Investigation on performance of water ion modified cement matrix

Kanuj Thenua 1, M Shanmugasundaram 1,2, S Karthiyaini 1
1 School of Civil Engineering, Vellore Institute of Technology-Chennai Campus, Chennai-600127, Tamilnadu, India
2 E-mail: shanmuga.sundaram@vit.ac.in

Abstract. The water used in preparation of cement composite is going to be altered through magnetization. When the water is kept in magnetic field the additional hardness elements i.e., Ca, Mg and Fe get separated from water. But this separation cannot be done through normal magnetic field. Hence high electromagnetic diffuser or high-end magnets are needed. In this study Neodymium (Nd) - N52 magnets were used which has an atomic number 60. The water kept under the magnetic field for various time periods. The strength variation and development will be studied for mortar on various edges.

1. Introduction
The construction activities throughout the world are causing depletion of our natural resources especially water, so the care should be taken of using water in most efficient way[1]. As the population is increasing, the consumption rate is increased and so the requirements of human[2]. India is the second country in the list of most consumption of cement (284 MT) following China (2386 MT) in 2017[3]. Water is the most important ingredient for the formation of concrete as it causes the heat of hydration as it comes in contact with cement. Some properties of water are changed when we keep it in Magnetic field, but it does not mean that water is magnetized[4]. Clusters are formed in water by means of hydrogen bonds[5].

When water is under the influence of magnetic field, the magnetic force leads to breakage of these bonds and single particles are formed. These particles can easily and efficiently complete the hydration process as compared to normal water and increase the compressive strength[6][7]. Dosage of cement can be reduced by this method and also there is influence in compressive strength[8]. The admixtures quantity can also be reduced which causes less environmental pollution[9].

Acidic and salty water are responsible for disturbing the concrete performance[10]. It has been observed that the samples which are prepared under the magnetic influence gives the values of compressive strength more than that of normal concrete samples which can be increased up to 39%[5].

2. Experimental study
2.1. Materials

| Table 1. Materials. |
|---------------------|
| Material used        | Specifications |
|----------------------|----------------|
| Cement               | JSW cement of Grade 53 |
| Fine Aggregate       | Specific gravity |

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd.
2.1.1. **Neodymium Magnet**

It is rare earth magnet which does not mean that they are in small amount it is because of its geochemical properties[11]. It is super magnet made up of mixture of Neodymium, iron and boron forming a tetragonal crystalline structure[6]. These are easily available in the market. They provide unparalleled levels of magnetism and resistance of demagnetization[12]. Neodymium magnets are 10 times stronger than ceramic magnets[13]. Though these magnets are very useful in various industries like electric motor manufacture, medical science etc., it can also make a huge change in construction industry[13]. Here we are using 15 thin strips having dimensions (40*10*2 mm each)[14][9].

2.1.2. **Sample preparation**

The sample is prepared by keeping the water under the influence of Neodymium magnetic field in centrifuge where water particles comes in contact with magnet while spinning[13].

2.2. **Methodology**

2.2.1. **Apparatus**

- Cube moulds shall be of (70.60*70.6*70.6) mm size confirming to IS: 10080-1982.
- Damping rod

2.2.2. **Proportions**

**Table 2.** The proportion for 10 cubes.

| Material used          | Content |
|------------------------|---------|
| Cement (kg)            | 1.9     |
| Fine Aggregate (kg)    | 5.7     |
| Water content (ml)     | 760     |
| Mix ratio              | 1:3     |
| Water cement ratio     | 0.4     |

2.2.3. **Procedure**

- The whole casting is carried out in laboratory.
- Then the weight of each material is taken.
- Place these materials on a nonporous plate.
- The materials should be mixed with trowel for about a minute before adding water.
- Pour the various samples of water till the sample is mixed thoroughly until it obtains a uniform color.
• The minimum time that should be taken for mixing is not less than 3 minutes.
• The mortar is placed in the first layer in the cube mould and tamped with the tampering rod[15]. Tamping the mortar is to be done for 20 times each time in three layers to avoid honeycomb formation and this process is to be continued till the mould is filled with mortar and after that the mould is to be kept undisturbed for drying,
• After a period of 24 hours, demould the sample and mark the specimen for identification.
• Immediately submerge the cubes in a curing tank and keep there until taken out just prior to test.
• For testing remove cubes 1 day earlier.

Figure 1. Cubes of water exposed for 150 seconds.  Figure 2. Cubes after testing.

3. Result and discussion
For conforming that properties of water are altered we perform pH test on each sample and recorded the values which is shown in Table 3[2].
Table 3. Temperature and pH of exposed water.

| Time period (sec) | Temperature (°Celsius) | pH Value |
|-------------------|------------------------|----------|
| 0                 | 30.7                   | 6.16     |
| 150               | 30.5                   | 6.90     |
| 300               | 30.5                   | 7.32     |
| 450               | 30.3                   | 7.38     |
| 500               | 30.5                   | 7.40     |
| 750               | 30.2                   | 7.42     |
| 900               | 30.5                   | 7.44     |
| 1050              | 30.7                   | 7.42     |
| 1200              | 30.5                   | 7.44     |
| 1350              | 30.5                   | 7.44     |
| 1500              | 30.3                   | 7.45     |
| 1650              | 30.5                   | 7.46     |
| 1800              | 30.2                   | 7.46     |

The increment in pH value as shown in Figure 3 is because of polarization making the atoms behaving as tiny magnets having both poles. This leads to uniform arrangement of atoms.

Figure 3. pH variation.
Table 4. Compressive strength.

| Magnetization Time (sec) | Compressive strength (N/mm²) |
|--------------------------|-------------------------------|
|                          | 7 days | 14 days | 28 days |
| 0                        | 21.61  | 24.07   | 25.51   |
| 150                      | 26.80  | 28.50   | 35.31   |
| 300                      | 26.87  | 29.59   | 35.37   |
| 450                      | 28.57  | 34.97   | 39.05   |
| 500                      | 32.24  | 35.26   | 39.52   |
| 750                      | 33.20  | 37.82   | 39.66   |
| 900                      | 33.81  | 38.78   | 40.68   |
| 1050                     | 33.67  | 37.96   | 40.88   |
| 1200                     | 33.94  | 38.50   | 40.97   |
| 1350                     | 34.08  | 37.96   | 41.09   |
| 1500                     | 34.01  | 38.36   | 41.15   |
| 1650                     | 34.15  | 38.43   | 41.30   |
| 1800                     | 34.01  | 38.50   | 41.32   |

The compressive strength for 7th day, 14th day and 28th day for the various kinds of water i.e., exposed for 0s, 150s, 300s, 450s, 600s, 750s, 900s, 1050s, 1200s, 1350s, 1500s, 1650s, 1800s to magnetic field are presented in Table 4. It is shown in Figure 4 that the compressive strength of cement matrix increases with the increased exposure of magnetized water, and this increase in the strength is due to formation of clusters of cement.

![Compressive Strength](image_url)

**Figure 4.** Compressive strength variation.
4. Conclusion

By following this procedure, the strength of cement matrix is increased without any dosage of admixture. Compressive strength of mortar cubes after 28 days for normal water and sample water is 25.51 MPa and 41.32 MPa respectively. As period of exposure increased the strength is increased accordingly and after certain time period it became stable. pH value also increased with increase in exposure time.

5. Reference

[1] Abdel-Magid T I M, Hamdan R M, Abdelgader A A B, Omer M E A, and Ahmed N M R A 2017 Effect of Magnetized Water on Workability and Compressive Strength of Concrete Procedia Eng. 193 494–500

[2] Siva Konda Reddy B, Ghorpade D G and Rao D 2014 Use of magnetic water for mixing and curing of concrete Int. J. Adv. Engg. Res. Stud. 2249–897493

[3] Salim H, Noushad B, Cheriyan J V, Jose M and Kunju A 2017 Effect of Magnetic Water on Split Tensile Strength and Flexural Strength of M25 Concrete 6031–6037

[4] Bharath S, Subraja S and Kumar P A 2016 Influence of magnetized water on concrete by replacing cement partially with copper slag J. Chem. Pharm. Sci., 9 2791–2795

[5] Ubale P, Rahul Pandit A D and Wadekar A P 2016 Performance Evaluation of Magnetic Field Treated Water on Conventional Concrete Containing Flyash Int. J. Sci. Technol. Manag., 5

[6] Ghorbani S, Tao Z, de Brito J and Tavakkolizadeh M 2019 Effect of magnetized water on foam stability and compressive strength of foam concrete Constr. Build. Mate. 197 280–290

[7] Ghorbani S, Gholizadeh M, and de Brito J 2018 Effect of magnetized water on the mechanical and durability properties of concrete block pavers Materials (Basel) 11 1–16

[8] Ngene B U, Olofinnade O M, and Agomo C E 2019 Effect of magnetized water on the mechanical properties of concrete containing recycled waste glass aggregate Int. J. Eng. Res. Africa 41 103–114

[9] Kotb A 2013 Magnetized Water and Memory Meter Energy Power Eng. 05 422–426

[10] Afshin H, Gholizadeh M, and Khorschedi N 2010 Improving Mechanical properties of high strength concrete by magnetic water technology Sci. Iran.17 74–79

[11] Esfahani A R, Reisi M, and Mohr B, 2018 Magnetized water effect on compressive strength and dosage of superplasticizers and water in self-compacting concrete J. Mater. Civ. Eng. 30 1–7

[12] Soto-Bernal J J, Gonzalez-Mota R, Rosales-Candelas I and Ortiz-Lozano J A 2015 Effects of Static Magnetic Fields on the Physical, Mechanical, and Microstructural Properties of Cement Pastes Adv. Mater. Sci. Eng. 2015 1-9

[13] P E, P E, M E and George S 2016 Comparative Study on Strength Enhancement of Concrete Using Magnetic and Normal Water Int. J. New Technol. Res. 2 263516

[14] Sammer M, Kamp C, Paulitsch-Fuchs A H A, Wexler D, Buisman C J N and Fuchs E C 2016 Strong gradients in weak magnetic fields induce DOLLOP formation in tap water Water (Switzerland) 8 1–19