EFFECT OF MAGNETIZED WATER ON THE PROPERTIES OF CEMENT MORTARS AT THE EARLIER AGES

Adnan Flayih Hassan

Qadisiya University / College of Engineering

Civil Engineering Department

Abstract

This study had been conducted to investigate the influence of magnetized water on the properties of cement mortars such as initial and final setting time, consistency and compressive strength with various water/cement ratios at the ages of 1 and 7 day. Results of (50) specimens with different shapes had been adopted, which represented mortars specimens having compressive strength ranging from (5.5) to (32.5) MPa, initial setting time ranging from (4) to (32) minutes and final setting time ranging from (303) to (546) minutes, by using two types of mixing water , first one is tap water , and the other is magnetized water.The results showed that the use of magnetized water in producing cement mortars lead to increase in the compressive strength and decreasing in the initial and final setting time with compare to use of tap water. Results also showed that the optimum water/cement ratio give best compressive strength under the conditions of this study was (0.45).

Key words: Initial setting time, final setting time, consistency, compressive strength, tap water, magnetized water.

تأثير الماء الممغنط على خواص المونة السمنتية في الأعمار المبكرة

عـــدنان فليح حسن

جامعة القادسية / كلية الهندسة

قسم الهندسة المدنية

الخلاصة :

أجريت هذه الدراسة للتحري عن تأثير استخدام الماء الممغنط على خواص المونة السمنتية, كزمن التجمد الابتدائي و النهائي و القوام و مقاومة الانضغاط باستخدام نسب (ماء/ سمنت) مختلفة , مقاومة الانضغاط تم فحصها بعمر 1 و 7 يوم . تم اعتماد نتائج 50 نموذج ذات مقاومة انضغاط تـــراوحت بين (5.5) و (32.5) MPa , زمن تجمد ابتدائي تراوح بين (4) و (32) دقيقة و زمن تجمد نهائي تـراوح بين (303) و (546) دقيقة وباستخدام نوعين من ماء الخلط , الأول هو ماء الحنفية و الثاني هو الماء الممغنط. النتائج بينت إن استخدام الماء الممغنط في إنتاج المونة السمنتية يؤدي إلى زيادة مقاومة الانضغاط و نقصان في زمن التجمد الابتدائي و النهائي بالمقارنة مع استخدام ماء الحنفية . أما أفضل نسبة (ماء/ سمنت) أعطت أعلى مقاومة انضغاط في ظل ظروف هذه الدراسة كانت (0.45).

Introduction

The water in the cement paste found in three types: free water which found in capillary pores, combined and adsorbed water, where the later types un-evaporation water and contribution in cement hydration. On the other hand the quality of used water plays a significant role: impurities in water may interfere with the setting of the cement, and adversely affect the strength of cement mortar or cause staining of its surface. For these reasons, the suitability of water for mixing should be considered.

In many projects specification, the quality of water is covered by a clause saying that water should be fit for drinking. Such water very rarely contains dissolved inorganic solid in excess of 2000 parts per million (ppm), and as a rule less than 1000 (ppm). The use of potable water as mixing water is generally satisfactory, there are some exceptions, for instance, in same arid areas, local drinking water is saline and may contain undesirable amounts of alkali carbonates and bicarbonates which could contribute to the alkali-silicate reaction[(1)].

Over the past years, research has been shown that magnetic treatment of water may reduce "hardness" caused primarily by calcium and magnesium. Water treatment magnets can prevent deposits of these minerals on the inside of the pipe walls, and descale the existing buildup of solids[(2)].

However, still limited amount of published literature is available about the effect of magnetized water on the properties of Portland cement mortar or concrete.

Significant of research

The main aim of this study is to remarking experimentally the behavior of cement mortars at earlier ages by using mechanism of water magnetizer depending upon bipolar system with different proportions of water/cement ratio ; therefore provide information on compressive, initial and final setting time of this type of cement mortars. Also, to compare with the results of tap water.

Experimental Program

Available materials in Iraq were used in this research to produce cement mortars with mix proportions 1 (cement) : 3 (sand) and by using two types of mixed water , the first one is tap water , and the other is magnetized water with discharge of (0.015 liter/second) . For the two types of water the (W/C) ratios used were 0.4, 0.45, 0.5, 0.55 and 0.6. The specimens tested for consistency, initial and final setting time. On the other hand, the compressive strength was measured for the cement mortar in 1 and 7 days. The specimens at age of (7) days cured in water then tested for compressive strength.

Materials Used in This Research

1.Cement

Sulphate resistance Portland cement type (V) manufactured by Yamama cement factory was used in this study. The essential physical properties of this type of cement were tested in this study , as results of this research refer to that , while the chemical properties of this cement were conformed to standard specifications.

2. Fine Aggregate

Normal natural weight sand from the Wilayt Ali source was used as a fine aggregate, before its incorporation into cement mortar mix, the sand was sieved, and used with a saturated surface dry condition. The properties of the used sand in this study were conformed to the requirement of Iraqi standard specification No.45-1984[3] zone (2) as shown in **Table (1)**.

3. Mix Water

Two types of water were used in this study, the first one is tap water and the second one is magnetized water .The magnetized water was produce by passing of tap water in the bipolar system from the positive north to the negative south perpendicular intersection the lines of magnetize, this mechanism obtained from the use of the magnetizer apparatus locally manufacture by Al-Juthari[4] as shown in the **Fig. (1)**. This apparatus have four circles, each circle contains two magnates with strength 500 Gauss and discharge 2000 liter / hour.

Test Procedures

1.Consistency , Initial and Final Setting Time

The initial and final setting time test were carried out according to ASTM Designation: C 191[5] by using Vicat needle apparatus, **Figs. (2) and (3)**, which consists of a movable rod weighing 500 grams; one end, the plunger end, being 10 mm in diameter for a distance of at least 5 cm and the other end having a movable steel needle, 1 mm in diameter and 5 cm in length. The rod is reversible and can be raised or lowered by the set screw, which has an adjustable indicator. The latter moves over a graduated scale attached to the frame. The cement paste is held in a circular mould, which has an inside diameter of 5 cm and has a height of 5 cm. The average results of three specimens were adopted at each test.

2. Compressive Strength

The compressive Strength test was determined according to BS.1881-part 116 -1989[6]. A cube specimens with dimensions 100 mm were tested by using standard testing machine with a capacity of 2000 KN, **Fig.(4)**.The test was conducted at ages of (1) and (7) day and the average results of three specimens were adopted at each test.

Results and Discussion

The results of the experimental work for this research are listed in Table (2), and then represented in **Figures (5) to (16)**.

Figures (5) and (6) represent the effect of magnetized water on the initial and final setting time respectively. From these figures with addition to **Figures (13) and (14)** can be seen that the increasing of initial and final setting time for both types of mix water with the increasing of water/cement ratio. The percentages of increasing in the initial setting time at W/C = 0.6 with respect to W/C = 0.4 were 220% and 525% for tap and magnetized water respectively, while the corresponding percentages of increasing in finial setting time at W/C = 0.6 with respect to W/C = 0.4 were 45.6 % and 44.8 % for tap and magnetized water respectively. This may be attributed to excessive water quantity and its inverse effect on the setting, where lead to elongation the setting time of cement paste.

Figures (5), (6), (9) and (10) showed that the use of magnetized water lead to reduce the initial setting time with percentage of 60% for W/C = 0.4 and 21.8% for W/C = 0.6 compared with the use of tap water. In the other hand the corresponding percentages of decreasing in finial setting time were 19.2% for W/C = 0.4 and 19.6 % for W/C = 0.6 compared with the use of tap water. This may be attributed to the use of magnet mechanism, which lead to redistribution of the water molecules and change interior angle between them, finally decreasing the surface tension[7], increasing the solubility of water and cause the setting in short time.

Figures (7) and (8) represent the effect of magnetized water on the compressive strength of cement mortar at ages of (1) and (7) day respectively. From these figures can be seen that the use of W/C = 0.45 give higher value of compressive strength in both ages. This is related to the volume of hydration products and the magnitude of calcium silicate hydrate (C-S-H) gel in the total hydration volume; where the C-S-H gel play essential role in the progressive of strength for the cement paste, where the (W/C = 0.4) having lower C-S-H gel due to finding unhydration cement particles in the volume of hydration products, also (W/C > 0.45) give lower C-S-H gel due to finding percent of capillary pores filling with water.

Figures (7), (8), (11) and (12) demonstrated that the use of magnetized water lead to increase the compressive strength at the earlier ages. The percentages of increasing in the compressive strength at age of (1) day due to use magnetized water compared with the specimens made with tap water with W/C = 0.4 and 0.6 were 9 % and 8.3% respectively, while the corresponding percentages values for the compressive strength at age of (7) day were 22.7% and 20%. This performance may be due to shortly setting time of cement paste, increasing its solubility and ability to form gel of calcium silicate hydrate, (i.e. increasing the speed of hydration to form C-S-H gel).

Figures (15) and (16) represented percentage of increasing in compressive strength at ages of (1) and (7) days for two type of mixed water compared with W/C = 0.4. These Figures showed that the percentage of increasing in compressive strength decreased with the increasing of W/C ratio. This behavior may be due to inverse effect of excessive water quantity on the strength, where lead to produce more porosity cement paste and increase the capillary pores filling with water

The consistency test results didn't give apparent performance, where all experimental results (unless cement mortar made by magnetized water with W/C = 0.4) have full penetration of steel needle to the surface of cement mortar, however can be conclude that the magnetized water lead to decrease the consistency, where the result of steel needle penetration at (W/C = 0.4) was equal to zero. This behavior may be related to the decreasing the setting time by using magnetized water.

The best fits lines and curves for the results of this study were draw with **Figures (5) to (8)**, and can be express by the following equations according to the Graphed program:

1. Initial setting time

A. The equation of best fit line for cement mortar made with tap water:

$$Y= 114 X – 36.8 \quad (1)$$

With Coefficient of determination (R-Squared) = 0.976

B. The equation of best fit line for cement mortar made with magnetized water:

$$Y=102 X – 38 \quad (2)$$

With Coefficient of determination (R-Squared) = 0.9633

2. Final setting time

A. The equation of best fit line for cement mortar made with tap water:

$$Y= 882 X – 6.8 \quad (3)$$

With Coefficient of determination (R-Squared) = 0.969

B. The equation of best fit line for cement mortar made with magnetized water:

$$Y= 676 X – 27.6 \quad (4)$$

With Coefficient of determination (R-Squared) = 0.989

3. Compressive strength at age of (1) day

A. The equation of best fit curve from 4^{th} degree for cement mortar made with tap water:

$$Y= -23333 X^4+ 47666 X^3 – 36341 X^2 + 12250 X – 1533 \quad (5)$$

With Coefficient of determination (R-Squared) for 4^{th} degree = 1

B. The equation of best fit curve from 4^{th} degree for cement mortar made with magnetized water:

$Y = -16666\ X^4 + 35000\ X^3 - 27458\ X^2 + 9527\ X - 1225$ (6)

With Coefficient of determination (R-Squared) for 4th degree = 1

4. Compressive strength at age of (7) days

A. The equation of best fit curve from 4th degree for cement mortar made with tap water:

$Y = -76666\ X^4 + 157000\ X^3 - 120008\ X^2 + 40557\ X - 5085$ (7)

With Coefficient of determination (R-Squared) for 4th degree = 1

B. The equation of best fit curve from 4th degree for cement mortar made with magnetized water:

$Y = -66666\ X^4 + 137333\ X^3 - 105633\ X^2 + 35926\ X - 4525$ (8)

With Coefficient of determination (R-Squared) for 4th degree = 1

Conclusions

The following points are fixed depending on the analysis of the results obtained from this study.

1. There is apparently different between the results adopted from used of magnetized water and tap water in producing cement mortar.
2. The initial and final setting times decreasing by using magnetized water.
3. The compressive strength of cement mortars at earlier ages significantly increase by using magnetized water.
4. The optimum water /cement ratio gave best compressive strength under the conditions of this study was 0.45.
5. The consistency of cement mortar decreasing by using magnetized water as a mixed water.

References

1. A.M.Neville ,*"Properties of concrete"*,3rd edition, 183 p,.
2. Master Magnetics Inc., *"Water treatment magnets "*,Watermags. Pdf, Internet file, pp1-4.
3. المواصفة القياسية العراقية رقم 5- 1984, الخاصة بالسمنت البورتلاندي.
4. Al-Juthari , Hiawe Wawa *"Technical paper "* , Qadissiya University, pp 1-3, 2006.
5. ASTM Designation: C 191 *"Standard Test Method for setting Time of Hydraulic Portland Cement by Using Vicat Needle "*, Pdf, Internet file, 50 p.
6. BS.1881. Part 116*" Method for Determination of Compressive Strength of Concrete Cubes "*, British Stander Institution, 1992, 3 p.

7. Al-Juthari, Hiawe Wawa *"Effect of Irrigation Water Quality, Magnetic Water and Potassium Fertilizer Levels on Some Chemical Properties of Soil, Growth and Yield of Corn"*, M.Sc. Thesis, University of Baghdad – College of Agriculture2006, 19 p.

Table (1): Properties of sand used throughout this study

1.Grading	Test result	Iraqi standard specification No.45-1984			
Size of sieve	% passing	Zone 1	Zone 2	Zone 3	Zone 4
10 mm	100	100	100	100	100
4.75 mm	98.6	90-100	90-100	90-100	95-100
2.36 mm	92.0	60-95	75-100	85-100	95-100
1.18 mm	89.0	30-70	55-90	75-100	90-100
600 μ m	51.1	15-34	35-59	60-79	80-100
300 μ m	25.0	5-20	8-30	12-40	15-50
150 μ m	8.80	0-10	0-10	0-10	0-15
2.Deleterious Substations	**Test result**	**Iraqi standard specification No.45-1984 (Allowable limit)%**			
Material	**% Deleterious Substations**	**Natural sand**		**Sand of crushed gravel**	
Lightness materials	0.07	1		1	
Percentage of clay	0.00	1		1	
Materials passing from size 75μ m	2.40	5		15	
Salts as SO_3	0.41	0.5 for the foundation concrete and the parts exposed for water and 0.75 for other		0.5 for the foundation concrete and the parts exposed for water and 0.75 for other	

Table (2): The results of experimental work

W/C	Consistency		Initial setting time		Final setting time		Compressive strength			
	Tap water (mm)	Magnetizer water (mm)	Tap water (min.)	Magnetizer water (min.)	Tap water (min.)	Magnetizer water (min.)	Tap water (MPa)		Magnetizer water (MPa)	
							1 day	7 days	1 day	7 days
0.40	50	0	10	4	375	303	5.5	22	6	27
0.45	50	50	14	7	390	327	7	27	8	32
0.50	50	50	18	13	439	366	6.5	25	7.5	30
0.55	50	50	27	16	489	393	6.5	24.5	7	29
0.60	50	50	32	25	546	439	6	22.5	6.5	27

Figure (1): Magnetizer Apparatus

Figure (2): Vicat Needle Apparatus

Figure (3): Vicat Needle Apparatus with Specimen

Figure (4): Compression Machine

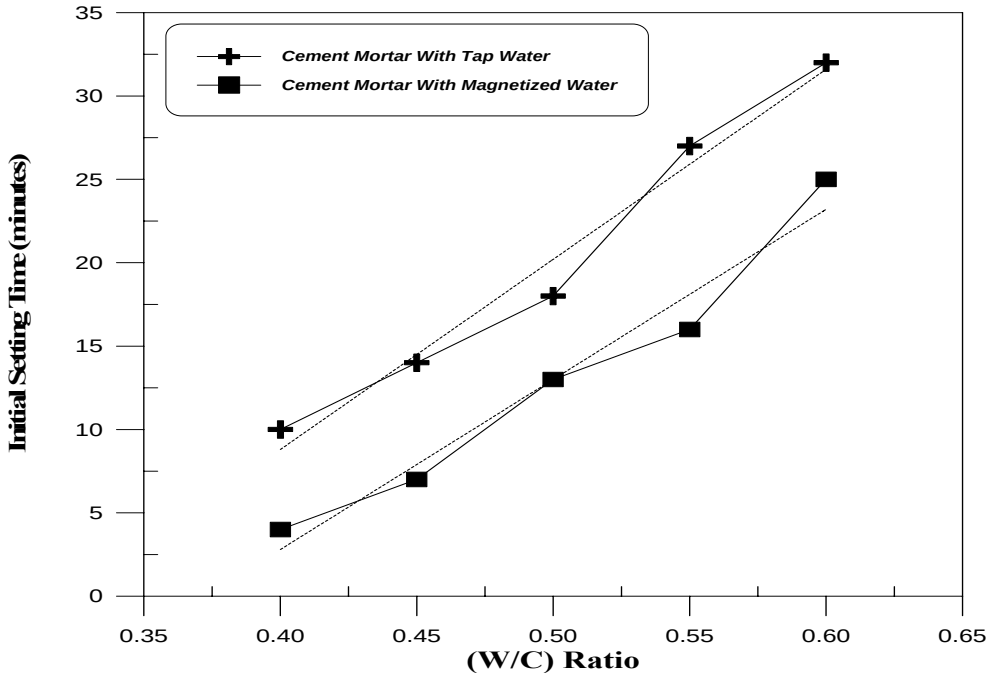

Figure (5): Effect of Magnetized Water on the Initial Setting Time of Cement Mortar.

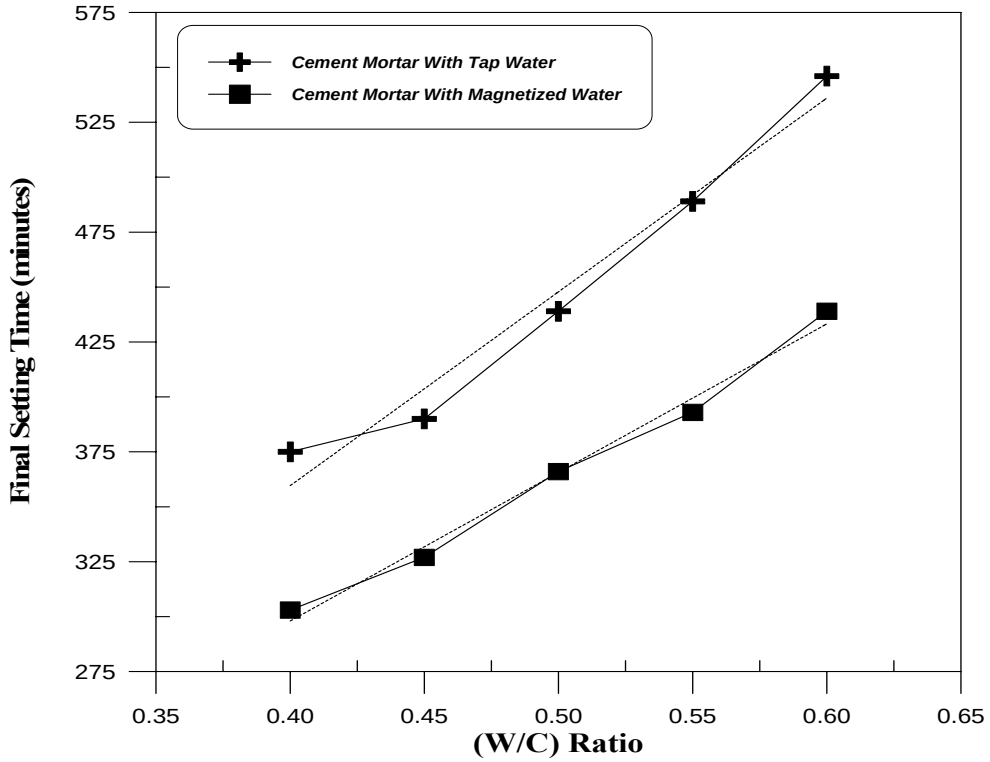

Figure (6): Effect of Magnetized Water on the Final Setting Time of Cement Mortar.

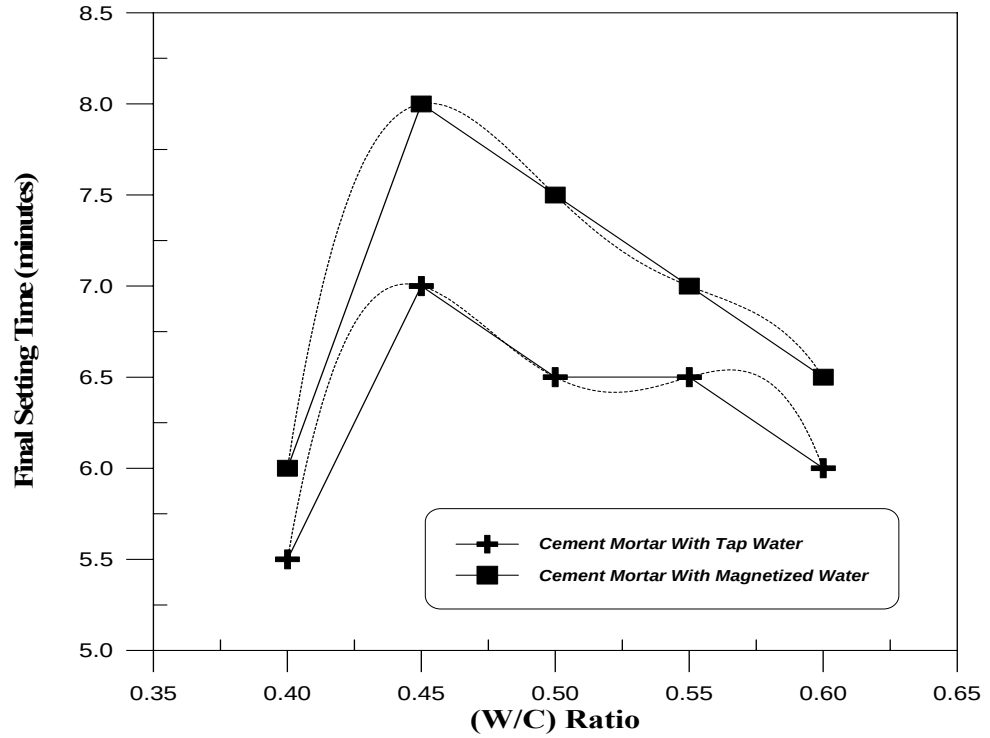

Figure (7): Effect of Magnetized Water on the Compressive Strength of Cement Mortar at Age of (1) Day.

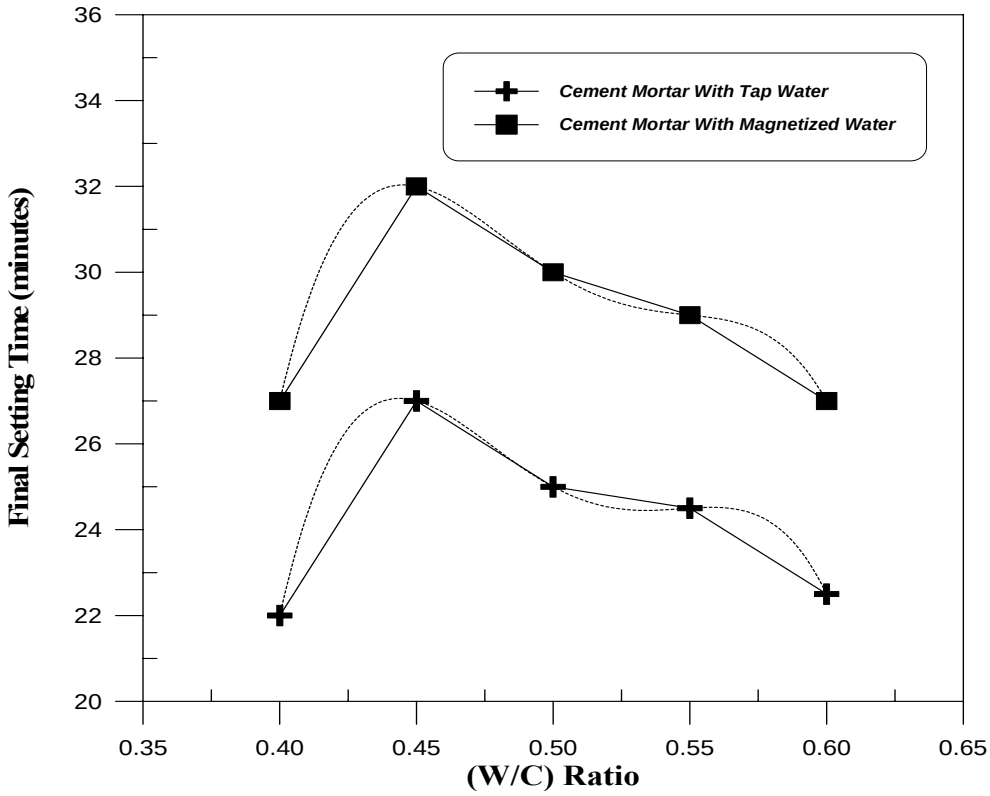

Figure (8): Effect of Magnetizer Water on the Compressive Strength of Cement Mortar at Age of (7) Days.

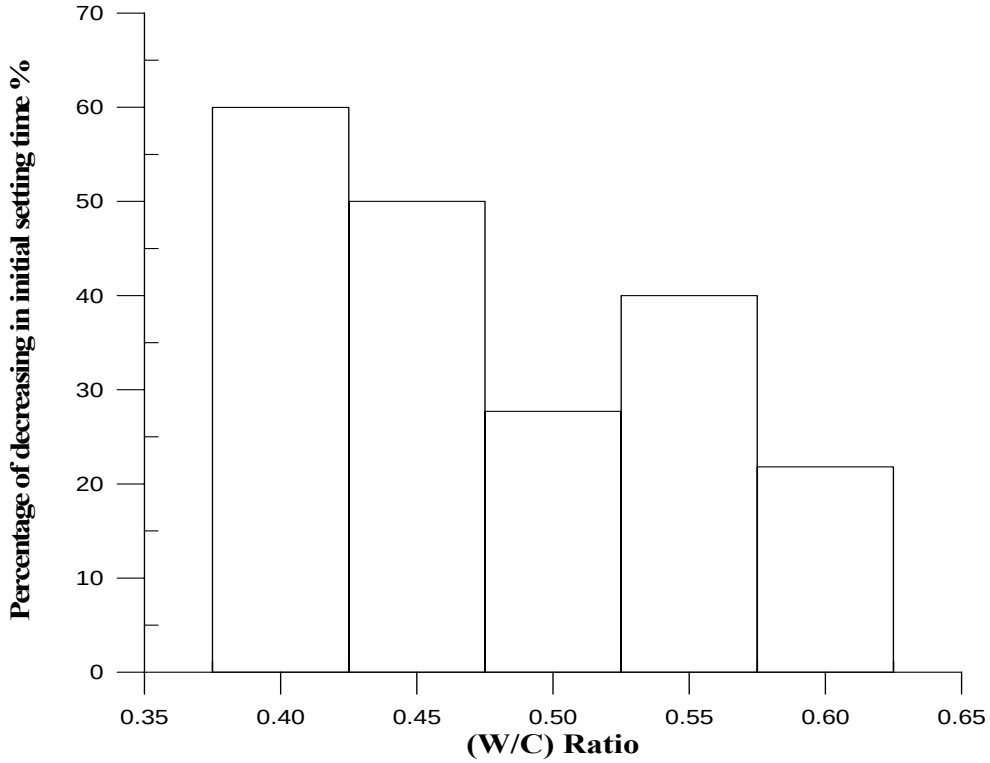

Figure (9):Percentage of Decreasing in Initial Setting Time Due to Use Magnetized Water Compared with Cement Mortar Made by Tap Water

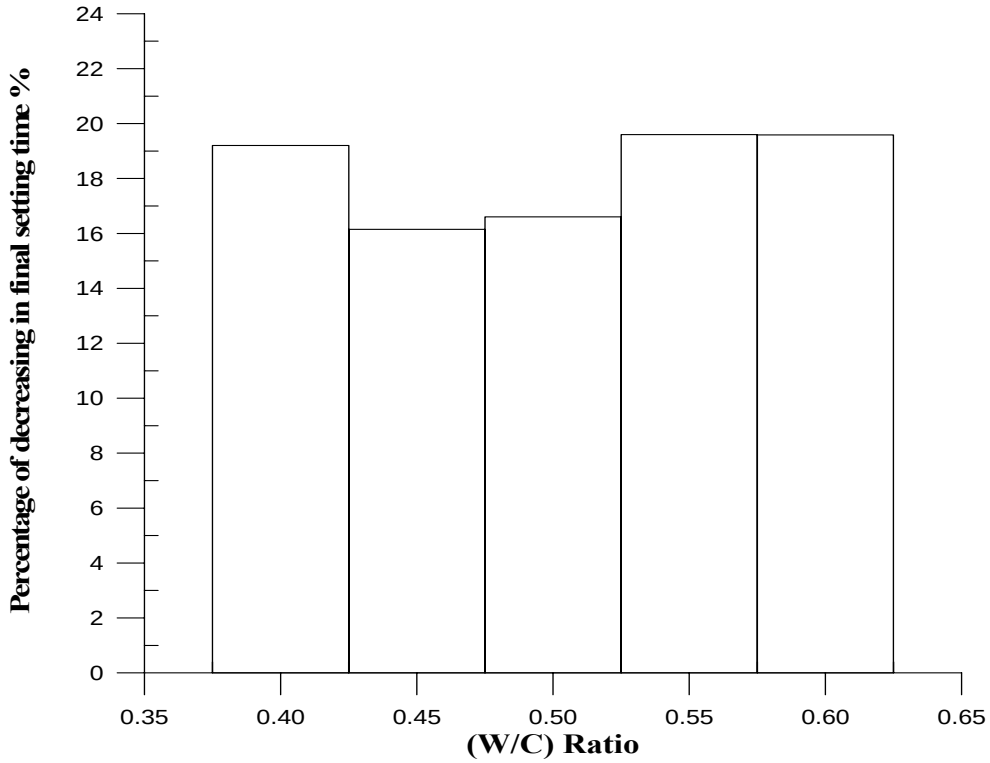

Figure (10): Percentage of Decreasing in Final Setting Time Due to Use Magnetized Water Compared with Cement Mortar Made by Tap Water

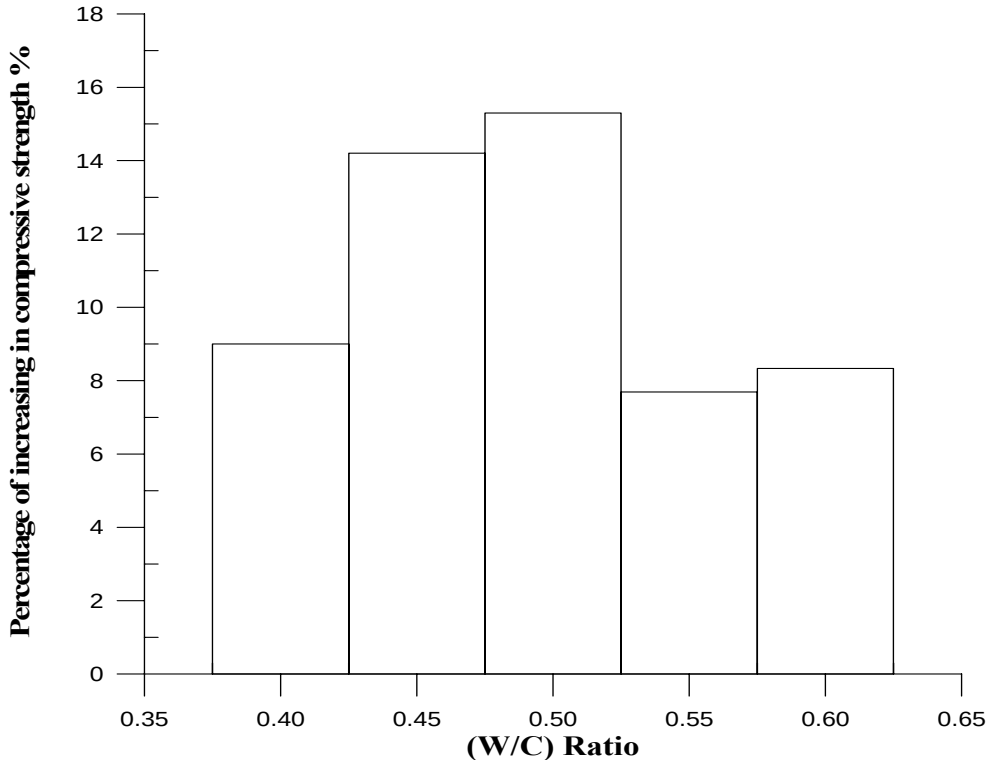

Figure (11): Percentage of Increasing in Compressive Strength at (1) Day Due to Use Magnetized Water Compared with Cement Mortar Made by Tap Water

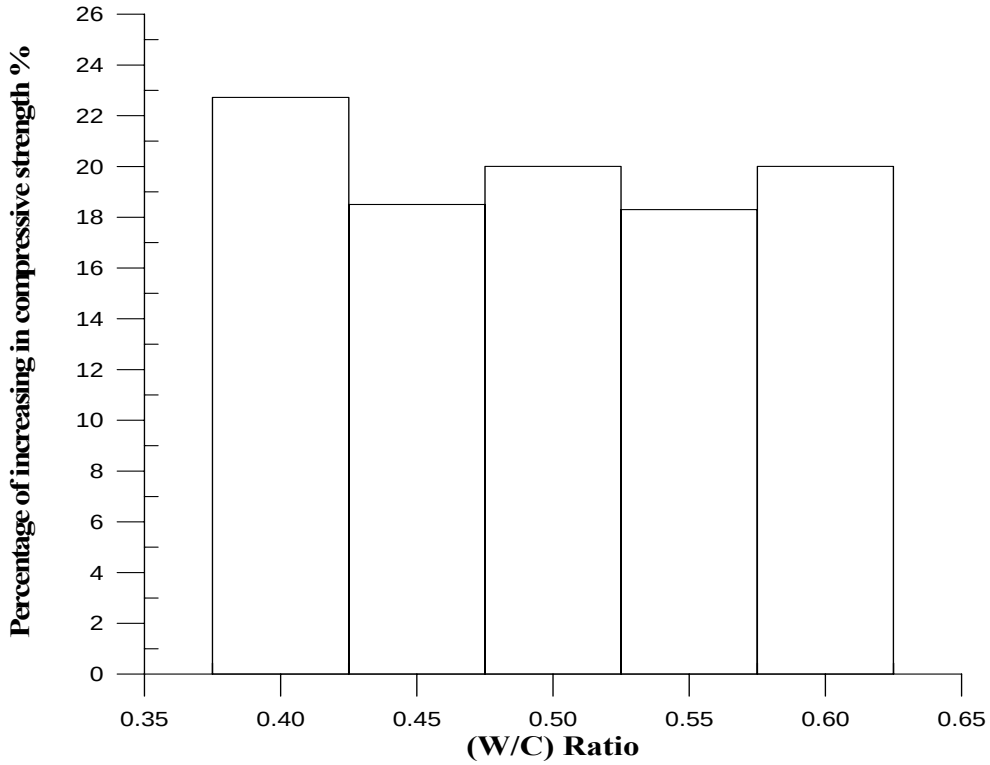

Figure (12): Percentage of Increasing in Compressive Strength at (7) Days Due to Use Magnetized Water Compared with Cement Mortar Made by Tap Water

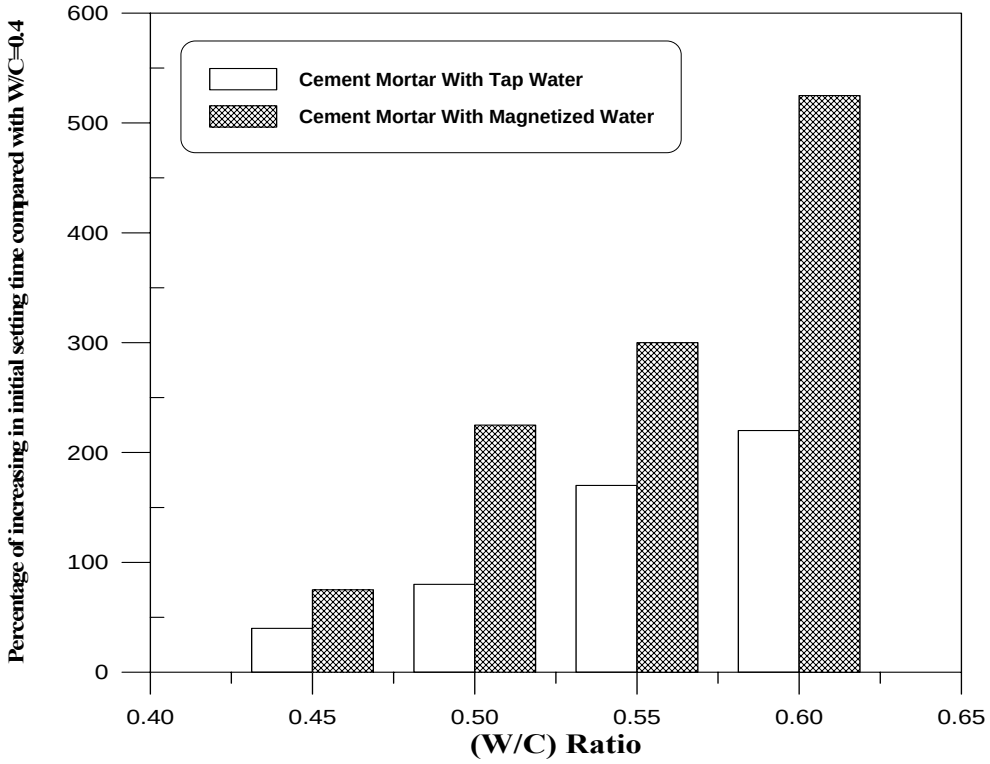

Figure (13): Percentage of Increasing in Initial Setting Time For Two Type of Mixed Water Compared With W/C = 0.4

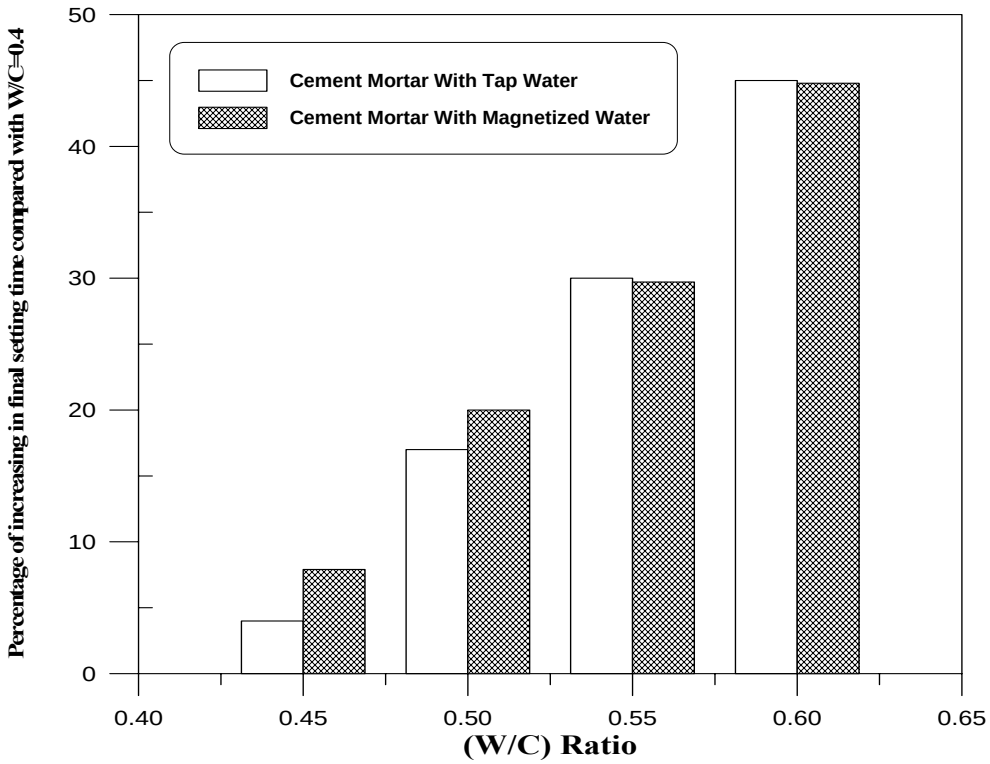

Figure (14): Percentage of Increasing in Final Setting Time For Two Type of Mixed Water Compared With W/C = 0.4

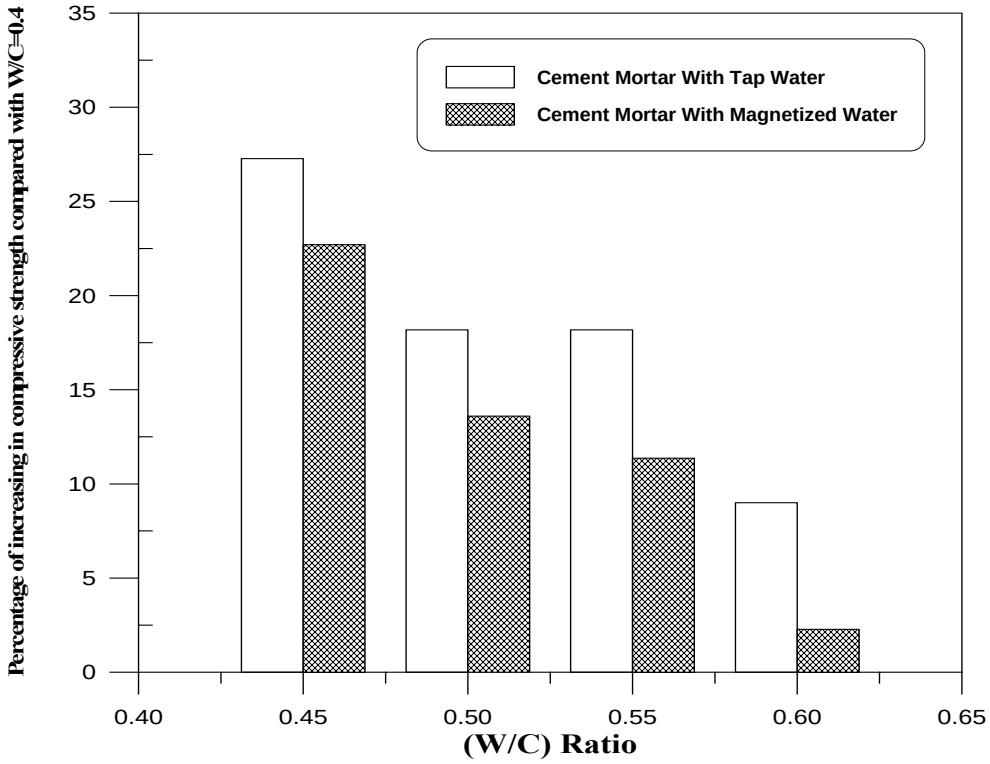

Figure (15): Percentage of Increasing in Compressive Strength at (1) Day For Two Type of Mixed Water Compared With W/C = 0.4

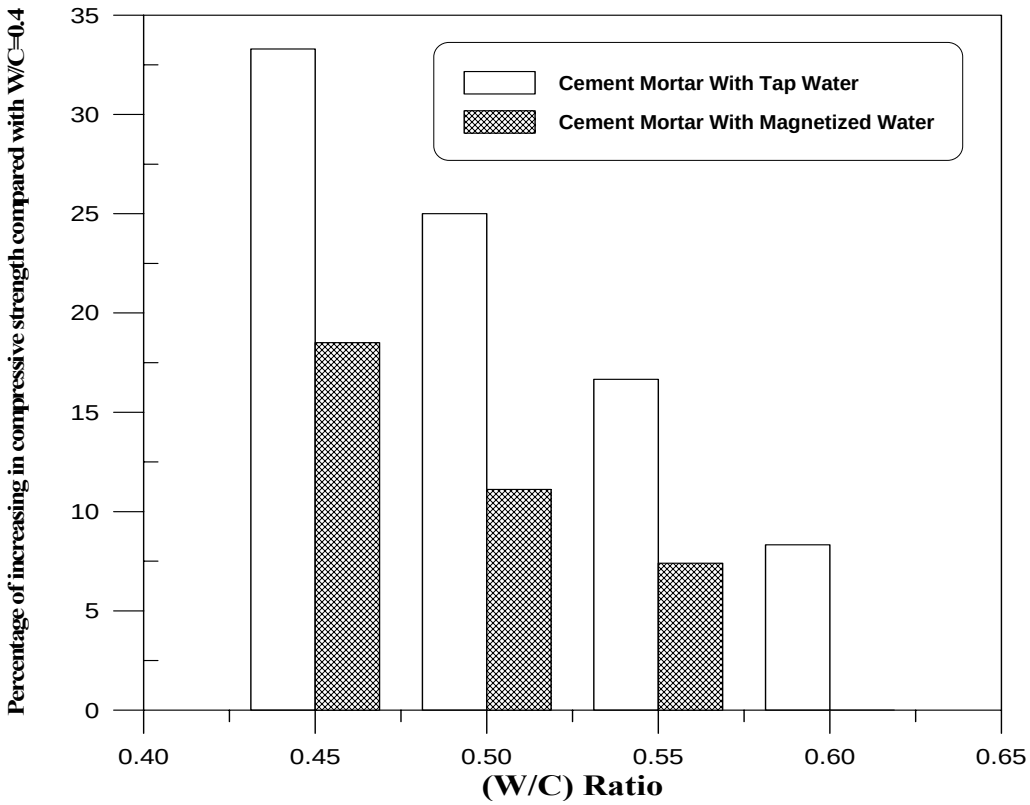

Figure (16) Percentage of Increasing in Compressive Strength at (7) Days For Two Type of Mixed Water Compared With W/C = 0.4