Analysis of the Use of Magnetic Water in the Construction of Structural andNon-Structural Concrete Using Multi-criteria Decision Making Method

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Abstract: Today, concrete is one of the most important and widely used products of human production. Improving the properties of concrete has always been one of the main issues facing structural engineers. Improving the physical properties of water, as one of the main elements of concrete, is one of the ways to improve the properties of concrete. Concrete with magnetic water resistance is called water that it has passed through the magnetic field and its physical quality has changed. Today, in special structures, for example, tall structures that require high pressure, it is not possible to provide the required strength by increasing the aggregate and cement, as a result, materials that are fully compatible with concrete materials and environments and improve compressive strength are needed. Structures that require high compressive strength and at the same time high rebar density, cannot increase the water to cement ratio to achieve the required performance, because it causes a sharp drop in compressive strength. Therefore, to solve this problem (achieving high resistance and efficiency), additives are examined and used. In this research, magnetic water analysis on structural and non-structural concretes has been investigated using multi-criteria decision making method, according to the experiments, magnetic water increases the compressive strength of 28 days by 28% and increases the slump of concrete by 30%, also, using the results of statistical tests such as Friedman test, magnetic water can be considered as one of the main components of concrete, also, using the results of the tests, the main priorities in the formation of structural and non-structural concrete and the expectations we have from structural and non-structural concrete were obtained.

Keywords: Concrete, Magnetic Water, Friedman, Structural Concrete, Non-structural Concrete, Pushing Resistance.
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1. Introduction

Significant advances in concrete technology have been made in recent decades, with the advent of additives, many innovations in the field of concrete have been created. Additives achieve technical advantages and facilitate the implementation of work and save labor and energy.

Today, in special structures, for example, tall structures that need concrete with high compressive strength, it is not possible to provide the required strength by increasing the aggregate and cement, as a result, materials that are fully compatible with concrete materials and environments and improve compressive strength are needed.

2. Research Background

Mazloum et al. (2016) investigated the effect of magnetic water and superplasticizer on concrete. The results show that the use of magnetic water has led to a psychological increase of fresh concrete by an average of 36%. Magnetic water in combination with superplasticizer has a more positive effect on the flow and compressive strength of concrete than magnetic water. Samples without microsilica have a greater effect of magnetic water than samples without microsilica. Increasing the magnetic intensity leads to an increase in concrete flow and compressive strength of 28 and 90 days. In this article, for better results, you can use superplasticizer to reduce costs and examine what is different from superplasticizer, if this difference is small, use a superplasticizer due to the reduction of financial costs. Ehsani et al. (2015) in this study, the effect of calcium carbonate with nano-carbon coating on the mechanical properties and durability of the studied concrete and one of the ways to reduce cement consumption is to replace it with available and environmentally friendly materials have been investigated. This is because the use of cement is increasing despite the destructive environmental effects of its production process, and the growing need of the industry for concrete. In the first phase of this study, the effect of replacement of these materials on initial and final compressive strength, tensile and flexural strength, total water absorption and specific electrical resistance of concrete has been investigated. The results show that the initial and final compressive strength of concrete has remained almost constant despite the reduction of cement due to the use of these particles. The condition of concrete durability parameters such as total water absorption and specific electrical resistance of concrete is also favorable. Due to the economic and environmental justification of reducing cement consumption, in general, the results of this study recommend replacing 3-7% of cement with calcium carbonate with nano-carbon coating. In this report, the reduction of financial costs can be considered and the costs of concrete production can be reduced as much as possible.

Henry et al. (2016) in this study, we examined ordinary Portland cement mixed with very fine steel spray with high zinc oxide content and samples of Portland cement based on paste and mortar with 70.0 wt% steel spray. The results of using these wastes as additives in cement and concrete as a way to reduce cement paste in buildings and infrastructure. Another result obtained by adding this slag to cement reduces the negative effect of slag on the environment. Due to the fact that CO2 produced by the samples made in this research is up to 70%, steel dust transfers 630 kg of CO2 to the air per ton. In addition to steel waste, the amount of cement required and the cost of concrete are significantly reduced. In this report, Henry could study the effect of this additive on different cements to get more results.

Abd al-Mati et al. (2016) investigated powdered glass waste as a substitute for cement and the pozzolanic activity of glass powder and the properties of powder mixed with cement. The use of glass powder as a cement substitute increased the properties of glass powder-modified concrete by 15.0%. Finally, the use of 15% glass powder as a cement additive resulted in an average improvement of 16.0% compressive strength and had a better performance compared to the cement alternative. Abd al-Mati could look at the cost of glass waste.

Zova et al. (2017) on the spontaneous mechanisms of contraction reduction in shrinkage-reducing admixture (SRA) with the ability to reduce water, and cause spontaneous deformation, Hydration rate, internal relative humidity (RH), electrical resistance, concentration of ions and polymeric additives reducing shrinkage in cavity solutions and crystalline fraction of cement pastes were thoroughly investigated. Capillary pressure due to self-drying of cement paste and expansion stress due to crystallization pressure affect how the shrinkage of mixtures decreases in spontaneous deformation of cement paste.

Ahri et al. (2015) evaluated the effect of elapsed time on the rheological and thixotropic properties of self-consolidating concrete (SCC) mixtures containing mineral additives. Concrete samples were evaluated according to the required water, setting time, slump, compressive strength, permeability and resistance to acid attacks. The results show that the use of water sludge in the concrete mix reduces the effect of both fly ash and lubricating cloud. Water sludge with a solids content of less than 6% is suitable for use in the production of concrete with acceptable strength and durability.

3. Research Method

The research method in any research is one of the most basic parts of that research and is one of the important chapters in any scientific research. Perhaps research that has practically lost its effectiveness due to the lack of appropriate methods and has not reached the desired results, therefore, in order to obtain accurate results from a research, it is necessary to use a scientific research method that is appropriate and appropriate to the subject to achieve the desired result with less cost and more speed and accuracy. The choice of research method depends on the objectives and nature of the research subject and its implementation possibilities, research is a process through which one can search for the unknown and gain the necessary knowledge about them.

The method of this research is applied in terms of purpose and in terms of data collection is laboratory, descriptive and survey (exploratory). The present study seeks to test the efficiency of the ingredients in the concrete basin and according to the research questions, one of the best methods of scientific research to conduct this research is to conduct research using the SPSS method. Thus, first several concrete designs were made in different strength classes without the use of magnetic water, it was then broken and tested at 7 and 28 days of age and recorded, then, with the same mixing design that was originally designed, instead of water in concrete, magnetic water with the same amount was used and it was broken and tested again at the ages of 7 and 28 days. After the results of the experiments and according to the purpose of the research, first questionnaires were designed and provided to experts (the first Delphi method), then the questionnaires were collected. After studying and reviewing a number of questionnaires, he returned them to make corrections. After reviews and corrections, the questionnaires were redistributed to experts to give final approval for the distribution of the questionnaire to the statistical community, the approved questionnaire was distributed in a sample selected from the community and after collecting data obtained from the subjects, statistical methods were analyzed and evaluated in SPSS software version.

3-1. Delphi Process in this Research

Step 1: Diagnose and define the problem.

The main issue of this research is the analysis of the use of magnetic water in structural and non-structural concrete using multi-criteria decision making method.

Step 2: Required expertise and selection of Delphi panel.

In this research, an expert is someone who is both academically familiar with structural and non-structural concretes and has written articles in this field. Therefore, three categories of experts were identified in this study:

1. People who are in the field of concrete and magnetic water research article or report.
2. Managers of laboratory companies in Mashhad.
3. Experienced and educated people with high work experience in this field.

Step 3: Prepare the first round questionnaire and arrange the research questions for the interview.

According to the subject and objectives of the research, the general questions of the questionnaire were designed in consultation with the supervisor and some academic experts. The questions were designed so as not to limit the presentation of information by experts. In this study, the questionnaire was presented to a group of experts who could be easily contacted.

Step 4: Analyze the questionnaires and identify the components.
At this stage, the questionnaires were collected and reviewed that after collecting the opinions of experts, the other two indicators were removed.

Step 5: Distribute the second round questionnaire.

In the second round, the mentioned factors were provided to the research experts and they were asked if there were other factors they thought might be influential as a result, two other factors were added to the questionnaire through surveys.

Step 6: Distribute the questionnaire in the next courses.

In the third round, based on the final results of the questionnaires, after saturation and theoretical persuasion in the direction of the study area, a complete questionnaire was prepared to examine the effective factors and rank these factors. For this purpose, a 5-point Likert scale was used and covered a range from very low to very high levels of agreement. The final questionnaire was provided to the laboratory engineers in consultation with the relevant supervisor.

Final step: end the process and prepare a report.

Review and analysis of the consensus between experts and prioritization and indicators obtained and statistical method will be used to analyze the questionnaire which will include inferential and descriptive statistics. In the descriptive statistics method, graphs will be analyzed and in inferential statistics, the data will be analyzed using the required tests such as SPSS.

3-2. Reliability Test Using Cronbach's Alpha

All the questionnaires of the present study were provided to 10 experts in this field, including professors, specialists, etc., to confirm the face and content validity and to express their expert opinions on how to write the questions, the content of the questions, the compatibility of the options with the questions and the compatibility of the content of the questions with the objectives of the research. Then, in order to determine the reliability (internal stability) of the research questionnaires, Cronbach's alpha test using SPSS software version 21 was used and the following results were obtained (Table 1).

Table 1. Reliability of Research Questionnaires

Variable	**Cronbach's alpha**			
pushing resistance	**number of samples**	**Number of questions**	**Structural concrete**	**Non-structural concrete**
Tensile strength	**44**	**4**	**0/770**	**0/786**
Bending strength	**44**	**4**	**0/780**	**0/907**
Cement setting	**44**	**4**	**0/733**	**0/865**
Islamp	**44**	**4**	**0/738**	**0/759**
Durability	**44**	**4**	**0/771**	**0/787**
Compressibility	**44**	**4**	**0/772**	**0/742**

Grading	**44**	**4**	**0/783**	**0/789**
Color	**44**	**4**	**0/708**	**0/783**
Appearance	**44**	**4**	**0/780**	**0/891**
pushing resistance	**44**	**4**	**0/779**	**0/802**

Any value of the Cronbach's alpha index is closer to 1, the internal correlation between more questions and as a result the questions will be more homogeneous. According to the results of Cronbach's alpha test and that all variables had a reliability higher than 0.7, the reliability and validity of research questionnaires can be understood.

3-3. Validity

To assess the validity of the questionnaire questions in the present study, since the Delphi technique was used to design the questionnaire, its validity was confirmed by experts.

According to the nominal size of the aggregate and the amount of weight remaining on each sieve in granulation Excel software, the range and amount of aggregate for the initial design is specified.

Table 2. Grain Range of Materials

Grading of materials and grading range according to Fuller-Thomson modified correction
P = 100% * [(d/D)n - (0/075/D)n] / [1-(0.075/D)n]

sieve	**almond**	**Pea shaped**	**Sand**	**Combined curve**		**n**		
						0.1	**0.35**	**0.67**
1 1/2	100	100	100	=100*x+100*y+100*z=	100	109	118	132
1	89	100	100	=89*x+100*y+100*z=	97	100	100	100
3/4	68	100	100	=68*x+100*y+100*z=	90	94	89	83
1/2	25	99	100	=25*x+99*y+100*z=	77	85	75	62
3/8	3	82	100	=3*x+82*y+100*z=	66	79	67	51
4	1	2	96	=1*x+2*y+96*z=	44	65	49	31
8	0	1	71	=0*x+1*y+71*z=	32	52	35	19
16	0	0	42	=0*x+0*y+42*z=	19	40	25	11
30	0	0	24	=0*x+0*y+24*z=	11	29	16	6
50	0	0	9	=0*x+0*y+9*z=	4	19	9	3
100	0	0	3	=0*x+0*y+3*z=	1	9	4	1
Soft model FM	7.28	6.15	3.55	5.32		Maximum aggregate size mm		
Share of materials	x **30**	y **25**	z **45**	x + y + z = 100		MSA = 25		

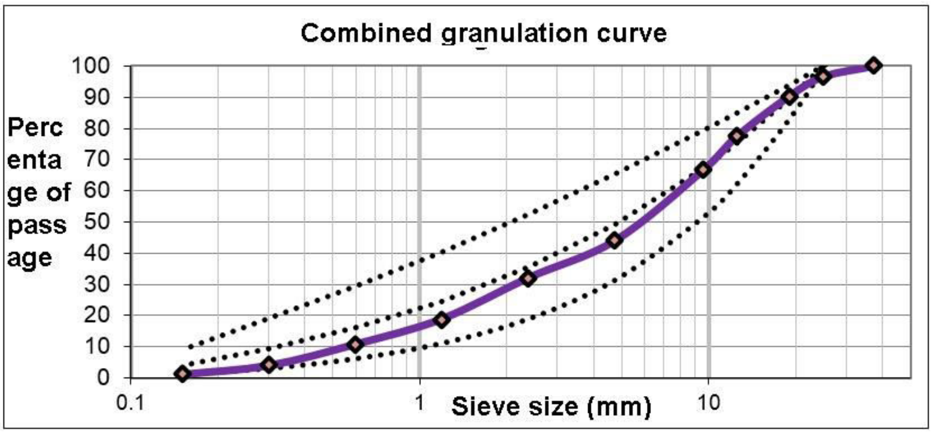

Figure 1. Combined Granulation Curve

In this research, 6 series of sampling is required and each series of 4 cubic molds for each characteristic resistance (C12, C20, C25) 2 series of sampling, two templates are for the 7-day sample and the other two templates are for the 28-day sample. To sample the slump, first divide the slump form into 3 parts and in each stage of concreting, apply 25 blows to compact the concrete and finally, it polishes the concrete surface and gently lifts the slump sample for 7 seconds then, with the ruler, the distance between the slump form with the sampled concrete is measured and read with a ruler. To sample the compressive strength of concrete, first lubricate the walls of the formwork with oil, then place the specifications of each sample under the formwork and divide each formwork into 3 parts and pour concrete in 3 stages and enter 35 blows in a helical way to compact the concrete and in each step, remove the air from the concrete formwork with a few blows to the wall and finally, the concrete surface of the mold is polished and after 24 hours, the sample is taken out of the mold and placed in a pool of water. The concrete is placed under the pressure jack at 7 and 28 days of age and the characteristic strength is read.

According to the steps performed, the final mixing plan of concrete is given in Table 3.

Table 3. Compressive Strength Mixing Plan of Concrete

Water to cement ratio	**Cementk$^{9}/_{cm^2}$**	**Magnetic waterk$^{9}/_{cm^2}$**	**waterk$^{9}/_{cm^2}$**	**Fine graink$^{9}/_{cm^2}$**	**Coarse graink$^{9}/_{cm^2}$**	**Mixing plan**
0.43	200	_____	86	1300	450	C10
.043	200	86	_____	1300	450	C10*
.043	300	_____	130	685	1065	C20
0.43	300	130	_____	685	1065	C20*
0.43	350	_____	150	685	1065	C25
0.43	350	150	_____	685	1065	C25*

4. Results

The results of concrete tensile strength and concrete toughness test are shown in Table 4. The compressive strength of the cubic sample with dimensions of 15 * 15 * 15 is broken after processing in the water pool at the ages of 7 and 28 days.

Table 4. Result of Compressive Strength and Slump of Concrete

Islamp CM	28-day resistance k$^{9}/_{cm^2}$	7-day resistance k$^{9}/_{cm^2}$	Mixing plan
8	135	98	C10
11.5	162	130	C10*
8	226	136	C20
10.5	272	217	C25
8	270	195	C25
10	324	260	C25*

4-1. Descriptive Distribution of Research Variables

Table 5. Descriptive Distribution of Structural Concrete Properties

Factor	**Number**	**Expected average**	**Average views**	**Standard deviation**
pushing resistance	**44**	**3**	**3/95**	**0/211**
Tensile strength	**44**	**3**	**1/59**	**0/520**
Bending strength	**44**	**3**	**2/55**	**0/750**
Cement setting	**44**	**3**	**3/59**	**0/578**
Islamp	**44**	**3**	**3/80**	**0/271**
Durability	**44**	**3**	**3/81**	**0/365**
Compressibility	**44**	**3**	**3/33**	**0/485**
Grading	**44**	**3**	**2/68**	**0/712**
Color	**44**	**3**	**2/78**	**0/433**
Appearance	**44**	**3**	**3/36**	**0/443**

According to Table (5), it can be seen that the average of 6 factors of compressive strength, durability, slump, cement setting, appearance and compressibility is higher than the average expected, therefore, it is descriptively said that 6 factors are of the highest importance in structural concrete.

Table 6. Descriptive Distribution of Non-structural Concrete Properties

Factor	Number	Expected average	Average views	Standard deviation
pushing resistance	**44**	**3**	**3/22**	**0/779**
Tensile strength	**44**	**3**	**1/42**	**0/607**
Bending strength	**44**	**3**	**1/95**	**0/865**
Cement setting	**44**	**3**	**3/23**	**0/570**
Islamp	**44**	**3**	**3/42**	**0/631**
Durability	**44**	**3**	**3/67**	**0/536**
Compressibility	**44**	**3**	**3/25**	**0/431**
Grading	**44**	**3**	**2/61**	**0/618**
Color	**44**	**3**	**2/59**	**0/684**
Appearance	**44**	**3**	**3/17**	**0/466**

According to Table (6), it can be seen that the average of 6 factors of durability, slump, compressibility, cement setting, compressive strength and appearance is higher than the average expected, therefore, it is descriptively said that 6 factors are of the highest importance in non-structural concrete. According to the obtained means, tensile strength, flexural strength and color were the least important in non-structural concretes, respectively.

Table 7. Priorities of Structural Concrete Properties

Factor	Number	Minimum	Maximum	Average views	Standard deviation	Priority
pushing resistance	44	1	1	1	0	1
Tensile strength	44	7	10	9/09	0/86	10
Bending strength	44	4	10	8/23	2/28	8
Cement setting	44	2	8	4/50	1/55	4
Islamp	44	2	5	3/14	1/11	3
Durability	44	2	6	2/59	0/95	2
Compressibility	44	3	7	5/18	1/13	5
Grading	44	4	7	5/23	0/96	6
Color	44	7	10	8/41	0/79	9
Appearance	44	7	9	7/64	0/84	7

Table (7) refers to the priority of effective factors in structural concrete that these priorities are given to the factors by the people present in the research in a continuum from 1 to 10 that a score of 1 has the first priority and a score of 10 indicates the last and tenth priorities in the factors affecting concrete. As can be seen, the factors are listed in Table (8), respectively.

Table 8. Effective Factors in Structural Concrete in Order of Priority of the Respondents

Rank	Factors
1	**pushing resistance**
2	**Tensile strength**
3	**Bending strength**
4	**Cement setting**
5	**Islamp**
6	**Durability**
7	**Compressibility**
8	**Grading**
9	**Color**
10	**Appearance**

According to the participants' answers in the interview, the priorities are slightly different from the priorities obtained through the Friedman test.

Table 9. Priorities of Non-structural Concrete Properties

Factor	Number	Minimum	Maximum	Average views	Standard deviation	Priority
pushing resistance	44	1	7	4/59	2/17	4
Tensile strength	44	1	10	8	2/93	9
Bending strength	44	5	10	9/05	1/68	10
Cement setting	44	2	8	4	1/14	3
Islamp	44	1	7	3/64	1/92	2
Durability	44	1	8	2/41	1/74	1
Compressibility	44	1	8	5/36	2/13	5
Grading	44	2	10	5/50	1/64	6
Color	44	2	10	6/27	2/90	8
Appearance	44	1	9	5/73	2/94	7

Table (9) also refers to the study of the priority of effective factors in non-structural concrete¸ these priorities have been given to the factors by the people present in the research in continuity from 1 to 10, with a score of 1 having the first priority and a score of 10 indicating the last and tenth priorities in the factors affecting concrete. As can be seen, the factors are listed in Table (10), respectively.

Table 10. Effective Factors in Non-structural Concrete in Order of Priority of Respondents

Rank	Factors
1	**pushing resistance**
2	**Tensile strength**
3	**Bending strength**
4	**Cement setting**
5	**Islamp**
6	**Durability**
7	**Compressibility**
8	**Grading**
9	**Color**
10	**Appearance**

4-2.Inferential Statistics

A set of methods is used to deduce the characteristics of a large group or community using data from a sample. Often the researcher's main goal is not to learn about small groups, rather, he is interested in obtaining the necessary information about the community from which he chose this small group through the findings (small group), researcher's goal is to generalize the principles and findings.

4-2-1.Inferential Statistics Identifying the Factors Affecting Structural Concrete and Non-structural Concrete

In this section, the questionnaire of the present research is reviewed and analyzed. The present study has 2 questionnaires. The first questionnaire measures the factors affecting structural concrete and the second questionnaire measures the factors affecting non-structural concrete. Each of the available questionnaires consists of two separate parts. In the first part, the descriptive information of the participants in the study, including age, work experience, position and degree were questioned and in the second part of the questionnaire, 10 categories of factors affecting concrete are included pushing resistance: Tensile strength, Bending strength, Cement setting, Islamp, Durability, Compressibility, Grading, Color, Appearance has been measured using a 5-point Likert scale from (very low) to (very high) and following results were obtained from the analysis of questionnaires.

4-3. Test the Hypotheses

First test:
H_0: There is no difference between the factors affecting structural concrete in terms of prioritization.
H_A: There is a difference between the factors affecting structural concrete in terms of prioritization.

Table 11. Result of Friedman Significance Test

Dimensions	Description
Number	**44**
The square is two	**202/061**
Degrees of freedom	**9**
Significance level	**0/000**

The result of this test is significant at the level of 99% confidence, ie at the level of 1% error (significance level P = 0.000) therefore, the null hypothesis is rejected and we conclude that there is a difference between the factors affecting non-structural concrete in terms of prioritization.

Table 12. Prioritization of Variables based on Friedman Test

Factors affecting non-structural concrete	Average rating	Rank
pushing resistance	6/59	5
Tensile strength	1/66	10
Bending strength	2/98	9
Cement setting	6/60	4
Islamp	7/48	2
Durability	8/45	1
Compressibility	6/68	3
Grading	4/57	7
Color	4/09	8
Appearance	5/91	6

According to the results of Friedman test and Table 12, the average rank of each of the effective factors in non-structural concrete has been determined.

Table 13. Effective Factors in Non-structural Concrete in Order of Priority

Rank	Factors
1	Durability
2	Islamp
3	Compressibility
4	Cement setting
5	pushing resistance
6	Appearance
7	Grading
8	Color
9	Bending strength
10	Tensile strength

In Table 13, using the results of Friedman test, the factors affecting non-structural concrete are ranked in order, which shows that durability, slump and compressibility were the most important factors. Also, tensile strength, flexural strength and color were in lower ranks than other factors and were in less important degrees.
Third test:

H_0: There is no difference between the applications of magnetic water in the factors affecting structural concrete in terms of prioritization.

H_A: There is a difference between the application of magnetic water in the factors affecting structural concrete in terms of prioritization.

Table 14. Prioritization of Magnetic Water Application in Factors Affecting Structural Concretes based on Friedman Test

Variable		Average	Rank	Number	The square is two	Degrees of freedom	Significance level
Pushing resistance	The amount of cement	3/45	1	44	98/663	3	0/000
	Water to cement ratio	3/14	2				
	The amount of aggregate	2/25	3				
	Magnetic water	1/16	4				
Tensile strength	The amount of cement	2/11	4	44	25/080	3	0/000
	Water to cement ratio	2/30	3				

	The amount of aggregate	2/61	2				
	Magnetic water	2/98	1				
Bending strength	The amount of cement	2/41	3	44	24/137	3	0/000
	Water to cement ratio	2/55	2				
	The amount of aggregate	2/30	4				
	Magnetic water	2/75	1				
Cement setting	The amount of cement	3/23	2	44	95/829	3	0/000
	Water to cement ratio	3/43	1				
	The amount of aggregate	1/43	4				
	Magnetic water	1/91	3				
Islamp	The amount of cement	2/73	2	44	78/339	3	0/000
	Water to cement ratio	3/66	1				
	The amount of aggregate	1/93	3				
	Magnetic water	1/68	4				
Durability	The amount of cement	3/41	1	44	99/682	3	0/000
	Water to cement ratio	2/95	2				
	The amount of aggregate	2/55	3				
	Magnetic water	1/09	4				
Compressibility	The amount of cement	2/75	2	44	54/784	3	0/000
	Water to cement ratio	2/59	3				
	The amount of aggregate	3/20	1				
	Magnetic water	1/45	4				
Grading	The amount of cement	2/57	2	44	99/193	3	0/000
	Water to cement ratio	1/91	3				
	The amount of aggregate	3/86	1				
	Magnetic water	1/66	4				
Color	The amount of cement	3/16	1	44	63/049	3	0/000
	Water to cement ratio	2/55	3				
	The amount of aggregate	2/95	2				
	Magnetic water	1/34	4				
Appearance	The amount of cement	3	1	44	74/108	3	0/000
	Water to cement ratio	2/91	2				
	The amount of aggregate	2/77	3				
	Magnetic water	1/32	4				

The results of all tests are significant at the level of 99% confidence, ie at the level of 1% error (significance level P = 0.000), therefore, the null hypothesis is rejected and we conclude that there is a difference between the application of magnetic water in the factors affecting structural concrete in terms of prioritization.

According to the results of Friedman test and Table 14, the average and rank of magnetic water in each of the effective factors in structural concrete has been determined.

Fourth test:

H_0: There is no difference between the applications of magnetic water in the factors affecting non-structural concrete in terms of prioritization.

H_A: There is a difference between the application of magnetic water in the factors affecting non-structural concrete in terms of prioritization.

Table 15. Prioritization of Magnetic Water Application in Factors Affecting Non-structural Concrete based on Friedman Test

Variable		**Average**	**Rank**	**Number**	**The square is two**	**Degrees of freedom**	**Significance level**
Pushing resistance	The amount of cement	3/23	1	44	51/860	3	0/000
	Water to cement ratio	2/77	2				
	The amount of aggregate	2/39	3				
	Magnetic water	1/61	4				
Tensile strength	The amount of cement	2/41	3	44	11/538	3	0/009
	Water to cement ratio	2/32	4				
	The amount of	2/48	2				

	aggregate						
	Magnetic water	2/80	1				
Bending strength	The amount of cement	2/41	2	44	15/176	3	0/002
	Water to cement ratio	2/30	4				
	The amount of aggregate	2/32	3				
	Magnetic water	2/98	1				
Cement setting	The amount of cement	3/36	1	44	67/119	3	0/000
	Water to cement ratio	3/07	2				
	The amount of aggregate	1/52	4				
	Magnetic water	2/05	3				
Islamp	The amount of cement	2/82	2	44	72/923	3	0/000
	Water to cement ratio	3/59	1				
	The amount of aggregate	1/77	4				
	Magnetic water	1/82	3				
Durability	The amount of cement	3/11	1	44	65/727	3	0/000
	Water to cement ratio	2/73	3				
	The amount of aggregate	2/77	2				
	Magnetic water	1/39	4				
Compressibility	The amount of cement	2/91	2	44	68/034	3	0/000
	Water to cement ratio	2/23	3				
	The amount of aggregate	3/39	1				
	Magnetic water	1/48	4				
Grading	The amount of cement	2/57	2	44	66	3	0/000
	Water to cement ratio	2/05	3				
	The amount of aggregate	3/55	1				
	Magnetic water	1/84	4				
Color	The amount of cement	3/32	1	44	57/976	3	0/000
	Water to cement ratio	2/61	2				
	The amount of aggregate	2/57	3				
	Magnetic water	1/50	4				
Appearance	The amount of cement	3/09	1	44	71/609	3	0/000
	Water to cement ratio	2/70	3				
	The amount of aggregate	2/93	2				
	Magnetic water	1/27	4				

The results of all tests are significant at the level of 99% confidence, ie at the level of 1% error (significance level P = 0.000), therefore, the null hypothesis is rejected and we conclude that there is a difference between the application of magnetic water in the factors affecting non-structural concrete in terms of prioritization.

According to the results of Friedman test and Table 15, the mean and rank of magnetic water in each of the effective factors in non-structural concrete has been determined.

5. Conclusion

Today, concrete is one of the most important and widely used products of human production. Improving the properties of concrete has always been one of the main issues facing structural engineers. Improving the physical properties of water, as one of the main elements of concrete, is one of the ways to improve the properties of concrete. Magnetic water is water that has passed through a magnetic field and its physical quality has changed. Today, in special structures, for example, tall structures that need concrete with high compressive strength, it is not possible to provide the required strength by increasing the aggregate and cement, as a result, a material is needed that is fully compatible with the concrete material and environment and improves the compressive strength. Structures that require high compressive strength and at the same time high rebar density, cannot increase the water to cement ratio to achieve the required performance, because it causes a sharp drop in compressive strength. Therefore, to solve this problem (achieving high resistance and efficiency), additives are examined and used. In this research, magnetic water analysis on structural and non-structural concretes has been investigated using multi-criteria decision making method that according to the tests performed, magnetic water increased the compressive strength of 28 days by 28% and increased the slump of concrete by 30%, and with the tests taken, including the Friedman test, magnetic water can be considered as one of the main components of concrete and the importance of components in concrete and the main priorities in the formation of structural and non-structural concrete.

References

Ahari, R, S,. Erdem, T, K,.& Ramyar, K. (2015). Time-dependent rheological characteristics of self-consolidating concrete containing various mineral admixtures. *Construction and Building Materials, 88*, 134-142

Ahmadi, J, Azizi, H, Koohi, M. (2015). Investigation of the effect of zeolite in different grades of cement on the strength and permeability of concrete. *Concrete Research,* No. 2, pp. 18-5.

Aliabdo, A,.Elmoaty, A,.&Aboshama, A, Y. (2016). Utilization of waste glass powder in the production of cement and concrete. *Construction and Building Materials,* 124, 866-877

Chatveera, B. &Lertwattanaruk, P. (2009). Use of ready-mixed concrete plant sludge water in concrete containing an additive or admixture, *Journal of Environmental Management,* 90, 1901-1908

Country Management and Planning Organization. (2000). *Iran Aba Concrete Regulations. Third Edition.* Publications of the Management and Planning Organization of Iran, Tehran.

Ehsani, A., Dehghani, A., Saleh Labbafzadeh, M. (2012). *The effect of calcium carbonate with nanocarbon coating on mechanical properties and durability of concrete.*Islamic Azad Construction and Concrete Industry Research Center, Qazvin Branch, No. 428, p. 12-1.

Hebhoub, H,. Aoun, H,.Belachia, M,. Houari, H,.& Ghorbel, E. (2011). Use of waste marble aggregates in concrete. *Construction and Building Materials, 25*, 1167-1171

Henry, A,. Edwin, G,.&Buchely, F. (2016). White Ordinary Portland Cement blended with superfine steel dust with high zinc oxide contents. *Construction and Building Materials, 112*, 816-824

Mazlum, M., Miri, M. (2016). The effect of magnetic water on the strength and validity of strong concrete. *Journal of Construction Engineering,* No. 2, pp. 42-30.

Mohammadi, Y., and Mir Islam Nouri Sadat, M. (2015). *Investigation of the effect of nano-thilis on compressive strength of concrete containing glass fibers against freezing and melting cycles.*

Office of National Building Regulations. (2013). *The ninth topic of design and implementation of reinforced concrete buildings, fourth edition.* Iran Development Publishing, Tehran.

Powell C. (2003). The Delphi technique: myths and realities. *J Adv Nurs.,* Feb; 41(4): 376-82.

Rahgozar, M, AS, Zamani, M. (2015). Performance and properties of concrete with magnetic water. *Concrete Research,* No. 1, pp. 85-99.

Siva Konda Reddy, B. and Ghorpade, V. G. and Sudarsana Rao,H. (2014). "Influence of Magnetic Water on Strength Properties of Concrete"; *Indian Journal of Science and Technology* 7, No.1(2014)14–18.

Su,N and Wu, Y.H and Mar, Ch.Y. (2009). "Effect of magnetic water on the engineering properties of concrete containing granulated blast-furnace slag"; *Cement and concrete research30*,(2009) 556-605.

Tadayonfar, Gh., Ghavamizadeh, M. (2013). Investigation of the effect of magnetic water on the initial setting time of concrete. *Fifth Annual National Iranian Concrete Conference.* Article code C, code 31F. Pp. 8-1.

Wenqiang, Z., Pan, F,. Peihua, Z,. Qian, T,.Nanxiao, G,. Yujiang, W,. Cheng, Y,.&Changwen, M. (2017). Effects of novel polymer-type shrinkage-reducing admixture on early age autogenous deformation of cement pastes. *Cement and Concrete Research, 100*, 413-422.