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EFFECT THE ADDITION OF MGO POWDER ON SOME PROPERTIES OF CONCRETE

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ABSTRACT

In this research used MgO powder have been particles size ≥ 0.241 ≤ 10.23 µm while particles size of cement was ≥ 2.38 ≤ 28.988 µm. MgO powder adding to the mixtures with ratios (1, 2, 3 and 4) % by weight of cement. Specimens were treatment by autoclave and conducted compressive strength, ultrasonic pulse velocity and absorption tests. Results showed that the best ratio when adding 2% MgO powder by weight of cement, where the rate of increase in compressive strength and ultrasonic pulse velocity at age 28 day were (148.76 and 59.57)% compared to the reference mixture also (81.57 and 21.1)% compared to the mixture containing the 4% superplasticizer DCP200 respectively. In addition to that get decrease in rate of absorption where the percentage of decrease at age 28 day was 80.95% with respect to the reference mixture and 47.83% with respect to the mixture containing the 4% superplasticizer DCP200.

Keywords: MgO powder, autoclave, particles size, compressive strength, ultrasonic pulse velocity, absorption.

1. INTRODUCTION

General

MgO concrete was developed by Chinese dam engineers and has been applied predominantly in the construction of concrete dams in Chinese-speaking regions. It has been successfully used in about 30 dams over the past three decades and remarkable results and experiences have been collected. However, knowledge of this novel material and technology is not widespread in other countries [1].

The limitation of the MgO content in Portland cement less than 5% by the Chinese National Standard GB175-2007[2], this kind of limestone' usage in Portland cement production is rare. It has been reported that for the Portland cement suitable MgO can lower the melting temperature, increase the quantity of the liquid phase [3, 4], and alter the mineral phases' crystal structure [5] and activate the reactivity of C3S [6, 7].

MgO is one of important secondary compound present in cement, and it is made from magnesia compounds in raw materials, and it is not necessary to be each magnesium oxide apparent in chemical analysis in oxide, it is likely to have been formed Magnesia present in the rigid solution, and magnesia in the form of glass have no effect on the concrete [8]. The proportion of this oxide in the cement between 4-1%, ASTM C150[9] specifications define the maximum rate of 4% by weight of cement and Iraqi specification, No.5/1984[10] define the maximum rate of 5% by weight of cement to control the expansion that resulting of rehydration process for this compound in the hardened concrete.

Previous studies show that delayed hydration MgO free magnesia in the original cement leads to concrete damage as the hydration products occupy larger than the original size of the non-lime challenger [11, 12].

Objective

The research aims to take advantage of the added MgO powder has fineness higher than the cement that interaction leads to great increase in the compressive strength because his character extended early when hydration the cement that lead to improve the properties of concrete. In addition to the possibility doing without using superplasticizer and reduce the cost.

2. MATERIALS

Cement

Ordinary Portland cement made in Alhabibia cement factory/Iraq type I was used throughout this research. The chemical properties of cement used throughout this research are shown in Table-1. Test results were indicated that the adopted cement was conformed to the Iraqi specification No.5/1984.

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Table 1: Chemical composition and main compounds of cement

Oxides composition	Content %	Limits of Iraqi specification No.5/1984
Calcium oxide CaO	66	-
Silica dioxide SiO_2	20.6	-
Aluminum oxide AI_2O_3	5.1	-
Iron Oxide Fe_2O_3	3.8	-
Sulfur dioxide SO_3	2.2	< 2.8%
Magnesium oxide MgO	2.8	< 5.0%
Loss by burning L.O.I	3.8	< 4.0%
Insoluble residues	0.9	< 1.5%
Alkali ($Na_2O + 0.658K_2O$)	0.277	
Forced saturation factor	0.95	1.02-0.66
Main compounds (Bogue's equations)		
C3S	66.084	
C2S	9.295	
C3A	7.093	
C4AF	11.552	

Water

In this research was used drinking water in mixing all mixtures.

Superplasticizer

Superplasticizer was used in this research as chemical additive to reduce the water in superior degree, which carries the trade name Flocrete PC200 of British Production Company DCP.

Magnesium oxide powder (MgO)

Magnesium oxide is a white powder used in this research; it is very fine particle size range between ≥ 0.241 ≤10.231 µm.

Fine aggregate

Sand was used saturated dry surface passing from sieve size 4.75 mm and remaining on a sieve size of 0.15 mm.

Coarse aggregate

Rounded gravel was used passing from sieve size 9.52 mm and remaining on a sieve size of 2.36 mm.

Materials proportion

This research included six mixtures as follows:

a) Mixing ratio (1:1.1:1.6) cement: sand: gravel and water to cement ratio of 0.48 (mixture of reference).

b) Mixing ratio (1:1.1:1.6) cement, sand, gravel, water to cement ratio of 0.32 and 4% Flocrete PC200.

c) Mixing ratio (1:1.1:1.6) cement, sand, gravel, water to cement ratio of 0.32, 4% Flocrete PC200 and 1% MgO powder.

d) Mixing ratio (1:1.1:1.6) cement, sand, gravel, water to cement ratio of 0.32, 4% Flocrete PC200 and 2% MgO powder.

e) Mixing ratio (1:1.1:1.6) (1.6:1.1:1) cement, sand, gravel, water to cement ratio of 0.32, 4% Flocrete PC200 and 3% MgO powder.

f) Mixing ratio (1:1.1:1.6) cement, sand, gravel, water to cement ratio of 0.32, 4% Flocrete PC200 and 4% MgO powder.

Casting and curing of test specimens

Mixing a dry material (sand with gravel) and cement mixed with magnesium oxide then add water or water mixed with superplasticizer according to the type of mixture and continue mixing for 4 minutes. After that casting mixture in molds cubic dimensions (100 * 100 * 100 mm) in two layers, and compact each layer on the vibrator device for 20 seconds.

The curing is done by covered the models by plastic cover with continuous spray of water for three days and then placed in the autoclave for 18 hours and the next day immersed in water until the test date

3. RESULT AND DISCUSSIONS

A parametric study was carried out to investigate the effect of added MgO powder with ratios (1, 2, 3 and 4) %, 4% Flocrete PC200 and curing by using autoclave on some of the properties of concrete.

3. 1 Compressive strength test

It was a test of compressive strength to its importance in the design of constructions as well as it gives an indication of most of the properties of concrete.

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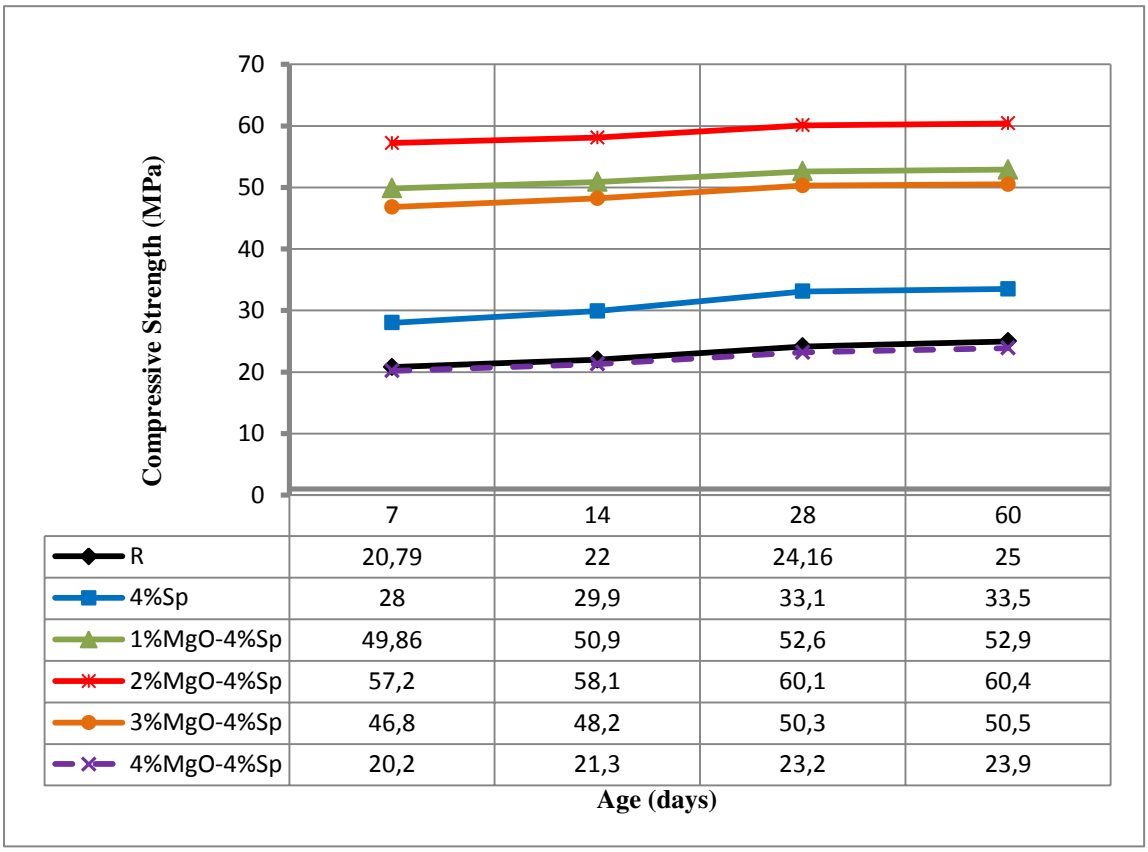
Figure and its data Table-3-1 shows the compressive strength of six mixtures conducted in this research and tested at ages (7, 14, 28 and 60) day, where the highest compressive strength of the mixture which addition 2 % of MgO powder with 4 % Flocrete PC200 where the percentage increases at 28 day (148.75, 81.57) % compared to the reference mixture and mix added 4% Flocrete PC200respectively. The reason for this increase may be due to the adding 2% high fineness of MgO which leads to interaction in the early ages in addition to treatment with autoclave that will accelerate the chemical interaction of MgO powder which gives the result of the interaction larger than the space that was occupied before the interaction which leads to reduce pores and cracks capillary.

From Figure and its data Table-3-1 , it can be seen also that there is a reduction in compressive strength when adding 4% MgO powder with 4% Flocrete PC200 where the percentage of reduction at 28 day was 4.14 % compared to the reference mixture. The reason may be due to the interaction of a large proportion of MgO powder and that the reaction products occupy space greater than the void volume located inside the concrete structure which leading to cracked the structural concrete construction and thus reduce the compressive strength. Where the rate of reduce was 4.14 % compared by reference.



	7	14	28	60
R	20,79	22	24,16	25
4%Sp	28	29,9	33,1	33,5
1%MgO-4%Sp	49,86	50,9	52,6	52,9
2%MgO-4%Sp	57,2	58,1	60,1	60,4
3%MgO-4%Sp	46,8	48,2	50,3	50,5
4%MgO-4%Sp	20,2	21,3	23,2	23,9

Figure and Table-1, Effect of adding 4%Sp, 1%MgO-4%SP, 2%MgO-4%Sp, 3% MgO-4% Sp and 4%MgO-4%Sp on the compressive strength with age.

Ultrasonic pulse velocity test

The results showed that ultrasonic pulse velocity of all mixtures increases with age and the results showed that the highest value when adding 2 % MgO powder with 4 % Flocrete PC200 where the percentage increase at 28 day were 59.78 % and 21.1% with respect to reference mixture and mix added 4 % Flocrete PC200 respectively and reduction when a rate increase to 4 % of MgO powder where the percentage of the reduce at 28 day was 6.88 % compared with reference as shown in figure and its data Table-2.

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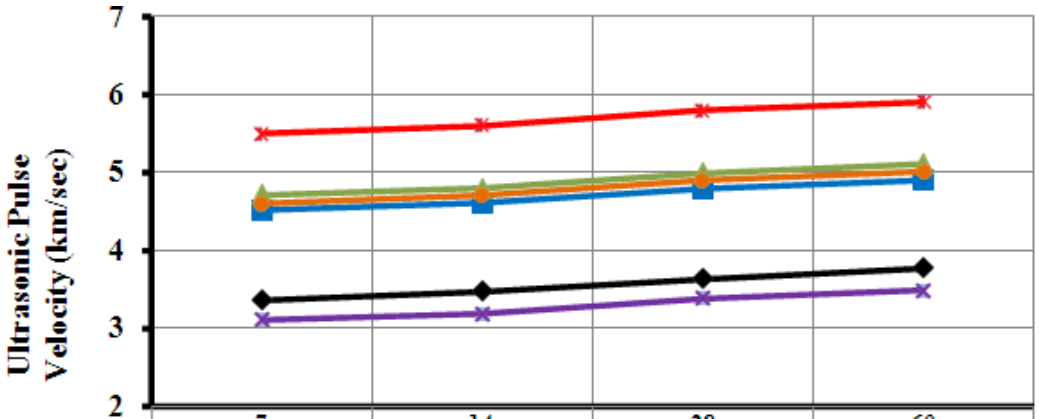

	7	14	28	60
R	3.36	3.47	3.63	3.77
4%Sp	4.52	4.61	4.79	4.9
1%MgO-4%Sp	4.71	4.8	4.99	5.11
2%MgO-4%Sp	5.5	5.6	5.8	5.9
3%MgO-4%Sp	4.6	4.71	4.9	5.01
4%MgO-4%Sp	3.11	3.19	3.38	3.49

Figure and Table -2, Effect of adding 4%Sp, 1%MgO-4%SP, 2%MgO-4%Sp, 3% MgO-4% Sp and 4%MgO-4%Sp on the Ultrasonic Pulse Velocity with age.

Absorption test

Absorption is the ability of the concrete to draw water into its cavities. Absorption leads to the swelling of the concrete and leads to its fragmentation when exposed to freezing and thawing cycles when saturated with water. From figures and its data Figure-3 to 6 can show a relationship between the mixtures and absorption ratios, the lowest absorption rate was at the addition of 2 % of the MgO powder at all ages. The percentage of decrease were 80.95 % and 47.83 % at age 28 day compared to the reference mixture and mix added 4 % Flocrete PC200, respectively.

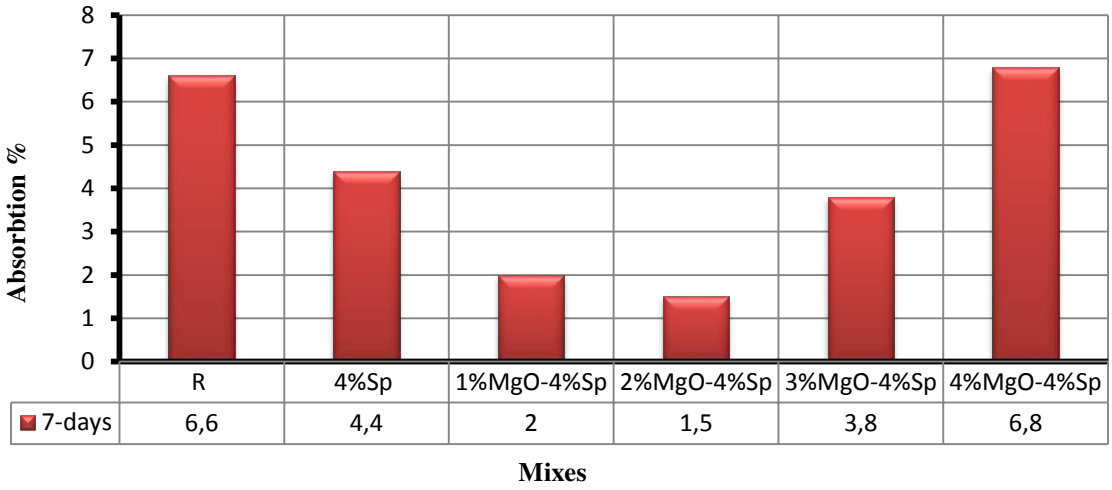

Figure-3. Explain the relationship between the rate of absorption and type of mix at 7 days.

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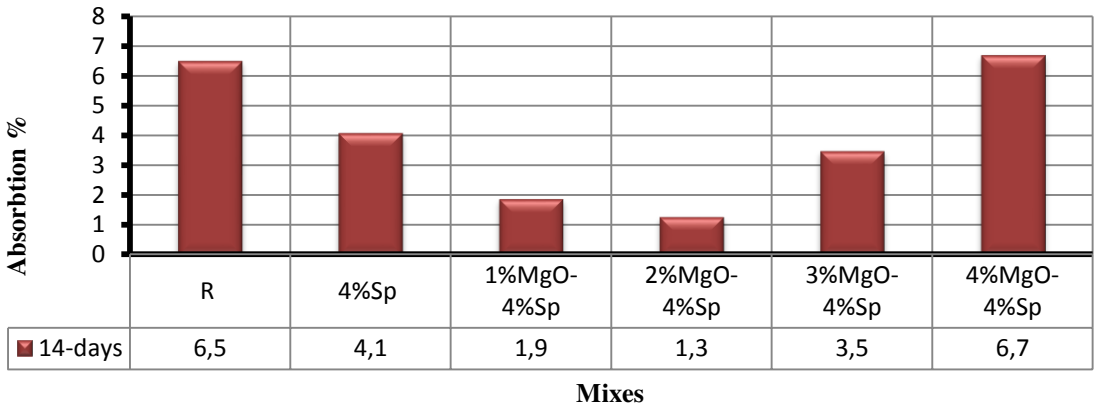

Figure-4. Explain the relationship between the rate of absorption and type of mix at 14 day.

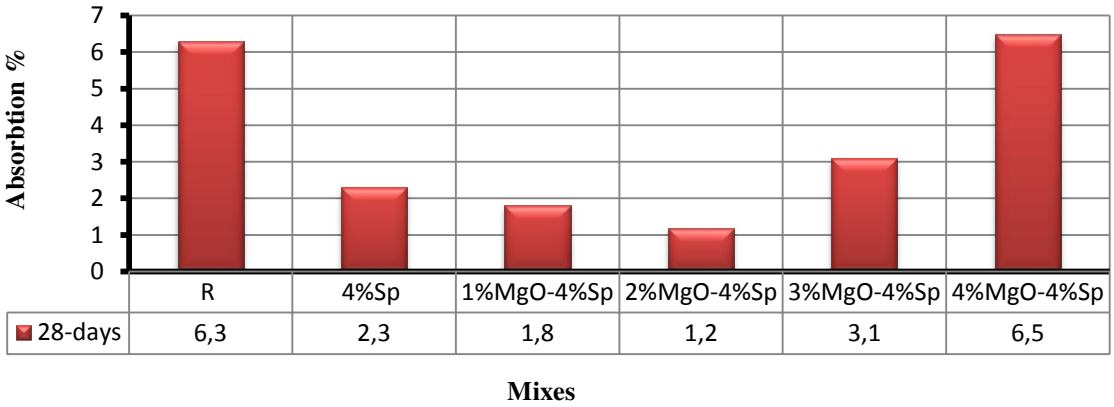

Figure-5. Explain the relationship between the rate of absorption and type of mix at 28 day.

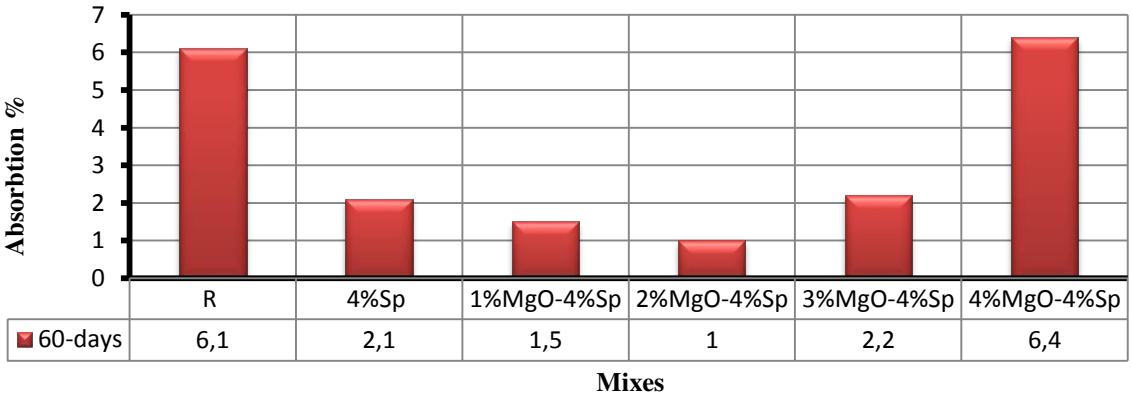

Figure-6. Explain the relationship between the rate of absorption and type of mix at 60 day.

4. CONCLUSIONS

a) When using MgO powder with particles size ≥ 0.241 ≤ 10.23 µm gives higher compressive strength specially when adding 2 % of magnesium oxide with 4% Flocrete PC200 to the mixtures where the percentage increase at 28 day (148.75 and 81.57) % compared to the reference mixture and mix added 4% Flocrete PC200, respectively.

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b) There is a reduction in compressive strength when adding 4% MgO powder with 4% Flocrete PC200 to the mixtures where the percentage of reduction at 28 day was 4.14 % compared to the reference mixture.

c) The results showed that ultrasonic pulse velocity of all mixtures increases with age and the results showed that the highest value when adding 2% MgO powder with 4% Flocrete PC200 to the mixtures where the percentage increase at 28 day were 59.78 % and 21.1% with respect to reference mixture and mix added 4% Flocrete PC200 respectively.

d) The lowest absorption rate was at the addition of 2 % of the MgO powder with 4 % Flocrete PC200 to the mixtures at all ages.

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