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Investigation of the Effect of Magnetic Water and Polyethylene Fiber Insertion in Concrete Mix

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Abstract: The features of a concrete mix are determined by the hydration of cement, which is accomplished utilizing the water quality utilized in the mix. Numerous researchers have worked on integrating pozzolanic or nanoparticles to increase hydration processes and impart high strength to concrete. Magnetic-field-treated water (MFTW) has been used in a novel method to enhance the characteristics of concrete. Due to magnetization, water particles become charged, and the molecules inside the water cluster fall from 13 to 5 or 6, lowering the hardness of water and so boosting the strength of concrete when compared to the usage of regular water (NW). Magnetic water (MW) is used in advanced building methods and procedures to improve physicochemical qualities. This study focuses on analyzing water quality standards using physiochemical analysis, such as electrical conductivity (EC), pH, and total dissolved solids (TDS) using the MW at various magnetizations (0.9 Tesla (MW0.9), 0.6 Tesla (MW0.6), 0.3 Tesla (MW0.3). Tests were carried out to assess the fresh, hardened, and microstructural behavior of concrete created with magnetic water (MW) using techniques for microstructural characterization such as Fourier-transform infrared spectroscopy (FT-IR). According to the findings, the magnetic influence on water parameters improved significantly with increasing magnetic intensity. As compared to regular water concrete, the MW0.9 mix increased workability, compressive strength and splitting tensile strength by 9.2%, 32.9%, and 34.2%, respectively, compared to normal water concrete (NWC).

Keywords: normal water; magnetic water; compressive strength; slump; Vebe time

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1. Introduction

Due to declining groundwater levels and a lack of annual monsoon rainfall, most major cities in Jordan are experiencing domestic water shortages. These days, the building sector consumes vast quantities of drinkable water for a variety of reasons. An issue of particular importance in this research is the fact that it takes about 200–300 L of fresh water to manufacture 1 m^3 of concrete. Fresh and hardened concrete qualities are greatly influenced by the water used in their production. Technologists in the concrete industry are starting to take notice of magnetic water's (MW) possible use in the concrete mixing process. In MW, the water is magnetized by being passed through a magnetic field. This leads to a rise in negative ionic hydration and the discovery of a water crystal form that might be hazardous [1]. The study of water chemistry, including mineralogy, the presence of different types of ions, total dissolved solids, and pH, plays a crucial role in the production of concrete. These factors have a significant impact on various mechanical properties of concrete, such as compressive strength, flexural strength, water absorption, workability, and durability [2–4]. Nevertheless, limited investigations have been undertaken regarding the impact of magnetized water on the mechanical characteristics of concrete mixtures. Magnetized water exhibits distinct mechanical, electromagnetic, and thermodynamic characteristics in comparison to conventional tap water [5]. The utilization of magnetized water has been on the rise in various sectors, including industrial, environmental, medical, and agricultural domains, owing to the advancements in magnetic technologies. This surge in usage can be attributed to the distinctive characteristics exhibited by magnetized water.

The process of magnetizing water is a straightforward technique that does not require additional energy when employing a permanent magnet. The installation of a permanent magnet on an existing water tube system eliminates the need for additional energy to magnetize the water [6]. The process of obtaining magnetized water involves the passage of water through a consistent and unchanging permanent magnetic field at a steady velocity. When such an event occurs, certain distinct alterations manifest in the molecular attributes of the entity. The cohesion between water molecules, facilitated by the presence of hydrogen bonds, prevents their complete separation in regular tap water. The entities exhibit a propensity to conjoin with one another, resulting in the formation of aggregates. When regular tap water is subjected to a permanent magnetic field, it has been observed that the size of the water clusters and the quantity of grouped molecules decrease [7,8]. The surface tension of magnetized water is observed to be lower compared to that of regular tap water, and this distinction is quantified using a device known as a tensiometer [9]. The decrease in surface tension has an impact on the hydration and hardening mechanisms of cement particles. The initial stage of the cement hydration process involves the interaction between water and cement, wherein the hydration reaction primarily occurs at the outermost layer of the cement particles. As a result, the cement particles experience the formation of a thin layer of hydration products, which subsequently impedes the ongoing hydration process of said particles [10]. The consequence of this action will impede the progress of enhancing the mechanical robustness of the concrete. The utilization of a permanent magnetic field during the water treatment process serves to hinder the aggregation of cement particles. Additionally, this application facilitates enhanced penetration of water molecules into the cement particles, thereby promoting the advancement of the hydration process within the concrete mixture [11]. As a result, it can be inferred that the inclusion of these additives in the concrete mix will lead to enhancements in its mechanical properties [9–13]. According to previous studies, the magnetization of regular tap water can have a lasting effect for extended periods of time, ranging from hours to days [14]. It has been shown that the compressive strength of concrete may be boosted by as much as 10–23% when using MW instead of normal water (NW) due to a greater degree of hydration of the cement. Because the magnet's strength determines how much force may be amplified, 0.8 or 1.2 Tesla (T) magnets can be used [10]. When MFTW is added to concrete, the material becomes strong after just 7 days [12]. India wastes almost a trillion gallons of water annually on the production of concrete [15]. One of the most promising initiatives to date has been the incorporation of polymeric fibers, particularly polyethylene (PE) fibers [16]. The incorporation of fibers made from polyethylene terephthalate (PET) [17] and polyvinyl alcohol (PVA) [18,19] into the cement matrix increases its plasticity. Specifically, Li et al. [20] used micromechanical models to create strain-hardening cementitious composites (SHCC) that exhibit strain hardening behavior up to several strain% while also providing ultra-fine fracture control (maximum crack width < 60 m) [21]. On top of that, the MW increases the concrete's workability, strength, and durability [22]. Studies have mostly concentrated on finding ways to produce high-strength concrete while increasing its workability by decreasing the amount of water needed as an additive via the use of superplasticizers (SPs) [23]. With a higher water-to-cement ratio, concrete is easier to work with, but it also has less compressive strength. Mixing MW into concrete may increase its workability and strength [24]. Specimens of concrete are cast without a reference NW and with MW of w/c 0.45, 0.5, and 0.55. More hydration results from a shift in bond angle and the orientation of the water structure. For a w/c ratio of 0.55, it has been discovered that adding MW increases the slump value by around 25% while reducing the weight of the concrete specimen by 3%. When utilizing MW to replace cement, the strength increases by 10%, while the amount of cement used is cut in half [25]. The water's physical properties, such as its specific heat and boiling point, are determined by utilizing NW and four varieties of MW. The magnetizing apparatus is a collection of 26 magnets, each of which has a minimum strength of 280 millitesla (mT): MW-1 (100 mT), MW-2 (200 mT), MW-3 (300 mT), and MW-4 (400 mT). MW has a rapid loss via evaporation. MW has a lower boiling point than NW and a maximum magnetization effect of just 300 mT [3]. The influence of MW over NW on concrete mixing results in a 10% decrease in water content and a 30% decrease in SP dose without compromising the strength parameter [5]. Magnetic-field-treated water (MFTW) may be used in concrete mixers to reduce pollution and save money [26]. Fiber-reinforced concrete (FRC) and self-compacting concrete (SCC) are two examples of specialized concrete whose performance has been studied recently with an emphasis on how magnetized water might enhance their properties [27–29]. The purpose of this research is to apply a novel technique for making magnetized water by passing regular water through a magnetic field of strength between 0.3, 0.6, and 0.9 T. This combination of a magnetic device and a vortex within the water generates tiny magnetic fields that push other ions away, keeping them separate and more efficient. Furthermore, the suggested method will aid in enhancing water quality in the concrete industry through water magnetization, which in turn improves the quality and durability of the structures. The main problem for investigating the effect of magnetic water and polyethylene fiber insertion in the concrete mix is the lack of sufficient and reliable scientific studies that have investigated the effect of these materials on concrete properties under different conditions. For magnetic water, limited scientific studies have investigated its effect on concrete properties. Most of the available studies are based on laboratory experiments, and their results may not directly apply to real-world concrete structures. Additionally, some studies have reported conflicting results, making it difficult to draw definitive conclusions on the effect of magnetic water on concrete properties. For polyethylene fibers, there are more studies available, but there is still a need for further research to fully understand the effect of these fibers on concrete properties under different conditions. The use of polyethylene fibers in concrete is a relatively new practice. Some of the available studies may have used different fiber types, lengths, and volume fractions, making it difficult to compare and generalize the results. Therefore, the main problem for investigating the effect of magnetic water and polyethylene fibers insertion in the concrete mix is the need for more rigorous and systematic scientific studies that use standardized methods and materials to investigate the effect of these materials on concrete properties under different conditions. These studies should also provide detailed documentation of their experimental setup, testing methods, and results. They should be published in peer-reviewed journals to ensure the reliability and accuracy of their findings. In this study, we investigated the effect of magnetic water and polyethylene fibers insertion in concrete mix. Through a comprehensive experimental program, we evaluated the mechanical properties, durability characteristics, and microstructural behavior of concrete specimens incorporating magnetic water and various percentages of polyethylene fibers. Our results demonstrate that the addition of magnetic water and polyethylene fibers has a significant influence on the compressive strength, flexural strength, impact resistance, and cracking behavior of the concrete. Moreover, we explored the potential mechanisms behind these observed effects, analyzing the interactions between the magnetic water, polyethylene fibers, and the cementitious matrix.

2. Materials and Methods

2.1. Materials

2.1.1. Physical and Chemical Properties of Water

In a water molecule, two hydrogen atoms are connected to an oxygen atom by a single chemical bond at an angle of 105 degrees. H^+ and OH^- ions comprise the atomic structure of hydrogen molecules in water. In this instance, the magnetic effect is directly associated with the hydrogen bond found in water molecules. It progressively increases the solubility of water ions, influencing physiochemical characteristics like TDS, EC, pH [30]. Table 1 displays the chemical characteristics of NW and MW according to Jordanian standards [31] and Table 2 displays the mix details for magnetic fields.

Table 1. Normal and magnetized water quality parameter values.

Parameter	Normal Water (NW)	Magnetic Water (MW)			Standard Values
		0.3 T	0.6 T	0.9 T	
Total dissolved solids (mg/L)	897	652	621	600	≤1000
Electrical conductivity (μs/cm)	425	401	387	354	
pH	7.89	7.99	8.24	8.37	6.5–8.5

Table 2. Mix details for magnetic fields.

Mix ID	Water Type	Magnetic Field (Tesla)	Percentage of Fibers (%)
NW	Normal	0	0
MW0.3	Magnetized	0.3	0.3
MW0.6	Magnetized	0.6	0.6
MW0.9	Magnetized	0.9	0.9

Electrical Conductivity and Total Dissolved Solids

Using a specialized EC/TDS/Salinity Meter—Hanna-HI2003, Viale Delle Industrie, Italy, we were able to determine the electrical conductivity (EC) and total dissolved solids (TDS) in the NW and MW in units of μs/cm, and mg/L, respectively. Through direct analysis, we were able to determine the TDS values. Standard procedures were used to test the TDS concentrations, and it is hypothesized that the EC value will rise steadily with increasing TDS concentrations [32].

pH Meter

Before and after magnetization, the hydrogen ion activity in water was measured using a pH meter according to the pH/ORP Meter— Hanna-HI2002, Viale Delle Industrie, Italy. All samples were tested for acidity or alkalinity using the method described in [32].

2.1.2. Properties of Concrete

The cement utilized in this research has a specific density of 3.08 g/cm^3, and it is Portland Pozzolan Cement (PPC). Polypropylene fiber (PF) used Master Fiber 012 from the Master Builders Solutions company and the typical properties for PF shown in [33] are added to the mixture as a percentage of cement weight. Specimens will be tested for compression and tensile strength. Synthetic fibers used are polyethylene fibers with a length range of 12 mm. Fibers will be added to the mixer by hand after adding the water to the mixture to minimize clumping and clustering. Results from several tests on this cement's fineness, beginning and final setting time, soundness, specific gravity according to [34], and chemical composition are summarized in the test values shown in Tables 3 and 4, respectively.

Table 3. Physical properties of Portland Cement.

Physical Requirements	Results	Standard Values
Specific Gravity	3.08	3.15
Fineness (Blaine) cm^2/g	4750	-
Soundness (Expansion) mm	3.5	≤10
Initial Setting Time (min)	148	≥60
Final Setting Time (min)	287	-

Tables 5 and 6 display the physical characteristics of fine and coarse aggregate in 25 mm maximum nominal sizes according to the ASTM standard [35,36], and the sieve analysis test was performed to ensure that both aggregate types were well graded [37]. A permanent magnet has been installed in the MW (0.3, 0.6 and 0.9 T). Magnetization charges water particles, which reduces the water's hardness and increases the concrete's strength compared to when regular water is used (NW) and Table 7 display the material quantities for all mixes (1 m^3).

Table 4. Chemical properties of cement.

Chemical Composition	Test Value (%)
Loss on Ignition (LOI)	1.55
Insoluble Residue	7.50
MgO	4.75
SO_3	3.06
Chloride Content	0.03
CaO	53.8
SiO_2	23.5
Al_2O_3	6.30
Fe_2O_3	2.00
K_2O	0.85
Free Lime	1.85

Table 5. The specific gravity and absorption for fine and coarse aggregates.

Type of Test	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.758	2.585
Water Absorption (%)	0.682	0.785
Fineness Modulus Combined (%)	3.00	

Table 6. Sieve analysis for combined aggregates.

Sieve Opening (mm)	Combined Gradation Mix (%)
38.0	100
25	100
19.5	96.9
9.5	55.9
4.75	38.8
2.36	35.8
1.18	28.9
0.600	24.8
0.300	14.7
0.150	4.2
0.075	3.8

Table 7. Material quantities for all mixes (1 m^3).

Mix Identity # (Mix ID)	Total Water (kg/m^3)	Coarse Aggregate (kg/m^3)	Fine Aggregate (kg/m^3)	Cement (kg/m^3)
NW	155	1200	800	420
MW0.3	155	1200	800	420
MW0.6	155	1200	800	420
MW0.9	155	1200	800	420

2.1.3. Microstructure Characterization of Concrete

The Microstructure characterization specifies the water medium's absorption and scattering characteristics. Analyses using an FTIR spectrophotometer determined the number of hydroxide (OH) groups contained in the cement particles. The FTIR spectra were recorded using the KBr pellet method (5% w/sample in KBr) with the FTIR (IRPrestige-21, Shimadzu Incorporation, Kyoto, Japan) instrument.

2.2. Methods

As can be seen in Figure 1, the experiment begins with two types of water (NW and MW) for mixed proportion concrete with a water cement ratio of 0.37.

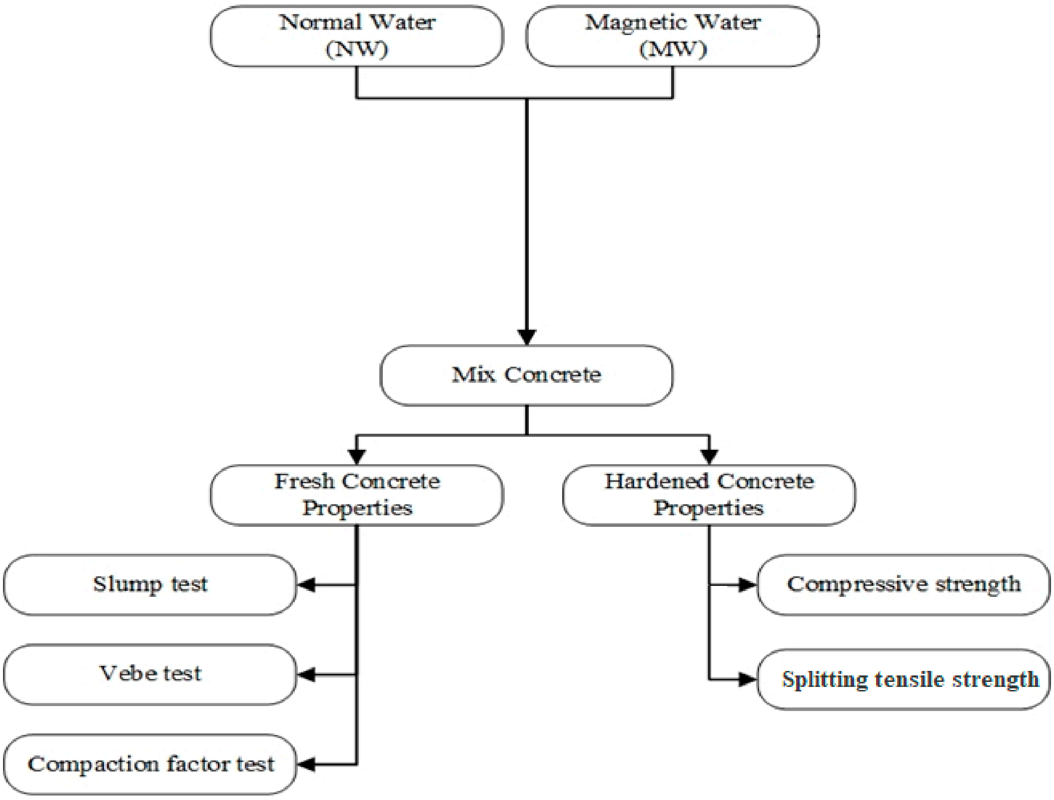

Figure 1. Framework for study.

Slump cone tests (both NW and MW) with magnetic water of varying intensity (0.3 T to 0.9 T, with a period of 0.3 T) and percent of fiber 0.3–0.9% were used to assess how well the materials worked toward the goal of workability. There were three tests performed on newly poured concrete: the slump cone, the Vebe, and the compaction factor (NW and MW) tests. The characteristics of the hardened concrete, such as the compressive strength at 7, 14, 21, and 28 days after casting, were also tested.

2.3. Properties for Fresh Concrete

2.3.1. Slump Test

Slump cone testing is the standard for measuring the fluidity of concrete mixes following ASTM C143 [38]. NW and MW were used in the workability test. The cone was filled with three layers of concrete mixture, and each layer was compacted with the tamping rod 25 times. As soon as the top layer was rounded, the mold was progressively lifted vertically to separate itself from the fresh concrete. Then, the magnetic field intensity (0.3 T, 0.6 T, 0.9 T) and fiber content 0.3–0.9% were changed and the slump values (NW and MW) were recorded.

2.3.2. Compaction Factor Test

The workability of concrete was evaluated by measuring the compaction factor. The apparatus has a hopper at the top, a hopper at the bottom, and a cylinder in-between. As specified by BS EN 12350-4:2019 [39], the test was carried out. The following magnetization at several intensities (0.3 T, 0.6 T, and 0.9 T) with fiber percent, and then the concrete mixture (NW and MW) was made.

2.3.3. Vebe Test

As per ASTM C1170 [40], a Vebe consistometer was used to determine the fresh concrete's workability and consistency. The magnetic field strength was varied while preparing the samples of a new concrete mixture (NW and MW) (0.3 T, 0.6 T, 0.9 T) and fiber percent 0.3–0.9. The purpose of this test was to determine the relative vibrational effort needed to transform a mass of freshly mixed concrete from a conical to a cylindrical shape.

2.4. Properties for Hardened Concrete

2.4.1. Compressive Strength

Concrete cube compressive strength was measured following BS EN 12390-3:2019. Cast in four sets of 48 molds measuring 150 mm on a side (NW and MW), these samples were subjected to testing using compression testing equipment with a capacity of 2000 kN (ELE Machine, Milton Keynes, United Kingdom). Ages 7, 14, 21, and 28 were used in the tests, with the load being delivered at a rate of 6.8 kN/s.

2.4.2. Splitting Tensile Strength

Splitting tensile tests were conducted for each mixture at 7, 14, 21, and 28 days, and it was performed according to ASTM C496 [41]. Three large (150 × 300 mm) cylinders were tested using a compression machine by laying the cylinder horizontally and placing a tamping rod on top of it to form a line load, and the maximum failure load was recorded for each cylinder. The tensile strength was calculated by dividing the maximum failure load by the cross-sectional area of the cylinders.

3. Results and Discussion

3.1. Concrete Physical and Chemical Properties of Water

Water molecules are inverted by MW treatment when the magnetic field detects the proton. Hence, MW concrete undergoes a shift in its physical and chemical characteristics.

3.1.1. Electrical Conductivity and Total Dissolved Solids

The EC and TDS of experimental water varies with the strength of the magnetic field. Figure 2 shows a comparison of the EC and TDS of NW and MW at varying magnetic intensities (NW, MW0.3, MW0.6, and MW0.9, respectively). Both the TDS and EC readings were lower for the MW than the NW, as seen in the Figure 2. When water was subjected to a magnetic field, the total dissolved solids (TDS) concentration dropped, and the electrical conductivity (EC) followed suit [32]. Both the EC and TDS values dropped by as much as 16.7% and 33.1%, respectively, as compared to the NW as a result of the magnetic impact. From the Figure 2, we can also deduce that exposure to a magnetic field resulted in a dramatic decrease in TDS and EC values. In their study, Alkhazan and Saddiq [42] observed a notable decline in the electrical conductivity of comparable water samples as the magnetic intensity and duration increased. The EC of mortar is proportional to the extent to which the cement has hydrated. Alkali salts in the cement and the calcium hydrate dissociate upon contact with water, creating electrically charged ions, which determines the EC of mortar [43]. Because of this, the hydration of cement may be linked to the electrical conductivity of water.

3.1.2. pH Meter

The alkalinity value both before and after magnetization is affected by the pH fluctuation. pH values for NW and MW at 0.3 T, 0.6 T, and 0.9 T magnetic strengths are shown in Figure 3. The pH of NW was measured to be 7.89, whereas the pH of MW0.9 was measured to be 8.37. The pH shift occurred because of the ions in the water. As the pH value rose in response to being exposed to the solution, it follows that the OH ions were to blame [44]. Once a 0.9 Tesla magnetic field was applied, calcium carbonate and other alkalis were formed form hydroxide ions. This raises pH levels naturally, neutralizing excess acidity [45]. On the other hand, alterations in the pH of the bulk solution subsequent to a magnetic treatment have been observed [46,47]. The pace at which the pH was increasing was drastically altered as the magnetization increased. The alkaline state, with its greater surface hardness, lower porosity, and less hydrated structure, reported the maximum compressive strength [48]. Increasing the cement's pH to 13 has a beneficial impact on its workability and compressive strength [49]. The constant ion product of water is changed by the magnetic field, which in turn affects the detachment of the aqueous solution, leading to increased pH values [6]. This is the primary reason why the pH value of magnetized water rises with increasing magnetic value compared to normal water.

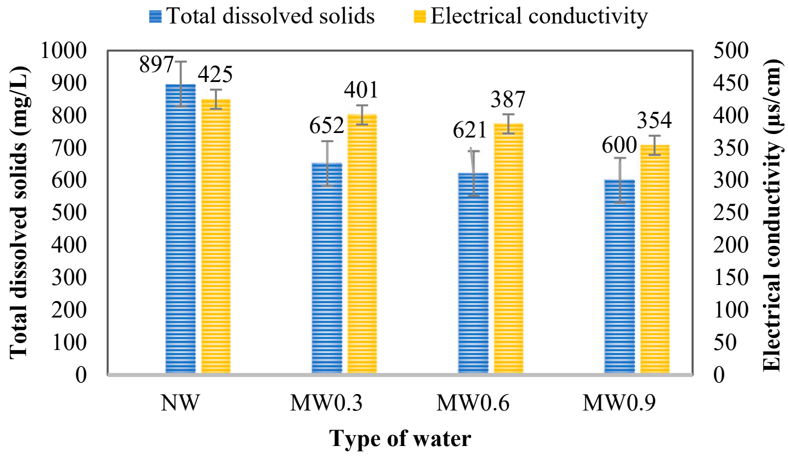

Figure 2. The EC and TDS variations in NW and MW with various magnetizations.

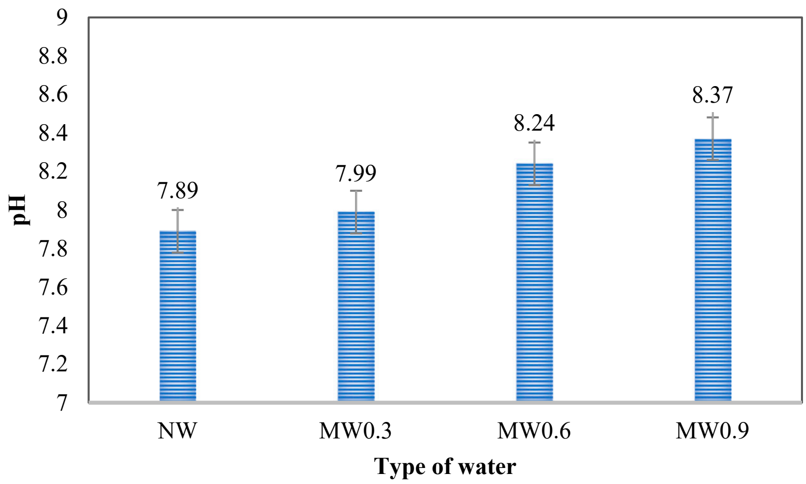

Figure 3. The pH variations in NW and MW with various magnetizations.

3.2. Properties for Fresh Concrete

3.2.1. Slump Test

The workability of concrete is primarily determined by the water–cement ratio, and the test for this, called the "slump cone test", is a widespread and straightforward method. Especially for highly reinforced parts, IS 456-2000 suggests a droop of 75 to 100 mm for medium workability. Slump values for NW and MW concrete mixes made with varying magnetization strengths are shown in Figure 4. The slump value of the mixtures was calculated by averaging the results of three separate tests conducted on each mixture. Slump values were measured to be 80 mm for the NW mix and 130 mm for the MW0.9, with the latter increasing with magnetic field strength. It was discovered that when the magnetic field strength was raised, the created mixtures were more workable. In addition, a compaction factor test was conducted to look for evidence of water demagnetization during vibration; the results showed no such thing, with just a little shift in the mixes' workability parameters. Water in its nano-state exists in clusters, and the size of these clusters depends on the dominant force of the water molecules. This contributes to the heightening of the slump. Due to its macroscopic features, water subjected to a magnetic field causes the cluster of molecules to break apart, with the binding angle between hydrogen atoms dropping from 105 degrees to 103 degrees [50]. Furthermore, the MW diffuses throughout the cement's middle portion during hydration, increasing the concrete's strength [12].

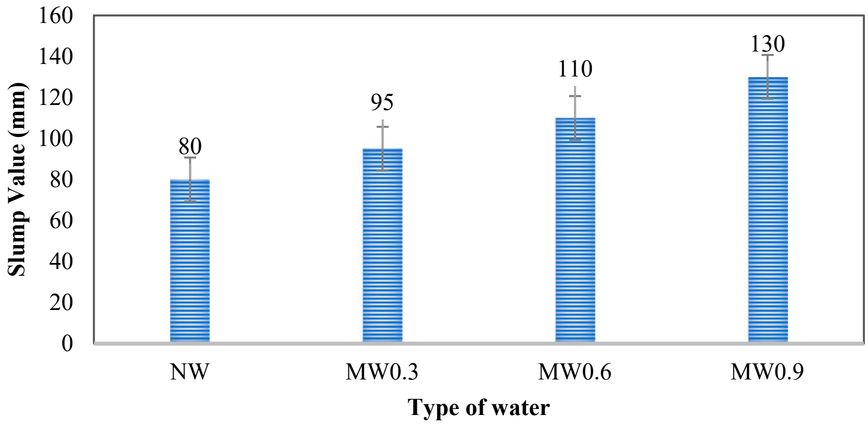

Figure 4. Slump value variations in NW and MW with various magnetizations.

The hydration process occurs when NW is used to make a concrete mixture. Cement particles have a tendency to deposit hydration byproducts on their leading edges, blocking access to the mixture for further hydration. As shown in [51,52], the hydration mechanism of cement is improved when magnetized water is used in the concrete mixing process. Because of this enhanced hydration, the concrete's characteristics are better developed. Including MW into the concrete mix has been shown to boost the concrete's strength and achieve a high degree of hydration of cement. When the strength of the magnetic field is increased, the Lorentz force likewise rises, making the material more malleable [53].

3.2.2. Compaction Factor Test

The compacting factor test was used to determine how easily the concrete could be worked. It can be shown in Figure 5 that the MW0.9 concrete has higher workability than the NW concrete. The compaction factor increased by 9.2% for MW0.9 compared to NW. Magnetic field strength does not affect the concrete's compaction factor. To initiate the MW hydration process without segregation and bleeding on concrete, just a minimal quantity of water must surround the cement particles [54].

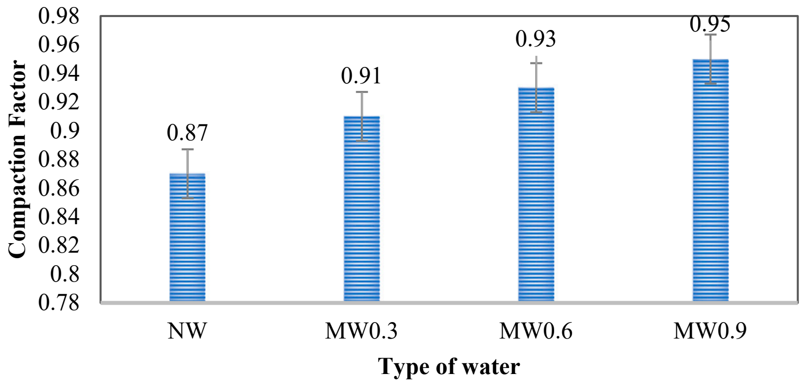

Figure 5. Compaction factor variations in NW and MW with various magnetizations.

3.2.3. Vebe Time Test

In Figure 6, we see the Vebe time of the created concrete mix (NW and MW). As the memory-equipped water attempts to revert to its non-MW state, the Vebe time increases as the strength of the MW's magnetic field rises in experiments [55]. The Vebe test result is best at MW0.9, where the slump is higher than it is in the NW. The MW functions as a super lubricant, penetrating cement particles to improve workability quickly at a range of intensities for magnetic fields [56].

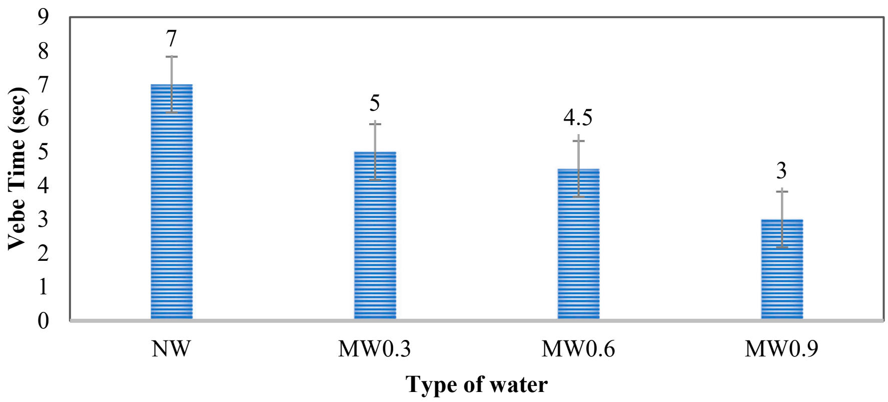

Figure 6. Vebe time variations in NW and MW with various magnetizations.

3.3. Properties for Hardened Concrete

3.3.1. Compressive Strength Test

Compressive strength testing was conducted on concrete cubes cast with NW, MW0.3, MW0.6, and MW0.9. The influence of NW and MW0.9 on the compressive strength of concrete mixes at 7, 14, 21, and 28 days of curing age is shown in Figure 7. On average, three cube specimens were obtained from each mixture to measure its compressive strength. Figure 7 shows that the compressive strength was increased by 32.9% after 28 days of MW mixing compared to NW mixing. As a result, the MWC was able to conserve cement content and shorten the curing time while still achieving the desired result. The obtained result is consistent with the findings of previous studies [54,57]. A more uniform mixing with the MW leads to full hydration of the cement particles, which may explain why MWC is stronger than NWC. In addition, it lessens both the capillary holes and the discontinuity in packing [58]. The basic idea underlying MFTW is that lowering the chemical composition of scaling ($CaCO_3$) leads to tinier water clusters being produced [54,58]. Magnetization aids the hydration process of concrete by making it easier for water molecules to enter cement particles. After then, the concrete mix's mechanical characteristics will have vastly improved. It has been shown that typical tap water may retain the magnetism effect for many hours or even days after being magnetized. As a result, magnetic water facilitates a more efficient hydration process for cement from the start, leading to a sooner strength growth (at day 3). For concrete made with MW, the rate of strength growth was shown to be greater than that of concrete made with NW, particularly at older ages. This might be because the MW distributes water molecules more evenly, improving the hydration characteristics of cement and resulting in greater compressive strength with age [59]. It has been noted that concrete mixes made with the magnetic water have a higher compressive strength, and this may be related to the greater specific area of magnetized water compared to regular tap water [53]. In addition, the cement particles are able to completely react with the water because the magnetized water breaks up the larger water mass into smaller water masses or individual water molecules. Water's hydrogen bonds also help synthesize hydration products and produce a compact C-S-H gel, which increases the material's compressive strength. Similarly, Ghorbani et al. [60] found more crystal formation in the mixes made with MW than NW in SEM micrographs.

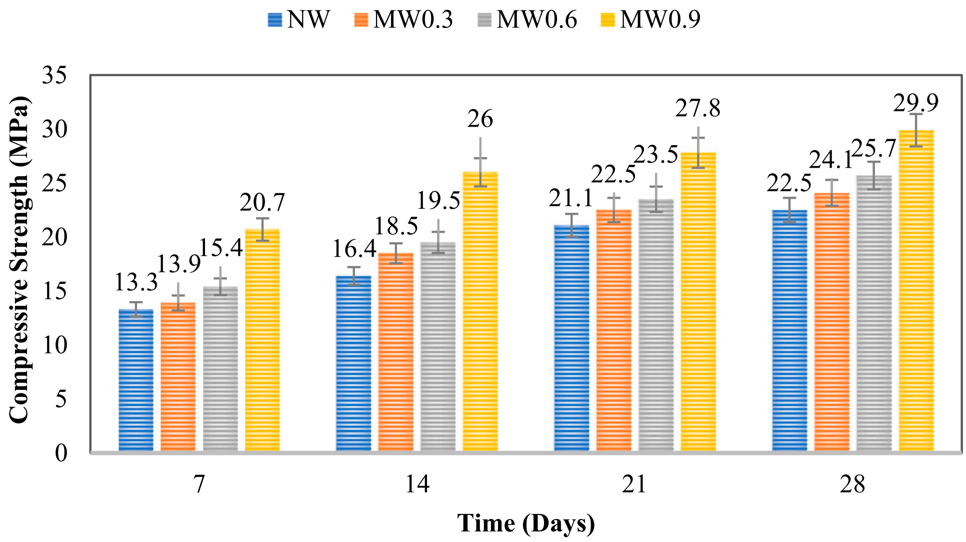

Figure 7. Compressive strength variations in NW and MW with various magnetizations.

3.3.2. Splitting Tensile Strength Test

As shown in the Figure 8, the 0.9% polyethylene fiber specimens resulted in higher tensile strengths, and the 0.9% fiber cylinders maintained their shape better than the control cylinders after testing, which will result in better long-term durability. The splitting tensile strength of all specimens subjected to magnetized water at various ages exhibits a higher value compared to the specimens treated with conventional tap water. The obtained result demonstrates strong concurrence with prior investigations [3,5,10,11].

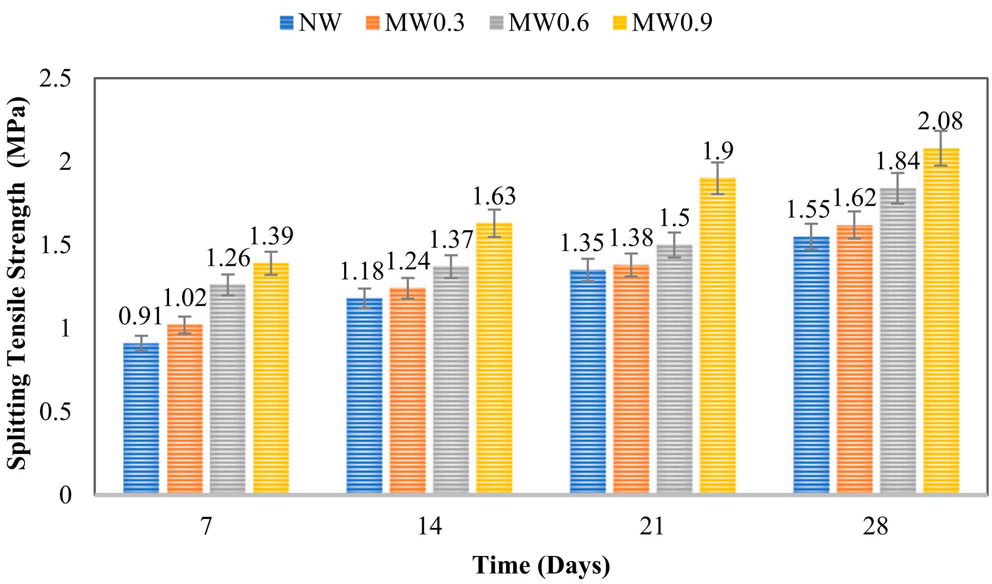

Figure 8. Splitting tensile strength variations in NW and MW with various magnetizations.

3.4. Microstructure Characterization of Concrete

During a 28-day curing period, FTIR spectrum analysis was performed on NW and MW0.9 concrete mixes, and the findings are shown in Figure 9. A band at 3070 cm^{-1} was detected with NW, MW0.9, and Si-OH layer deformation modes in C_3S and C_2S [61]. A peak corresponding to H_2O emerged above 3000 cm^{-1} (3795 cm^{-1} for MW0.9 and 3770 cm^{-1} for NW), indicating the elongation vibration mode of the OH layer.

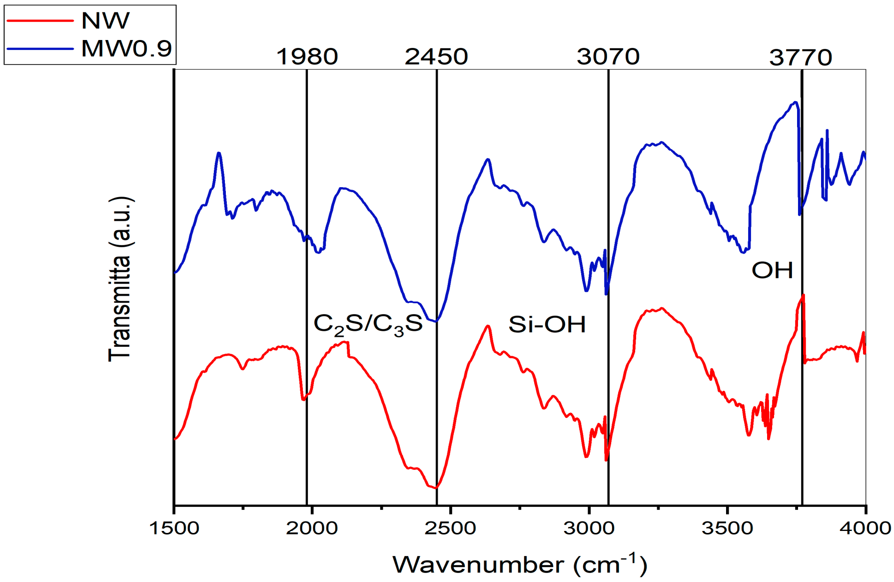

Figure 9. FTIR spectrum of NWC- and MWC-prepared concrete samples.

4. Conclusions

In this study, the water quality criteria were assessed using physiochemical parameters, including electrical conductivity, pH, and TDS, using magnetic water at three different magnetizations (MW0.9, MW0.6, and MW0.3) and compared to those of conventional tap water (NW). With an increase in magnetization, the experimental findings demonstrated that the magnetic field increased the physiochemical characteristics of water.

- It was noticed that the absorption of MW crystals revealed greater molecular integrity inside the crystal. It was also found that the TDS and EC values fell by 33.1% and 16.7%, respectively, after applying the magnetic field of strength 0.9 Tesla.
- Hence, the concrete's workability increased. Increasing the slump value of concrete using MWC assisted in adjusting the cement-to-water ratio, hence decreasing the cement content of the concrete. This study concludes that the compressive strength of the MWC grew by 32.9% in comparison to the NWC and that the MW attained the 28-day strength of the NWC in only 21 days.
- In addition, investigations showed that when the qualities of the MW were improved, cement hydration and workability-related parameters were also improved. Using FTIR research, the hydration products of the NW and MW0.9 concrete mixes were analyzed. In conclusion, it was discovered that the use of the MW for mixing concrete enhanced the physiochemical qualities of fresh and hardened concrete with little water use and curing time.
- Due to water magnetization, the quality of water in the concrete industry improves, which directly improves the quality and life span of structures. The need for magnetic water concreting is urgent, and there is a significant demand to construct sustainable building structures with reduced usage of potable water, thereby increasing the construction industry's sustainability.

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