Experimental Study on Strength Enhancement of Concrete using Magnetic and Normal Water

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***Abstract*:- The most important challenge for concrete technologists is to improve the properties of concrete. In the last two decades, in Russia and China, a new technology, called magnetic water technology, has been used in the concrete industry. In 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 number of molecules in the water cluster decreases from 13 to 5 or 6, which causes a decrease in the surface tension of water, with an improvement in the workability and strength of concrete.**

Magnetic treatment of water increases the ion solubility and pH. The influence of magnetic flux changes the mode of calcium carbonate precipitation such that circular disc-shaped particles are formed rather than the dendritic (branching or tree-like) particles observed in non-treated water. This technique is mostly used for the softening of water and, for the first time in this research, it has been adopted by the scientists for the production of concrete with improved strength. Some researchers hypothesize that magnetic treatment affects the nature of hydrogen bonds between water molecules which increases the pH and softens the water.

From the refered literature, it has been observed that the concrete made with magnetic water has higher slump values. Also in some cases, the compressive strength of the magnetic concrete samples was higher than that of the control concrete samples (up to18%). The cement content can be reduced by 28% in the case of magnetic concrete.

Result of our project shows increase in compressive strength of concrete around 20% for non recirculated magnetic water specimen and it ranges 25% in case of recirculated magnetic water specimens. Similarly the test conducted on recirculated magnetic water shows change in pH value from 7.8 to 8.7 with increase in recirculation time. The hardness also reduced from 310 to 190 mg/lit due to recirculation of magnetic water

I. INTRODUCTION

In general, adding certain chemicals while mixing concrete is practiced to alter the properties of concrete to obtain a concrete with desired property. But in most of the cases these admixtures 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. The usage of magnetic water while mixing concrete will increase compressive strength and also there will be higher workability for the same water cement ratio. Many researchers proved that the scaling property and corrosion phenomenon in magnetic water is greatly reduced if the water is passed through an intense magnetic flux which in turn changes the physical structure of water molecules and softens the hard water. This softening intensity is based on the magnitude of flux induced. To achieve higher intensity and magnetization, water is made to recirculated by designing a setup with motor and auto transformer. The initial research and scientific testing regarding the application of a magnetic field to concrete manufacturing were commenced in Russia in 1962 for military constructions such as airports and jetties. This research was continued step by step in other institutes, such as the VNLL Jelezobeton Research and Scientific Institute in Russia, and some positive results were found in this regard. Magnetic devices include one or more permanent magnets, which induce changes and effects on ions and molecules. A magnetic field has a considerable effect on clusters of water molecules and causes the decrease of such a mass.

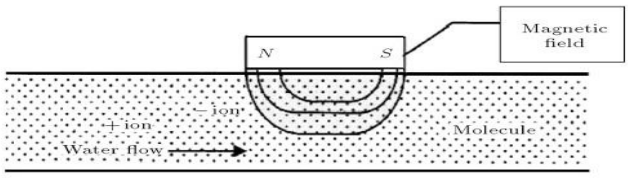


Fig1.1 Effect of a magnetic device with permanent ions passing through its magnetic field (Afshin et al, 2010)

Such a decrease of molecules causes more participation of water molecules in the cement hydration reaction. Also, when water is mixed with cement, cement particles are surrounded by water molecule.

II.MAGNETIC DEVICE

Magnetic fields are produced by the motion of charged particles. For example, electrons flowing in a wire will produce a magnetic field surrounding the wire. The magnetic fields generated by moving electrons are used in many household appliances, automobiles, and industrial machines. One basic example is the electromagnet, which 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.

Permanent magnets do not use an applied electrical current. Instead, 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.

II. MAGNETIC WATER

The water which was subjected to high intense and focused magnetic field is called magnetic water. More than one hundred relevant articles and reports are available in the open literature, so clearly magnetic water treatment has received some attention from the scientific community. The reported effects of magnetic water treatment are varied and often contradictory. The Australian Fluid Energy mentions that 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. Joshi et al 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 magnetic field on water depends on the following three conditions according to Huchler et al,

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

PERMAG AND ITS PROPERTIES

- PERMAG is entirely made up of strong rare earth magnets called Neodymium (N406).
- It is the instrument used to induce the high intense and focused magnetic field.
- Its magnetic field intensity is 9000 gauss power.
- 10000 gauss power= 1 Tesla, therefore magnetic flux density of PERMAG N406 is 0.9 Tesla.
- It removes algae formation and prevents further growth of algae.
- It does not require electricity / batteries / chemicals.
- It requires no maintenance & replacement of parts.

(1)

WORKING PRINCIPLE OF PERMAG

When the **'PERMAG'** units are fitted on a pipeline, the water flowing through the pipe line is subjected to the intense, focused magnetic field. The strong magnetic field, affects the physical structure of the minerals, thereby altering their shape. There is no chemistry involved, only physics. The minerals continue to remain in the water, but now, the altered physical state prevents the minerals from exhibiting hardness, thus the water becomes soft.

Water is a liquid, chemically called H_2O. If we freeze water, it becomes ice, which is a solid, but it is still chemically, H_2O. If we boil it, it becomes a vapour, but chemically it is still H_2O. Water transforms from a liquid to ice, to a vapour (and vice versa), thus exhibiting 3 distinct physical states, while it is still the same chemical. **'PERMAG'** performs in a similar manner, by changing the physical state of the minerals, while maintaining their chemical state. These structurally changed minerals do not stick to any surface and remain suspended in the water in an inactive state and thus exhibit the soft water nature.

INGREDIENTS OF CONCRETE

Cement is used as a binding material for concrete. It is sieved using 90 micron IS sieve. The specific gravity of cement is 3.15. The following are the type and grade of cement used in our project.

- ACC Cement
- Portland pozzolana cement (ppc)
- Grade 53
- Sieved using 90 micron sieve
- Specific gravity of cement=3.15

COARSE AGGREGATE

The coarse aggregate occupies the major volume in concrete. The nominal size of aggregate used in our project is 20mm.

- Aggregate passing through 20mm IS sieve and retained on 17.5mm IS sieve
- The Specific gravity of coarse aggregate is 2.6

FINE AGGREGATE

The fine aggregate act as a gap filling material in concrete. The fine aggregate conforms to zone-II.

- The fine aggregate passing through 4.75mm IS sieve
- The specific gravity of fine aggregate is 2.6

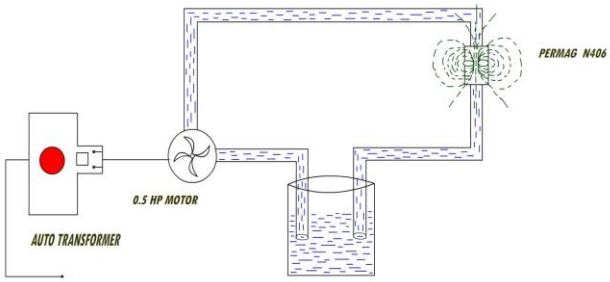
MIX DESIGN

- In general, most of the construction areas use M20 grade of concrete without adding any admixtures. so, here M20 grade of concrete is used to increase the compressive strength using magnetic water. The Design of M20 concrete has been carried out as per IS: 10262-2009.

MAGNETICALLY TREATED AND RECIRCULATED WATER SYSTEM – (EXPERIMENTAL SETUP)

In this process the water is recirculated for one hour to induce magnetic flux in the water by the action of applied

magnetic field. This recirculated water is used for the casting of concrete specimens. The setup to achieve the above mentioned process includes AutoTransformer, 0.5HP General purpose Motor, Permag N406. The autotransformer is used to reduce the supply voltage of the motor, this controls the flow of water in the setup. By this process the hardness in the water is reduced, this enhances the resistance to corrosion of steel reinforcement.



DESCRIPTION OF THE SETUP

The recirculating set up shown above consists of a motor (0.5 HP) which performs the action of lifting water from the container and then make the water to flow through the magnetic flux which is fixed around the tube as shown in fig 5.1.This process of lifting water from the container and allowing it to flow through the magnetic flux is repeated for certain period of time. By doing so the effect of flux induction will be more in water so that the harness in water reduces more. It is also illustrated in literature that the flow velocity should be around 0.6-1.0 m/s, so the instrument named auto-transformer is used in the setup to reduce and maintain the flow velocity within the range specified.

CONCRETE PREPARED USING	COMPRESSIVE STRENGTH (N/mm^2)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
NORMAL WATER	21.5	22	22.6	22
MAGNETIC WATER	26.7	24.5	28	26.4
AVERAGE INCREASE IN COMPRESSIVE STRENGTH AT THE END OF 28 DAYS				20%

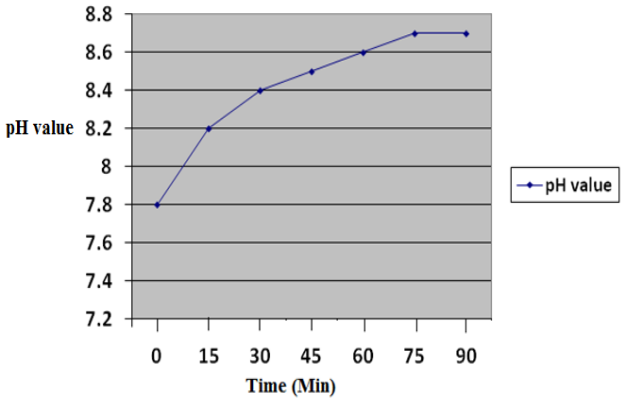
IMPACT OF RECIRCULATION TECHNIQUE ON PROPERTIES OF WATER

pH

pH is the measure of activity of the hydrogen ion. The pH test is conducted for every fifteen minutes of recirculation. pH test is conducted for magnetically treated - recirculated water and normal tap water, the results are shown below,

EFFECT OF pH VALUE ON RECIRCULATION TIME

S NO	MAGNETIC WATER RECIRCULATION TIME (Min)	pH VALUE
1	0	7.8
2	15	8.2
3	30	8.4
4	45	8.5
5	60	8.6
6	75	8.7
7	90	8.7



This graph shows the change in pH value based on increase in recirculation time of magnetic water. Here the graph interprets the result, that increase in recirculating time will considerably increase the pH value. so the increase in pH value will change the nature of water from acidic to basic which decreases the corrosion rate.

HARDNESS

Hardness was originally defined as the capacity of water to precipitate soap. Hard water forms scale, usually calcium carbonate, which causes a variety of problems. . Left to dry on the surface of glassware, silverware, and plumbing fixtures (shower doors, faucets and sink tops), hard water

leaves unsightly scale, called water spots. Scale that forms on the inside of water pipes eventually reduces the water pipes' carrying capacity. Scale that forms within appliances, pumps, valves, and water meters causes wear on moving parts. The most commonly used units include grains per gallon (gpg), parts per million (ppm), and milligrams per liter (mg/L)

TABLE 6.2 EFFECT OF HARDNESS ON RECIRCULATION TIME

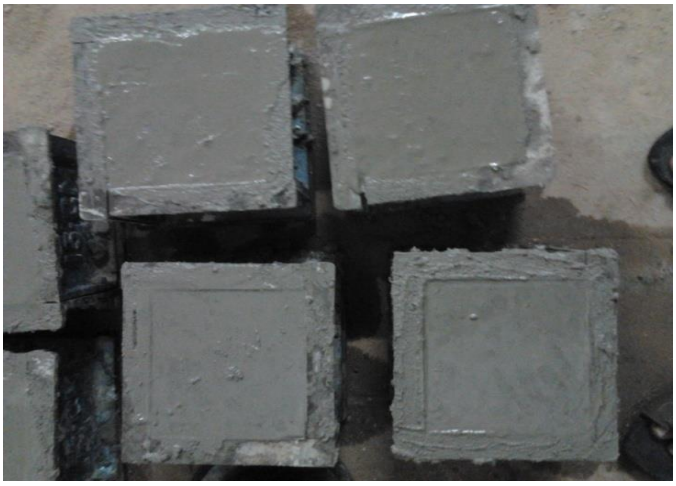
S NO	MAGNETIC WATER RECIRCULATION TIME (Min)	HARDNESS (mg/lit)
1	0	310
2	15	260
3	30	213
4	45	200
5	60	250
6	75	225
7	90	190

The above table shows variation of hardness (in mg/lit) with change in recirculation time. As the recircuating time increases hardness decreases, which shows that induction of magnetic flux in water changes the property of hardness.

PREPERATION AND TESTING OF CONCRETE SPECIMEN USING NORMAL WATER, NON-RECIRCULATED AND RECIRCULATED MAGNETIC WATER

CUBE CASTING AND TESTING

Size of the cube = 150mm*150mm*150mm



Testing the cube (magnetic water) using CTM

TEST RESULTS OF CUBE PREPARED USING NORMAL AND NON-RECIRCULATED MAGNETIC WATER

COMPRESSIVE STRENGTH OF CONCRETE AT THE END OF 28 DAYS

CONCRETE PREPARED USING	COMPRESSIVE STRENGTH (N/mm^2)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
NORMAL WATER	21.5	22	22.6	22
MAGNETIC WATER	26.7	24.5	28	26.4
AVERAGE INCREASE IN COMPRESSIVE STRENGTH AT THE END OF 28 DAYS				20%

TEST RESULTS OF CUBE PREPARED USING NORMAL AND RECIRCULATED MAGNETIC

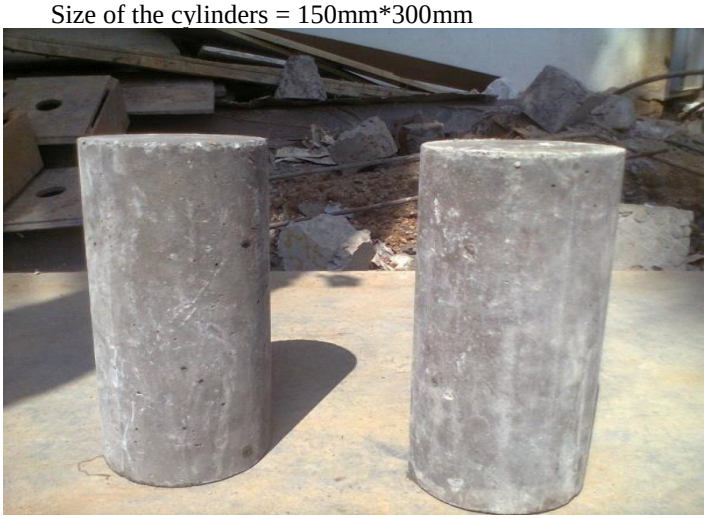
CONCRETE PREPARED USING	COMPRESSIVE STRENGTH (N/mm^2)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
NORMAL WATER	13.9	14.2	14.8	14.3
RECIRCULATED MAGNETIC WATER	16.8	17.5	17.6	17.3
AVERAGE INCREASE IN COMPRESSIVE STRENGTH AT THE END OF 7 DAYS				20.9%

COMPRESSIVE STRENGTH OF CONCRETE AT THE END OF 28 DAYS

CONCRETE PREPARED USING	COMPRESSIVE STRENGTH (N/mm^2)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
NORMAL WATER	23	22.5	22	22.5
RECIRCULATED MAGNETIC WATER	28	27.5	28.5	26.8
AVERAGE INCREASE IN COMPRESSIVE STRENGTH AT THE END OF 28 DAYS				24.4%

CYLINDER CASTING AND TESTING

Size of the cylinders = 150mm*300mm



Testing the cylinder (magnetic water) using CTM

CONCRETE PREPARED USING	SPLIT TENSILE STRENGTH (N/mm^2)			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
NORMAL WATER	2.33	2.78	2.43	2.51
MAGNETIC WATER	3.33	3.1	2.9	3.11
AVERAGE INCREASE IN TENSILE STRENGTH AT THE END OF 7 DAYS				23.9%

TESTING COMPRESSION CYLINDER

RESULT & CONCLUSION:

By conducting various test on the concrete specimens, compressive strength obtained is quite high when compared to normal concrete specimens up to 25%. The increase in strength with the help of recirculated magnetic water is much higher than the magnetic water(with out recirclation The pH value gradually increases with increase in recirculation time which reduces the rate of corrosion. Hardness also considerably decreases with increase in recirculation time.

REFERENCES

[1] K. M., Joshi, and P. V. Kamat, (1966) "Effect of Magnetic Field on the Physical Properties of Water" Pages (620-622).
[2] K. J., Kronenberg, (1985) "Experimental Evidence for Effects of Magnetic Fields on Moving Water" Pages (2059-2061).
[3] Coey JM (2000). Magnetic Water Treatment. J. Mag Mater., 209: 71-78.
[4] B. N. Ke and X. La, Magnetization of water, Measurement Press, Beijing, 1982, pp. 78-82.
[5] Su N, Wu YH, 2000 "Effect of magnetic water on the engineering properties of concrete containing granulated blast-furnace slag"
[6] Nan Su; Wu Y.-H. and Mar C.-Y.,(2003) "Effect of Magnetic Field Treated Water on Mortar and Concrete Containing Fly Ash", *Cement and Concrete Composites*, Volume 25, Issue 7,Pages (681-688).
[7] P. S., Chechel, and G. V. Annenkova, (1972) "Influence of Magnetic Treatment on Solubility of Calcium Sulphate" Pages (60-61).
[8] S.O., Mirumyants, E. A. Vandyukov, and R. S. Tukhvatullin, (1972) "The Effect of Constant Magnetic Field on the Infrared Absorption Spectrum of Liquid Water" PageS (124).
[9] O. T., Krylov, I. K. Vikulova, V. V. Eletskii, N. A. Rozno, and V. I. Klassen, (1985) "Influence of Magnetic Treatment on the Electro-Kinetic Potential of a Suspension of CaCO3" Pages (820-824).