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Effect of Various Curing Regimes on Some Properties of Reactive Powder Concrete RPC

Saif Ibrahim Hendi *, Nada Mahdi Aljalawi

Department of Civil Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq

ABSTRACT

In the current study, the impacts of various curing states on some properties of reactive powder concrete (compressive strength, flexural strength, and dry bulk density) are being experimentally studied. The curing conditions include four different methods: immersion in normal water temperature (considered the reference curing state), immersion in warm water at 35ºC, immersion in boiling water, and curing with steam. For every combination, the water/binder ratio stayed unchanged at 0.2. Each reactive concrete mix was cast into three different configurations: 50mm only for cubes and 50×50×250 mm for prisms. Based on the improvement of RPC mechanical characteristics, the optimum curing method, as determined by the results, is immersion in warm water at 35ºC for all mixtures containing quartz powder of 20% by mass of cement and fly ash as a filler. The outcomes exhibited that using a warm water curing regime increased the RPC's compressive strength by 22.1%, flexural strength using 18.3% and dry density by 0.62% at 28 days following the comparison of the test grades to the reference curing regime.

Keywords: Reactive powder concrete, Quartz powder, Warm water, Curing regime, Steel fiber.

1. INTRODUCTION

The composite known as Reactive Powder Concrete (RPC) has a cementitious base. It was created using a process called microstructure augmentation. This entails removing coarse aggregate, lowering the ratio of water/binder, and adding fine aggregate with micro-cementitious substances, such as crushed quartz and silica fume with a high surface area to volume ratio and particles ranging in size from 45 to 600 mm. P. Richard and M. Cherezy created RPC for the initial time in the Bouygues lab in France at the beginning of the 1990s **(Richard and Cheyrezy, 1995)**. RPC was created to generate elevated order flexural and compressive strengths. Two crucial factors in the RPC production process are:

- choosing the right ingredients.

*Corresponding author
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- the curing method **(Hiremath and Yaragal, 2017)**.

Curing is the act of preserving acceptable temperature and damp content in the concrete for a specific duration of time. Cement must be hydrated over an extended period and at the right temperature. Thus, curing permits ongoing hydration and, as a result, ongoing increases in the strength of the concrete **(Mamlouk and Zaniewski, 2014)**. The time interval starting at putting, continuing through consolidation and finishing, and ending when the desired concrete qualities have emerged is known as the curing period **(ACI 308R-1, 2008)**. Accelerated curing refers to any method that yields concrete with high youthful strength. Due to the formwork's high early-age strength, which allows it to be removed in less than a day and reduces cycle time and costs, these approaches are very useful in the prefabrication industry **(Erdem et al., 2003)**. In extreme circumstances, the hydration is finally discontinued. Cement components and water cannot react to produce enough calcium silicate hydrate (CSH) when the hydration is stopped. The primary reaction product of cement hydration that provides strength is calcium silicate hydrate. Furthermore, shrinkage cracks that are caused by the drying of concrete surfaces could make the durability issues worse. As a result, effective curing is required to stop moisture from moving about or water from evaporating from the surface of concrete. Until the water-filled voids are significantly decreased by hydration products, the concrete element can be kept fully saturated or as saturated as possible. Thus, to create robust and long-lasting concrete, an appropriate curing technique—such as water ponding, water spraying, or covering with wet burlap and plastic sheet—is necessary **(Seffo and Ismaeel, 2012).** Two factors are usually involved when discussing the "curing" of concrete: time and temperature **(Concrete *et al.*, 2000).**

The main element influencing the rate at which strength develops is the curing temperature. Increasing the curing temperature generally hurts the qualities of concrete, particularly the compressive strength. High-temperature-cured concrete often has greater early strengths than low-temperature-cured concrete, although the strengths decrease with age and beyond 28 days **(ACI 305, 1999)**. Utilizing inexpensive steel fibers and guaranteeing RPC performance could significantly lower RPC costs and increase its accessibility **(Xun et al., 2020).** After seven days of heated water curing at 90 degrees Celsius, they were able to reach an extreme strength of about 160 MPa **(Hassan and Jones, 2012)**.

They used a one-day ATC method and two days of 90°C Steam Curing (SC) for UHPC that included large amounts of mineral additives. A maximum strength of about 153 MPa was attained **(Yazici, 2007)**. Early on, a high curing temperature accelerates the development of strength more quickly than a lower one; the greatest increase in compressive strength is 10.83% at 50°C associated with 21°C at seven days after the cure. The strength attained at higher curing temperatures has, however, decreased with ageing, with the largest percentage of the reduction occurring at 50°C related to 21°C at 91 days of curing age. Additionally, the outcomes demonstrated that samples cured in the field (with curing compound) had varying rates of strength development; the lowest field-standard curing strength ratio, according to the data, is 92.11% **(Fawzi and Agha, 2023)**. To reach these values, RPC is categorized by the addition of high cement content and pozzolanic ingredients that create in the other hand its construction highly cost and not naturally friendly. This work studied the chiefs of rising RPC, the constituent materials, curing techniques and the constituent percentages that affect the compressive strength **(Mayhoub, 2021).**

Most concrete qualities are determined by several elements, such as the type of cement used, the water-to-cement ratio, and the curing techniques used. Accelerated curing is considered one of the techniques that have only progressively emerged to attain the high youthful strength of concrete. Therefore, the primary objective of the work is to compare the wanted

properties of super-plasticized and retarding concrete that yielded accelerated curing methods with those of normally curing concrete. Examples of these properties include compressive strength and water absorption. In addition, the research addresses how aggregate surface roughness and excessive additive dosing affect concrete performance under certain kinds of circumstances. The test findings showed that the temperature utilized for curing, the concrete **(Atwan, 2023)**. By examining the effects of employing various cement and silica fume amounts as well as regionally adjusted steel fiber aspect ratios as reinforcement for this concrete, the mechanical properties of RPC were examined and assessed. For reinforced RPC with 910 kg/m^3 cement content, 185 kg/m3 silica fume content, 2% fiber volume fraction, and compressive strength of approximately 125.2 MPa, the indirect tensile strength of 16.0 MPa, modulus of elasticity of 48.7 GPa, the flexural strength of 15.5 MPa, impact energy of 3294.4 kN.m, and abrasion loss of 0.59% have been attained. Compared to reactive powder concrete, the normal strength concrete's water absorption values were 1.5 times greater **(Kadhum, 2015)**. They demonstrated that no appreciable strength development is seen after seven days of curing in a hot environment **(Yang et al., 2009)**. They noted that because there would be future workability and cost barriers, RPC hinges on two innovations. The current priorities remain lowering the cost of manufacture and enhancing RPC's features. RPC is approximately four times more expensive per unit volume than regular concrete **(Hajar et al., 2004).**
The primary goal of this work is to investigate the effect of the curing regime by determining the properties (compressive strength, flexural strength and dry bulk density) of RPC with the varying curing regime on the reactive powder mortar with ageing which is made of sustainable resources by replacing (28%) of cement with (18%) silica fume and (10%) quartz powder which is affected by heating.

2. MATERIALS AND METHOD

2.1. Materials

2.1.1 Cement

Ordinary Portland cement Cem I (42.5R) was utilized, which is locally available. The test's outcomes matched the Iraqi standard's criteria **(IQS No.5, 2019)**. This cement's physical and chemical characteristics are listed in **Tables 1 and 2**, respectively.

Table 1. Physical tests and Specifications Limits of ordinary Portland cement (42.5 R).

Cement Property		Test result	Specification Limits 42.5 R Cement
Setting time	Initial (mins)	149	Min. 45 (mins)
	Final(hrs.)	6:30	Max 10 (hrs.)
Compressive strength (MPa)	2 days	24	Min. 20
	28 days	47	Min. 42.5

Table 2. Chemical Analysis and Specifications Limits of ordinary Portland cement (42.5 R).

Cement Property	Test result*	Specification Limits 42.5 R Cement
SiO_2 %	19.8	-
AI_2O_3 %	6.15	-
Fe_2O_3 %	3.55	-

CaO %		61.72	-
MgO %		2.61	Max 5
SO_3 %Max	C_3A < 3.5%	2.15	2.5
	C_3A > 3.5%	Not applicable	2.8
LOI %		2.16	Max 4
I R %		0.55	Max 1.5
C_3S %		48.18	-
C_2S %		20.49	-
C_3A %		10.29	-
C_4AF %		10.79	-

* Confirmed in the German laboratory Services at the College of Science, University of Baghdad.

2.1.2 Fine Aggregate (FA)

According to Iraqi specifications **(IQS No.45, 1984)**, the sand utilized in the concrete mix is referred to as zone 4. **Tables 3 and 4**, display the properties of the sand sieve analysis and chemical characteristics.

Table 3. Sand sieve analysis.

Sieve size (mm)	Passing of sand (%)	Limits of **(IQS No.45/1984)**/Zone 4
10	100	100
4.75	100	95-100
2.36	100	95-100
1.18	100	90-100
0.6	100	80-100
0.3	31	15-50
0.15	3	0-15

Table 4. Chemical properties of sand.

Properties	The test result of sand *	Limits of **(IQS No. 45/1984)**
Fineness modulus	1.68	-
Specific gravity	2.62	-
Absorption	1.04(%)	-
SO_3	0.17(%)	≤ 0.5(%)
Dry density	1670 (kg/m^3)	-

* Confirmed in the German laboratory Services at the College of Science, University of Baghdad.

2.1.3 Water

Regarding this experiment's objectives, all concrete mixes were mixed and cured using regular tap water complying with **(IQS No.1703, 2018)**.

2.1.4 Silica Fume (SF)

The silicon industry produces silica fume, a byproduct that is 100 times finer than Portland cement. The tiny particles of silica fume fill the spaces created by the cement and aggregates as well as those between cement particles when employed as a filler and cementitious material in concrete. Additionally, during the cement hydration process, silica fume and calcium hydroxide combine to generate additional calcium silicate. This reaction results in concrete that is denser, stronger, and less permeable. It was applied by substituting 10% of the cement weight percentage with it. As per the specification **(ASTM C1240, 2015)**, the silica fume used in concrete is of superior quality and can be relied upon. **Tables 5 and 6,** provide further details.

Table 5. Physical values of silica fume.

Physical properties	Test result	**(ASTM C1240, 2015)** Specification
% Retained on 45-µm (No. 325) sieve	7.4	≤10
Strength Activity Index at 7 days	111	≥105
Specific surface (m^2/g) *	16	≥15

*Given by the manufacturer.

Table 6. Chemical properties of silica fume.

Composition	Test results (%) *	**(ASTM C1240, 2015)** Specification
Silicon Oxide (SiO_2)	92.3	≥85.0
(AL_2O_3)	0.34	**---**
(MgO)	0.35	**---**
(Fe_2O_3)	1.31	**---**
Calcium Oxide (CaO)	2.85	**---**
Loss on Ignition	2.17	≤6.0

* Confirmed in the German laboratory Services at the College of Science, University of Baghdad.

2.1.5 Admixtures (SP)

In this study, the concrete's early and final resistance is improved by using the superplasticizer ViscoCrete 180 GS. The flow was enhanced by the addition. The superplasticizer employed in the experimental combinations complies with **(ASTM C494, 2019). Table 7** displays the specifications for this additive.

Table 7. *Data Sheet of Superplasticizer properties.

Category	**Description**
Appearance	Light brownish liquid
Specific gravity	1.070 ± 0.005 (g/cm^3)
PH- value	4 – 6
Typical dosage	0.5 – 1 (L/100 kg) of cement
Total chloride ion content	Nil

* Given by manufacturer.

2.1.6 Quartz Powder (QP)

In this experiment, quartz powder was used because it had undergone the required refining by specifications **(ASTM C311, 2015).** The strength activity index and chemical and physical properties conform with **(ASTM C618, 2018)** as given in **Table 8**.

2.1.7 Micro Steel Fiber (MSF)

In this study, straight microsteel fibers were employed. These fibers were fabricated using mild carbon steel and exhibited an average tensile strength of 2600 MPa **(Muhsin and AbdElzahra, 2016)**. The diameter of the fiber is 0.2 mm and the length of 10 mm, resulting in an aspect ratio (L/D) of 50, following **(ACI Committee 544, 2018).** The percentages of micro steel fibers used in the reactive powder concrete by volume of concrete, as illustrated in **Fig. 1**. The properties of the micro steel fibers are provided in **Table 9**.

Table 8. Chemical and physical properties of quartz powder

Composition	Result (%) *	**(ASTM C618, 2018)** class F specification
SiO_2	64.22	Min 70
AL_2O_3	9.6	
Fe_2O_3	5.2	
SO_3	2.15	Max 5
CaO	4.27	---
MgO	1.66	---
Loss of ignition	3.22	Max 6
% Retained on 45μm (NO.325)	30(%)	Max 34(%)
Strength activity index at 7 days.	102	Min 75

* Confirmed in the German laboratory Services at the College of Science, University of Baghdad.

Table 9. Data of Micro steel fibers.

Description	**Specification**	**Description**	**Specification**
Surface	Brass coated	Aspect ratio	50
Fiber Shape	Straight	Bulk Density	7890 (kg/m^3)
Length (mm)	10	Tensile strength of fibres (N/mm^2)	2600
Fibre diameter (mm)	0.2	Melting point	1500 °C

Figure 1. Micro steel fiber

2.1.8 Design of Reactive Powder Concrete

RPC is made with a high cement content, sand grading that is between 150 and 600 micrometers in size, very low water-to-cement ratio, superplasticizer content of (1 Liter to 100 kg of cement), micro steel fibers, quartz powder and silica fume. and this study used different curing regimes (Normal (MF1), Warm water 35 °C (MF2), Boiling water (MF3) and steam curing (MF4)) as shown in **Table 10**. The mortar, which is made of sand, cement, and silica fume, greatly increases resistance to 95 MPa of compressive strength is the desired result for the reactive powder concrete mix design. The materials are mixed in the mixer as shown in **Fig. 2.**

Table 10. Specifics of RPC mix proportions

Mix Symbol	Sp L/100 kg of cement	Water (kg/m³)	Cement content (kg/m³)	Sand (kg/m³)	Micro steel fibers by volume	Silica Fume (kg/m³)	Quartz powder (kg/m³)	Type of curing
MF1	1%	220	792	1035	1%	110	198	Normal
MF2		220	792	1035	1%	110	198	Warm Water (35°C)
MF3		220	792	1035	1%	110	198	Boiling Water (95°C)
MF4		220	792	1035	1%	110	198	Steam

Figure 2. Mixer used to mix materials

2.1.9 Cast of Samples

Following the mixing process, the mix's contents must be drained and discharged into the molds utilizing the iron molds that have been reserved for this purpose. Before casting, every mold needs to be cleaned. To stop the hardened concrete from sticking to the inside surface of the molds, the inner faces of the molds must be lubricated. the prisms are cast in two layers and the cubes are cast in two layers, with an electric vibrator applied to each layer to cause vibrations **(ASTM C192, 2007)**, the molds have been compacted and filled with the necessary number of layers roughly similar volume. Following casting, the specimens are cured and kept in a dry location while being addressed with plastic sheeting for a full day to prevent shrinkage-induced plastic cracking. cubes with dimensions of (50*50*50) mm and prisms of dimensions (250*50*50) mm used cubes after casting shown in **Fig. 3.**

Figure 3. Cubes (50×50×50) mm after casting

2.1.10. Curing Processes

Four different methods of curing were used: immersion in normal water temperature for twenty-eight days, immersion in warm water at 35 °C for twenty-eight days, immersion in boiling water above 95 °C for 3.5 hours (after that in normal water) and lastly, in steam with temperature 90ºC for 5 hours (after that in normal water) by **(ASTM C684, 2017)** specifications, as revealed in **Fig. 4**.

(a) **(b)** **(c)**

Figure 4. (a)Warm water curing; (b) boiling water curing; (c) Steam curing

3. EXPERIMENTAL WORK

3.1 Compressive Strength Test

For cubes (50 * 50 * 50) mm, the measurement of the compressive strength was done using **(ASTM C109, 2020)** where the cube's reverse sides bear the load and are perpendicular to the casting direction. As illustrated in **Fig. 5**, At the ages of (7, 28, and 60) days, a rate of three cubes strength was chosen for four different mixes measured as soon as water was added to the mixture.

Figure 5. Compressive strength test

3.2 Flexural Strength Test

The flexural strength test (Fr) of RPC was measured using concrete prisms with dimensions of 250 * 50 * 50 mm and the one-point loading method by **(ASTM C293, 2019)** as shown in **Fig. 6.** For each RPC mix at the ages of 7, 28, 60 days, the average of three prism findings was chosen for four different mixes measured as soon as water is added to the mixture.

Figure 6. Flexural strength test.

3.3 Dry Bulk Density Test

The test was conducted in compliance with Guide 274 (RG 274). The results showed that the dry density of the mixture healed in warm water at ages 7, 28, and 60 days was more than that of the reference mixes. The increase can be attributed to the interaction between quartz powder and the calcium oxide (CaO) formed during the cement reaction. As a result of this interaction, more calcium silicate hydrate gel is created, a binder material that fills in the spaces among the cement paste and sand, so increasing the density of the mortar.

4. RESULTS AND DISCUSSION

4.1 Compressive Strength Test

One of the most important properties of hardened concrete is its compressive strength, which is closely related to other physical properties. The results of compressive strength tests on cubes of all concrete mixtures at 7, 28, and 60 days are shown in **Table 11** and **Fig. 7.**

Table 11. Results of Compressive Strength

Mix Symbol	Compressive Strength (MPa)					
	7 days		28 days		60 days	
	Result	Average (increase%)	Result	Average (increase%)	Result	Average (increase%)
MF1	68	71 (ref.)	91	95 (ref.)	109	105 (ref.)
	72		98		106	
	73		96		100	
MF2	80	83 (16.9%)	120	116 (22.1%)	130	129 (22.8%)
	87		118		129	
	82		110		128	
MF3	82	80 (12.6%)	110	108 (13.7%)	122	118 (12.4%)
	81		106		117	
	77		108		115	
MF4	80	78 (9.8%)	104	101 (6.3%)	114	111 (5.7%)
	77		99		112	
	77		100		107	

Silica fume (18%), quartz powder (10%) and micro steel fibers must now be used to produce superior-quality concrete (RPC). As a result of significant modifications to the cement paste-aggregate interfacial zone. The minuscule particles comprising silica fume and quartz powder enhance the bonding between cement pastes and aggregate by augmenting the density of the interfacial zone **(Aïtcin and Mindess, 2011)**.

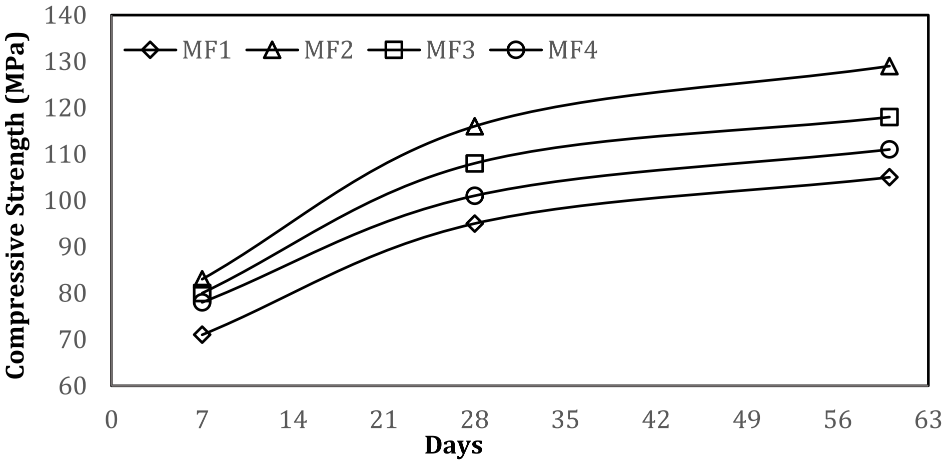

Figure 7. Relationship between the compressive strength and age of RPC.

In comparison to other curing methods and the reference curing regime (MF1), the reactive powder concrete sample that was cured with warm water (MF2) exhibited greater strength. Because of the heat curing treatment that used 28 days and is attributed to the pozzolanic action of sustainable materials, which creates strong compressive strength by making denser microstructures and micro steel fibers that act as a barrier to stop or delay the occurrence of cracks up to a certain percentage of fiber (1%). They came to the same conclusion **(Xun et al., 2020)**. The warm water curing achieves higher compressive strength (MF2) as shown in **Table 11** and **Fig. 8**. The outcomes are consistent with the findings of **(Khreef and Abbas, 2021; Hiremath and Yaragal, 2017; Aljalawi, 2021)**.

4.2 Flexural Strength Test

The process of flexural strength testing assesses how materials react to basic beam loads. Prisms measuring 50x50x250 mm were used in the experiment at three distinct ages: 7, 28, and 60 days. The results of testing concrete mixtures for flexural strength are shown in **Table 12,** and **Fig. 8.** The addition of quartz powder, silica fume, and micro steel fibers to the concrete greatly improved its flexural strengths. Concretes created just of silica fume did not function as well as RPC prepared with quartz powder, micro steel fibers, and silica fume. Because pozzolanic activity fills the gaps between the RPC, it was discovered that silica fume, quartz powder, and micro steel fibers appeared to more significantly alter flexural strength with heating or curing. Silica fume and quartz powder, however present in high concentrations, greatly enhanced flexural strength. These are all in agreement **(Sulaiman et al., 2015)**. This increase in flexural strength results from the fibers' ability to both span and confine cracks. The findings show that, in comparison to other curing regimes (MF1, MF2, and MF3), concrete mixes with warm water curing (MF2) have stronger flexural qualities. As seen in **Table 12** and **Fig. 8.** the flexural strength of mix MF2 increased relative to mix MF1 by approximately 24.2%, 18.3%, and 14.8% for 7, 28 days, and 60 days, respectively. These concur with **(Khreef and Abbas, 2021; Yazici *et al.*, 2009)**.

Table 12. Results of flexural strength

Mix Symbol	Flexural Strength (MPa)					
	7 days		28 days		60 days	
	Result	Average (increase%)	Result	Average (increase%)	Result	Average (increase%)
MF1	9.8	9.5 (ref.)	13.3	13.1 (ref.)	13.9	14.2 (ref.)
	9.4		12.9		14.1	
	9.3		13.1		14.6	
MF2	12	11.8 (24.2%)	15.4	15.5 (18.3%)	16.4	16.3 (14.8%)
	11.7		15.6		16.3	
	11.7		15.5		16.2	
MF3	10.4	10.1 (6.3%)	14.2	14 (6.9%)	14.6	14.8 (4.2%)
	9.8		14		14.9	
	10.1		13.8		14.9	
MF4	10.2	10 (5.3%)	13.9	13.6 (3.8%)	14.1	14.4 (1.4%)
	10.1		13.5		14.3	
	9.7		13.4		14.8	

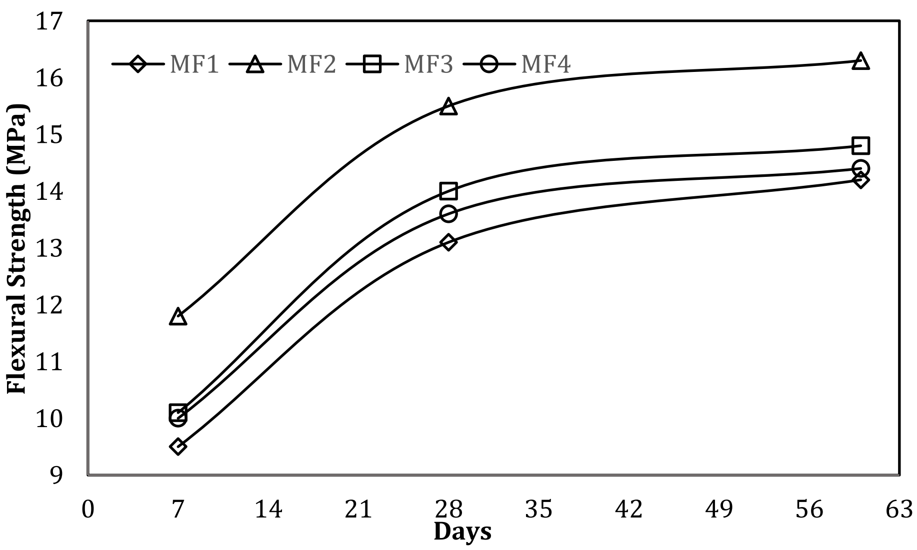

Figure 8. Relationship between the flexural strength and age of RPC.

4.3 Dry Bulk Density Test

The density of the concrete gives an indirect indication of the mechanical properties of RPC, from the results shown in **Table 13 and Fig. 9** below increase density with ageing and the warm water curing results (MF2) give higher results than other curing regimes (MF1, MF3 and MF4), This increase can be attributed to the interaction between the cement reaction-produced Cao and quartz powder, which forms more calcium silicate hydrate gel (pozzolanic action of both powder and silica fume). The curing heat stimulates the formation of this gel, a binder material that fills in the spaces between the sand and cement paste, increasing the density of the mortar and solidifying the microstructure **(Juenger and Siddique, 2015)**. the outcomes are consistent with the findings of **(Hussain and Aljalawi, 2022)**.

Table 13. Results of dry bulk density test

Mix Symbol	Dry Bulk Density (kg/m^3)					
	7 days		28 days		60 days	
	Result	Average (increase%)	Result	Average (increase%)	Result	Average (increase%)
MF1	2404	2410 (ref.)	2430	2425 (ref.)	2450	2442 (ref.)
	2406		2422		2447	
	2420		2423		2429	
MF2	2428	2421 (0.45%)	2432	2440 (0.62%)	2445	2454 (0.49%)
	2418		2448		2460	
	2417		2440		2457	
MF3	2417	2411 (0.04%)	2421	2430 (0.2%)	2437	2445 (0.1%)
	2412		2433		2440	
	2404		2436		2458	
MF4	2419	2414 (0.1%)	2436	2432 (0.2%)	2453	2447 (0.2%)
	2415		2435		2442	
	2408		2425		2446	

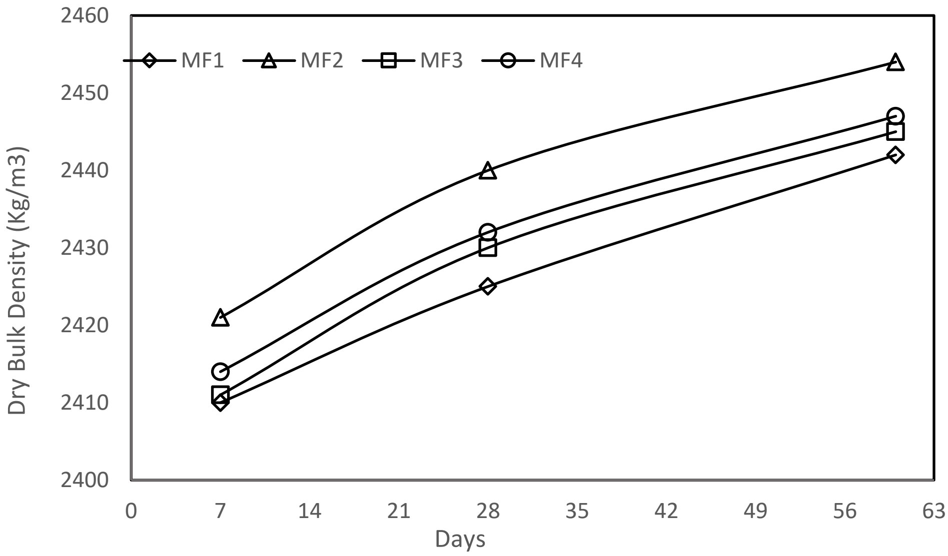

Figure 9. Relationship between dry bulk density and age of RPC.

4.4 Relationship between Compressive Strength and Flexural Strength.

Fig. 10, revealed the relationship between compressive strength and flexural strength of All curing regimes applied to RPC at (7, 28, 60) days, as shown in Eq (1) for MF2**.**

$$(y = 0.1006x - 3.532). \quad (1)$$

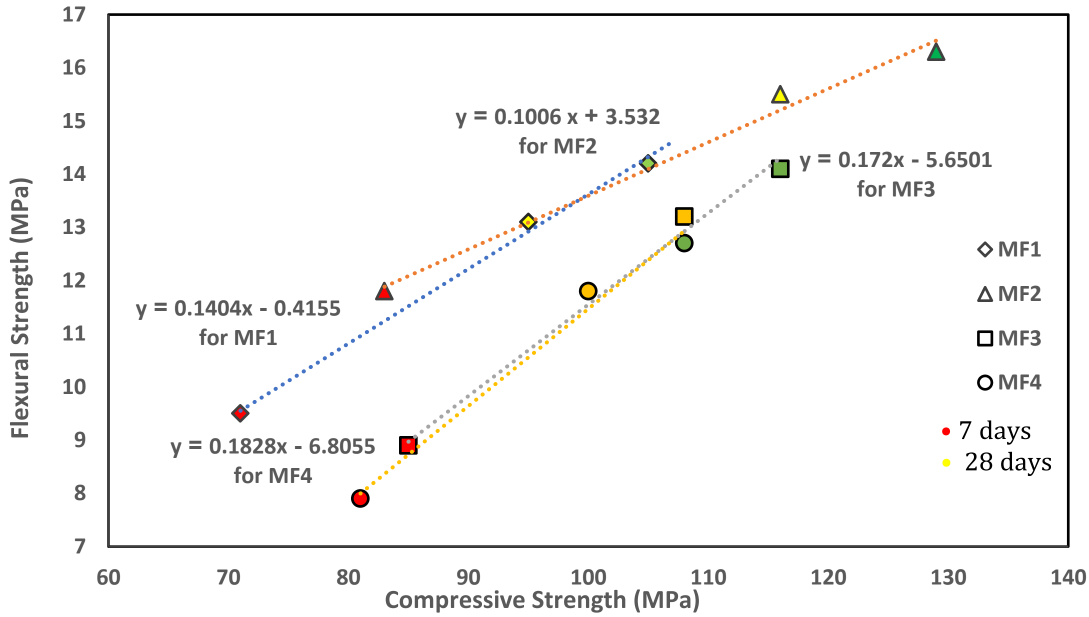

Figure 10. Variation of the flexural strength of RPC and the compressive strength

4.5 Relationship Between Compressive Strength and Dry Bulk Density.

Below **Fig. 11** revealed the relationship between compressive strength and dry bulk density of All curing regimes applied to RPC at (7, 28, and 60) days, as shown in **Eq (2)** for MF2.

$$(y = 0.6897x - 2362.9). \tag{2}$$

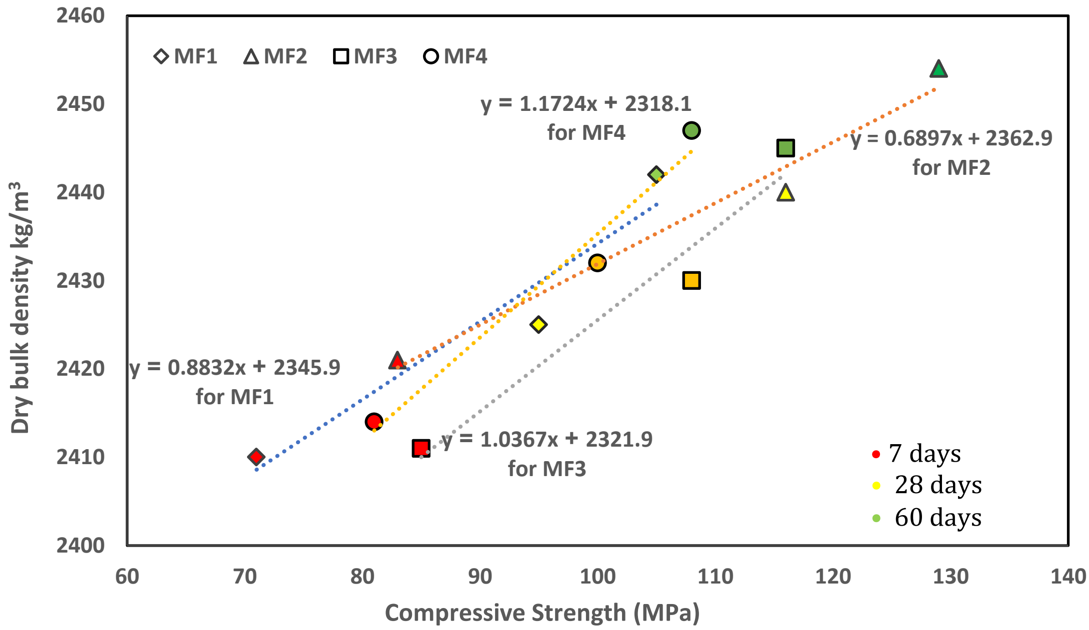

Figure 11. Variation of the dry bulk density of RPC with the compressive strength

5. CONCLUSIONS

The findings follow the testing RPC under four different curing regimes are reached in this work. The conclusions extracted from comparing the results of the RPC reference mixture (MF1) cured with normal curing to the mixtures MF2 (warm curing), MF3 (boiling curing) and MF4 (steam curing) and the warm water (MF2) is optimum curing regime as follow:

- Through the results obtained after using four types of curing regimes (normal, warm water, boiling water, steam) with the presence of sustainable materials, the warm water achieved higher results than other curing regimes.
- Under using four types of curing regimes (normal, warm water, boiling water, steam) curing and in the presence of sustainable materials, all mixes cured with warm water (MF2) achieved high compressive strength compared to normal curing (MF1), boiling water curing (MF3) and steam curing (MF4), where the results of compressive strength at 7 days improved by approximately 16.9%, at 28 days by 22.1%, and at 60 days by 22.8% compared to the normal curing (reference mix).
- At all ages, the flexural strength enhancement of the RPC reinforced with micro steel fibers in the presence of sustainable materials (quartz powder and silica fume) cured with warm water (MF2) was (24.2%, 18.3%, and 14.8%) times stronger than the RPC cured with the normal curing (reference mix).
- It was also shown through the results obtained from this examination that the use of sustainable materials (quartz powder and silica fume) cured with warm water (MF2) led to higher results of dry bulk density of the RPC compared to other curing regimes, in the enhancement at 7 days by approximately 0.45%, at 28 days by 0.62%, and 60 days by 0.49% compared to the normal curing (reference mix).

Credit Authorship Contribution Statement

Saif Ibrahim Hendi: Investigation, Formal analysis, Writing –original draft.
Nada Mahdi Aljalawi: Supervision, Writing –review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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تأثير اختلاف نظام المعالجة الرطبة على بعض خواص خرسانة المساحيق الفعالة

سيف أبراهيم هندي*، ندى مهدي فوزي الجيلاوي

قسم الهندسة المدنية، كلية الهندسة، جامعة بغداد، بغداد، العراق

الخلاصة

في الدراسة الحالية تم دراسة تأثير الحالات المختلفة للمعالجة الرطبة الحرارية على بعض الخواص لخرسانة المساحيق الفعالة (مقاومة الانضغاط، مقاومة الانثناء، الكثافة الجافة). تتضمن تكنولوجيا المعالجة الرطبة للخرسانة أربع طرق مختلفة: الغمر في الماء في درجة الحرارة الاعتيادية (يعتبر هذا الوضع المرجعي للمعالجة)، الغمر في الماء عند درجة حرارة 35 درجة مئوية، والغمر في الماء المغلي عند درجة حرارة اعلى من 95 درجة مئوية والمعالجة بالبخار لكل مجموعة، نسبة الماء \ المادة الرابطة (0.2). تم صب كل خلطة من خرسانية المساحيق الفعالة في ثلاث تشكيلات مختلفة: مكعبات بأبعاد 50 ملم ومواشير بأبعاد (50*50*250) ملم. بعد ذلك، تم التوصل الى إن الطريقة المثلى للمعالجة استنادا الى نتائج البحث هي الغمر في الماء الدافئ بدرجة حرارة 35 درجة مئوية لجميع الخلطات والتي تحوي على مسحوق الكوارتز والرماد المتطاير كمادة مالئة. أظهرت النتائج الخاصة بخرسانة المساحيق الفعالة ان استخدام نظام المعالجة بالماء الدافئ يؤدي الى زيادة في مقاومة الانضغاط مقدارها 22.1% وزيادة في مقاومة الانثناء بنسبة 18.3% وزيادة في كثافة الخرسانة بنسبة 0.62% عند مقارنتها بالطريقة المرجعية للمعالجة الرطبة.

الكلمات المفتاحية: خرسانة المساحيق الفعالة، مسحوق الكوارتز، الماء الدافئ، نظام المعالجة الرطبة، الالياف الحديدية.