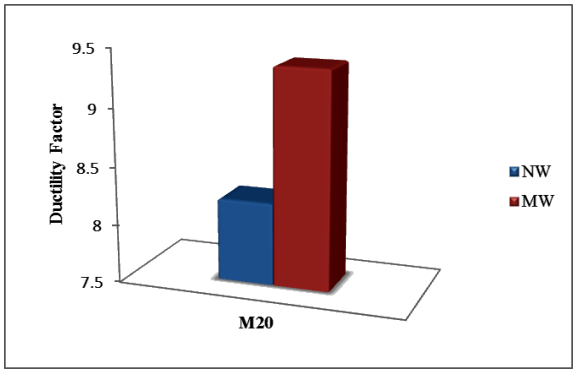


Fig 8 Ductility factor of M_{20} grade RC beam

From the Fig 8, it is seen that the ductility is improved up to 15% magnetized water RC beam when compared with normal water RC water.

D(V)Energy Absorption Capacity

Energy absorption capacity was calculated from the load-deflection curve. The area under the load-deflection curve was considered for calculating the energy absorption capacity. Fig 9 shows the energy absorption capacity of M_{20} grade RC beam.

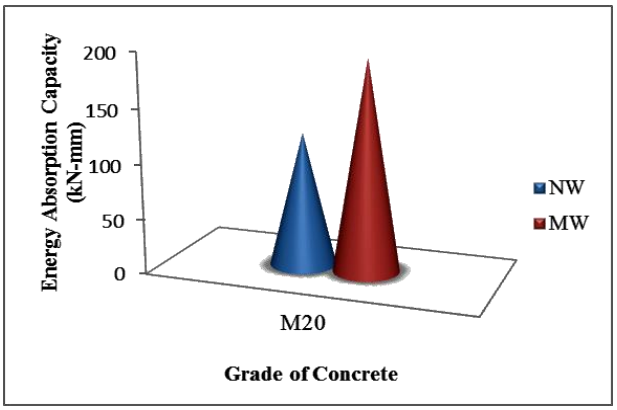


Fig 9 Energy absorption capacity of M_{20} grade RC beam

From Fig 9, it is noted that the energy absorption capacity is increased significantly in magnetized water RC beam compared with normal water RC beam.

VII. Drying Shrinkage Properties

The drying shrinkage of mortar was determined based on IS: 4031 – 1988 (part 10). The drying shrinkage occurs when the concrete or mortar is subjected to drying conditions. It is the loss of water held in gel pores that causes change in volume. To measure the drying shrinkage, the mortar bars of size 25mm x 25mm x 250mm were used. The mortar was mixed with required proportions (CM 1:3) and compacted by hand compaction. Gauge studs were inserted in the bar moulds coaxial with the bar before the mortar was poured into the moulds. After 24 hours, the mortar bar specimens were demoulded and subsequently submerged in water for curing for 7 days. Length of each specimen was measured using a length comparator immediately after curing. Soon after measuring the initial length, the specimens were kept under the laboratory conditions. The length of the specimen was measured at different periods of 7, 14, 21 and 28 days to calculate the drying shrinkage.

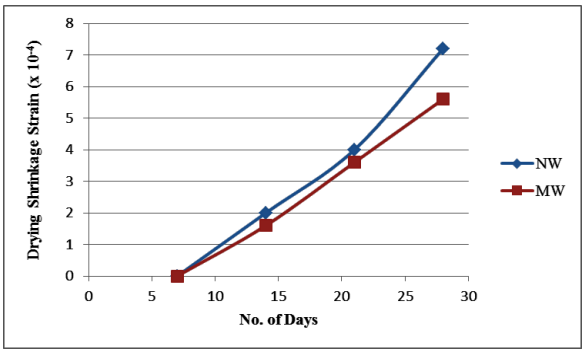


Fig 10 Drying Shrinkage of mortar bar

Drying Shrinkage of the mortar with potable water and magnetized water was measured at different periods. Fig 10 informs that the drying shrinkage is reduced while using

magnetized water due to breakdown of water molecules in the treatment of water.

VIII Conclusion

The water exposed after magnetic treatment is possible the change of the hydration of ions, salts solubility, pH value, which results in changing the rate of corrosion process. The magnetic water used in concrete has the advantage of reducing the hardness of water depends upon its magnetic field intensity also increases the pH value of MW with the reduction of total salinity of water. The magnetic field effects of water increases with increasing magnetizing time after which the properties of MW was constantly increased. The use of magnetic water has the advantage that it has less scale deposition produced in pipes after long use. The concrete prepared by using magnetized water will be cost effective, environmentally accepted and required low maintenance for the devices. The main advantage of using magnetized water in concrete is that increment in the strength properties and also reduction in the cement content from 9 to 11 %. The compressive strength increased up to 25.85% and tensile strength increased up to 29.26%. For further validation, the durability property of concrete using magnetized water need to be investigated.

Acknowledgment

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