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# INCREASING THE COMPRESSIVE STRENGTH OF CONCRETE WITH USING MAGNETIZED WATER AND COPPER SLAG

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**Abstract**
In this paper we are increasing the compressive strength of concrete with the use of magnetized water also we are using copper slag with magnetized water in concrete for the purpose of increasing the compressive strength and the flexural strength of concrete. In that case we are using 85% cement and 15% copper slag. So, indirectly we are saving 15% cement in concrete.
In very large projects, when cement stored more than 8 months then compressive strength of cement is reduced automatically. So, in that case we can use magnetized water for gaining more compressive strength and also when the project is large, the quantity of cement to be used can be reduced effectively, thus we can have a control on expenditure.
***Index Terms:*** *tap water, magnetized water, copper slag, etc.*

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## 1. INTRODUCTION

Water is an important ingredients for manufacturing as well as curing process of concrete. Water should be clean and free from oil, acid, salt and organic materials which affects the properties of concrete. Generally, the water used for making the concrete is potable tap water. The Indian Standard says that use of water for the manufacturing of concrete should be drinking water but it is not possible in many cases.
In this we are used the water which is passing through the magnetic field that is magnetized water. Basically, the magnetic field can be generated artificially with the help of magnetizers with the help of which we can obtain the magnetic water. Magnetic water was prepared by passing normal tap water through magnetic field generated by electromagnets in physics lab .Water was rotating in electromagnetic field for 120 minutes for 30 litres water. The materials were used in preparation of MFTW electromagnets, gauss meter, 9V toy motor, propeller, plastic straws. This water should be used within minimum 42 hours from its production time as the magnetic properties of the water will gradually start to decrease. This magnetic water can also be found naturally in some places below the ground where the surrounding rocks comprise of magnetic properties. An example of such location is some parts of asia.
Another innovative technique to strengthen the concrete is adding copper slag with magnetized water into the concrete mix. Copper slag is a by-product obtained from the process of manufacturing of copper. Copper slag is widely used in sand blasting industry and it has been used in the manufacture of abrasive tools. Nowadays copper slag, due to cheaper cost, has been used in production of concrete as a partial replacement of cement. Its mechanical and chemical properties makes it suitable to be used in production of concrete. Copper slag exhibits pozzolanic properties since it contains a low calcium oxide content and other oxides content such as Al2O3, SiO2 and Fe2O3. The summation of these three oxides in copper slag is nearly 95% which is more then minimum requirement (70%) of any pozzolana that can be used as a cement binder in concrete.

## 2. EXPERIMENTAL WORK

**Materials:**
The materials used in the experimental program were Cement, Copper slag, coarse aggregates, Fine aggregates, Magnetized Water.

**Cement:**
Ordinary Portland cement of 43 grades conforming to IS: 8112 – 1989 has been used. The physical properties of the cement were studied by conducting appropriate tests. The specific gravity and standard consistency of cement was found out to be 3.6 and 31% respectively. The initial and final setting time of cement was determined as 60 and 400 minutes respectively.

**Copper slag**:
Copper slag used in this experimental work was grinded to match the size of the cement particle. It is black glassy and granular in nature. The specific gravity of copper slag was found to be 3.56. The chemical composition of copper slag are given in Table 1.

**Table.1.Chemical Composition Of Copper Salg**

| Fe as | SiO | Al2O 3 | Ca O | Mg O | CuO | Free Silica | Sulphat es |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fe O | | | | | | | |
| 55 % | 30 % | 5% | 1% | 0.8 % | 0.075 % | <0.5 % | 0.1% |

**Coarse aggregates:**

The coarse aggregate used in this study was crushed (angular) aggregate of size 20 mm and 10 mm conforming to IS 383: 1970 reaffirm 1997. Tests such as sieve analysis, specific gravity and water absorption were conducted for coarse and fine aggregates as per the specification of IS: 383-1970 reaffirm 1997 and IS 2386-1963 reaffirm 1997.

**Fine Aggregates:**

Locally available clean river sand passing through 4.75 mm sieve have been used.

**Magnetized water:**

Water used for mixing the concrete was circulated through a magnetized water-setup as shown in Figure 1. PERMAG N406 magnetizer of strength 1 Tesla was used in the study. A pump was used to pass the water through the magnetizer and the velocity of water passed through the magnetizer was determined as1.32 m/s. The surface tension of tap water was found to be 0.07275 N/m Figure.1.Magnetized Water Setup and it was reduced by 7.77% after magnetization. The parameters of potable tap water and magnetized water were tested and shown in Table 2.

**Table.2.Properties of Tap Water And Magnetized Water Mix design and testing plan**:

| Test Parameters | Test Results | |
|---|---|---|
| | Tap Water | Magnetized Water |
| Surface Tension (N/m) | 0.07275 | 0.06750 |
| Viscosity ($m^2$/sec) | $7.5x10^{-6}$ | $7.13x10^{-6}$ |
| Electrical Conductivity (µs/cm) | 343.20 | 353.30 |
| pH | 8.10 | 8.15 |

Mix design for M25 grade concrete was prepared confirming to IS 10262-2009. Two trail mixes were attempted and the best suitable mix was adopted for casting the concrete samples. Ingredients of different mixes used in the study are given in Table 3.

**Table.3.Ingredients of different mixes for 1 cum of concrete**

| Ingredients | Mix 1 | Mix 2 | Mix 3 | Mix 4 | Remark |
|---|---|---|---|---|---|
| Cement | 365 | 328.5 | 311 | 292 | Total cementitious materials in all mixes were 365 kg/$m^3$. All mixes were prepared with Tap water (MTW) & Magnetized water (MMW). |
| Copper Slag | 0 | 36.5 | 55 | 73 | |
| Water Content | 199 | 199 | 199 | 199 | |
| Fine Aggregate | 862 | 862 | 862 | 862 | |
| Coarse Aggregate 10mm 20mm | 452 739 | 452 739 | 452 739 | 452 739 | |

Mix 1 consists of 100 % Cement. Mix 2, Mix 3 and Mix 4 were replaced with 10%, 15% and 20 % of cement respectively. All other ingredient was kept same in the investigation. Cubes of size 100mm X 100mm X100mm, beams of size 100mm X 100mm X 500mm and cylinders of diameter 150mm and height 300mm were casted using a pan mixer. For compaction of the concrete specimens, each layer was given 25 to 35 manual strokes using 20 mm rod. Concrete specimens were vibrated using vibration table for another 10 to 15 seconds. Then, it was pond cured at room temperature and was tested at 7 & 28 days.

## 3. RESULTS AND DISCUSSIONS

**Effect of Magnetized Water on Workability of Concrete**:

Concrete mixes were checked for workability through slump test. Adequate workability or slump value was achieved for the control mix (TWC1). Due to the low water absorption, high specific gravity and glassy surface of copper slag, more amount of free water was present when copper slag was added in concrete. There was further increase in the slump value when magnetized water was added with copper slag in concrete. This was because of the dispersion effect of magnetized water on cementitious material. From the experimental study, it was observed that the slump of MWC containing copper slag was increased up to 50% in comparison with TWC containing the same amount of copper slag. It was also observed that, same slump value was achieved with reduced water content (10-12%) in MWC containing copper slag.

**Effect of magnetized water on compressive strength of concrete:**

The compressive strength of the concrete samples was measured at 7, 28 and 56 days. The graph was prepared between Compressive Strength vs. % of Copper slag used in the concrete for 7, 28 days as shown in Figure 2.

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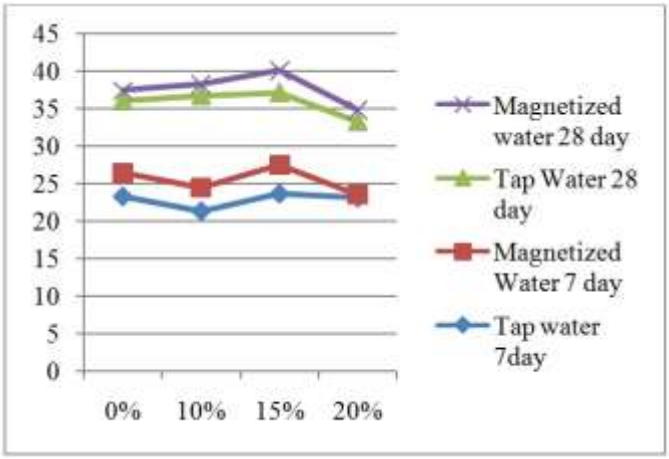


**Figure 2.Comparison of compressive strength for tap water and magnetized water for 7&28 day**

Experimental results of compressive and flexural strength (average of 3 cubes) are tabulated in Table 4. The increase in compressive strength of MWC over TWC was significant at 7 days. It was observed the 7 day compressive strength of MWC with 85% Cement + 15% Copper slag (85C+15CS) as 27.53 MPa which was higher than 23.33 MPa that of control mix (TWC1). This 18% increase in the compressive strength of MWC over TWC1 could be due to the formation of more homogeneous mixture because of using magnetized water that cause complete hydration of cement particles, moreover copper slag provide filler and pozzolanic effect which reduce the capillary pores and the discontinuity in packing. Nan Su et al. (2003) also observed 15% increase in 7 day compressive strength in MWC containing Fly ash.

**Table 4: Exprimental Results**

| Concrete Mix | Average Compressive strength (MPa) | | Average Flexural Strength (MPa) | |
|---|---|---|---|---|
| | 7 days | 28 days | 7 days | 28 days |
| Mix 1 (100%C + 0%CS)<br>TWC1<br>MWC1 | 23.33<br>26.43 | 36.12<br>37.50 | 4.0<br>4.27 | 4.47<br>4.53 |
| Mix 2 (90%C + 10%CS)<br>TWC2<br>MWC2 | 21.33<br>24.53 | 36.80<br>38.26 | 3.87<br>4.20 | 4.40<br>4.54 |
| Mix 3 (85%C + 15%CS)<br>TWC3 MWC3 | 23.70<br>27.53 | 37.20<br>40.16 | 4.13<br>4.40 | 4.60<br>4.73 |
| Mix 4 (80%C + 20%CS)<br>TWC4 MWC4 | 20.14<br>23.16 | 32.87<br>34.80 | 3.73<br>3.80 | 4.33<br>4.40 |

**Effect of magnetized water on flexural strength of concrete:**

The Flexural strength of concrete samples were measured at 7 and 28 days. The graphs were prepared for Flexural Strength against % of Copper Slag in concrete for 7 and 28 days as shown in Figure 3 respectively. Flexural strength of MWC with (85C+15CS) was 4.40 MPa which was higher than 4 MPa of TWC1. The 10% increase in flexural strength of MWC over TWC1 was due to the mutual effort of magnetized water and copper slag. It was also observed that beyond 15% of cement replacement by copper slag in concrete exhibited lesser strength. This could be because of less cementitious material present in the mix and beyond 15% replacement, magnetize water might not support the increase in strength of concrete.

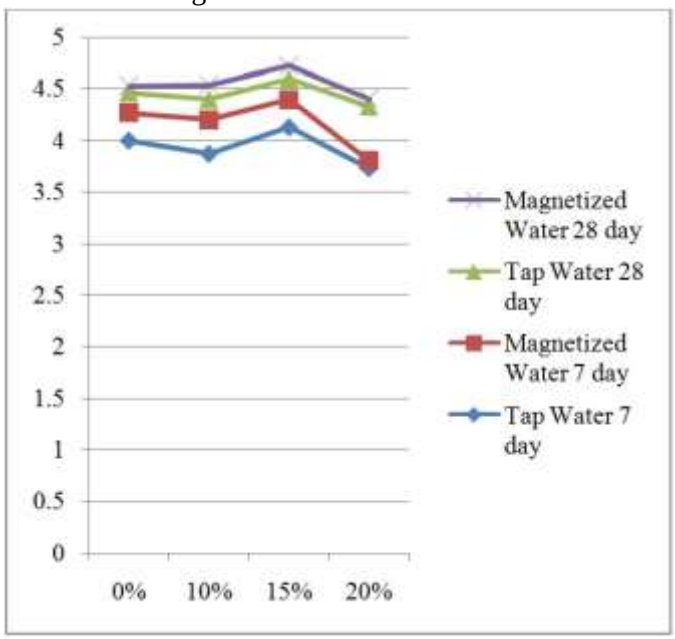


**Figure.3.Comparison of Flexural Strength for Tap water and Magnetized Water for 7&28 day**

**Effect of Magnetized Water on Microstructure of Concrete:**

The engineering properties of concrete with (85C+15CS) was higher comparing to other mixes. Therefore, (85C+15CS) mix was observed under scanning electron microscope after 28 days of curing. Figure 4 (a) and (b) show the Scanning Electron Microscope (SEM) image of concrete prepared with tap water and magnetized water respectively. It was observed that large amount of C-S-H was found in magnetized water in comparison with tap water. It was also observed that larger calcium hydroxide Ca(OH)2 crystals were present in concrete prepared with tap water. However, Ca(OH)2 crystals were smaller and separated in the concrete prepared with magnetized water as cement reacts with the smaller molecules of magnetized water more easily resulting in faster and complete formation of C-S-H. This could be the reason for the increase in strength parameters of MWC.

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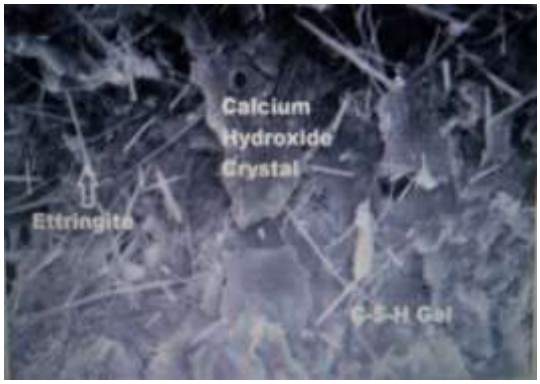


**Figure.4.(a)microscopic image of concrete**

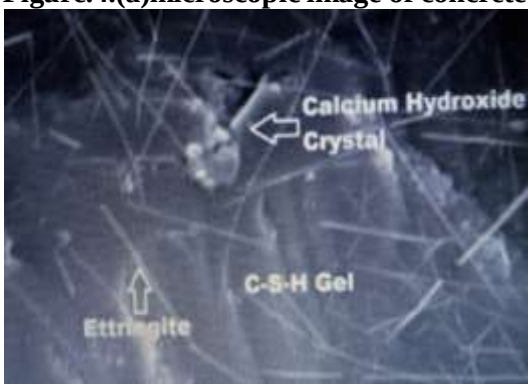


**Figure.4.(b)microscopic image of concrete with copper slag and magnetized water**

## 4. CONCLUSION

Based on the results obtained in this experimental study, and within the limitations of the test parameters, the following conclusions could be drawn. The use of magnetized water improves the workability (slump) of concrete containing copper slag up to 50% over control mix due to low water absorption of copper slag and dispersion effect of magnetized water. Hence, 10- 12% of water content could be reduced without compromising the workability of the concrete. Since magnetized water has improved the flow properties, it could be advantageous to use in SCC mixes as it does not have any setting time issue which is generally found with admixtures used in SCC. The Compressive, Split Tensile and Flexural strength were found maximum in concrete with 85% of Cement + 15% of Copper Slag with magnetized water. Hence replacement could be carried out for effective saving of cement in sustainable construction. Early significant increase in strength parameters of concrete due to the use of magnetized water would be helpful for early removal of formwork of concrete. For high rise structures where time is important, the magnetized water could be the best option for concrete production. The microstructure study shows that large amount of C-S-H at early age in MWC in comparison with TWC.

## REFERENCES

[1] Ahmed SM, Effect of Magnetic water on engineering properties of concrete" journal of Al-Rafidain Engineering, 7(1), 2009, 71-82.

[2] Gholizadeh M and Arabshahi H, The effect of magnetic water on strength parameters of concrete, Journal of Engineering and Technology Research, 3(3), 2011, 77-81.

[3] Goel P, Dr Rakesh Kumar, Magentized Water: An Upcoming Technology for Construction Industry. NBM&CW, 2014, 126-132.

[4] Gorai P, Jana RK, and Premchand, Characteristics and utilization of copper slag a review. Resources, Conservation and Recycling, 39, 2003, 299-313