The Effect of Different Curing Methods on the Properties of Reactive Powder Concrete Reinforced with Various Fibers

Ahmed A. Luti
Department of Construction Materials, College of Engineering, University of Baghdad, Iraq
ahmed.udah2101m@coeng.uobaghdad.edu.iq (corresponding author)

Zena K. Abbas
Department of Civil Engineering, University of Baghdad, Iraq
dr.zena.k.abbas@coeng.uobaghdad.edu.iq

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ABSTRACT

The current study explores the effects of four curing methods on the strength of Reactive Powder Concrete (RPC) reinforced with different fibers. Four mixtures of RPC, reference (RM-RPC), wavy fiber reinforced (WF-RPC), carbon fiber reinforced (CF-RPC), and micro steel fiber reinforced (MF-RPC) mixes were prepared and cured following four curing methods (normal, autogenous, coating, and warm water). The results revealed that warm water curing achieved the highest values of compressive, flexural, and splitting strength, attaining 138.9 MPa 22.4 MPa, and 20.89 MPa, respectively. The results of using different fiber reinforcement displayed that the compressive strength of fiber-reinforced RPC mixes was notably higher than that of the RM-RPC. The compressive strength increase results were 9.04% for WF-RPC, 24% for CF-RPC, and 27.96% for MF-RPC regardless of the curing method adopted. Flexural strength increased by 21.2%, 38.47%, and 55.86% for WF-RPC, CF-RPC, and MF-RPC, accordingly in autogenous curing, whereas the change in flexural strength was 30.65%, 39.14%, and 36.59%, correspondingly in coating curing and 21.27%, 29.22%, and 39.55%, respectively, for warm water curing. The optimum flexural values were mainly obtained for MF-RPC regardless of the kind of curing used. CF-RPC almost achieved the same results as MF-RPC with slightly lower values. It can be concluded that fiber reinforcement had a more positive influence on the flexural and splitting strength of RPC than on the compressive strength.

Keywords-Reactive Powder Concrete (RPC); carbon fibers; micro fibers; wavy fibers; autogenous curing; coating curing; warm water curing

I. INTRODUCTION

Ultra-High Performance Concrete (UHPC) has received a lot of research attention due to its ultra-high strength (over 100 MPa) and better toughness than ultra-high strength concrete due to the incorporation of fibers [1, 2]. Also, UHPC is characterized by better workability and durability [3, 4]. The utilization of UHPC in the construction of buildings and bridges is widespread [5, 6]. Reactive Powder Concrete (RPC) belongs to the family of UHPC [7]. The term reactive powder reflects that all the powder components in the RPC are chemically reactive [8]. RPC is a special type of ultra-high strength super plasticized silica fume concrete, often fiber-reinforced, with improved homogeneity because traditional coarse and fine aggregates are replaced by very fine sand [9, 10]. RPC is composed of very fine powders, i.e. Portland cement, sand, quartz powder, and silica fume. Sometimes (but not always), steel fibers are used, and super plasticizers are always employed to reduce the water to cement ratio (w/c) to less than 0.2, while improving the workability of RPC [11, 12]. The compact microstructure gives the RPC its ultra-high strength and long-term durability [13]. When glass is utilized as an aggregate, its high alkali content facilitates the formation of the pozzolanic reactions and the inclusion of glass powder has a positive effect on the properties of concrete [14]. Additive fibers can improve concrete responsiveness under static and dynamic loads [15]. The cementitious compositions of RPC cause brittle failure in tension or compression, therefore fiber reinforcement is added [16, 17]. The mechanism of bonding is activated when the cracks are crossed by conventional reinforcement. The latter links the two surfaces of the crack and their stress is distributed into the concrete [18]. Authors in [19] studied the compressive strength of RPC reinforced with fibers. The results revealed a higher compressive strength than that of the non-fiber reinforced RPC by 33%, which made it suitable for use in structural elements that need high early compressive strength. Authors in [11] studied RPC reinforced with various steel fibers. The inclusion of steel fibers leads to a considerable increase in tensile strength, while the addition of steel fibers causes a slight increase in compressive strength as the fiber volume fraction rose from 0% to 3%. Authors in [20] concluded that straight steel fibers were easily pulled out and had the least inhibitory effect on cracks. Connections using wavy steel fibers had the lowest initial stiffness and shear capacity, but the highest energy dissipation capacity. Utilizing deformed fibers, like those that are hooked, corrugated, or twisted, can further boost the mechanical strength of composite materials. Reportedly, deformed steel fibers give 3 to 7 times the fiber-matrix binding strength of straight fibers. Several factors, including fiber shape, fiber length, and curing conditions, influence the degree to which the mechanical properties are enhanced [21, 22]. Curing of concrete is an important factor in getting the required properties, such as strength and durability. Curing is of major importance, especially in the early stages of concrete, since it enhances the process of cement hydration [23]. The use of different curing methods has a significant impact on the strength of concrete. Various studies have shown that curing methods such as water curing, steam curing, and autoclaving can enhance the mechanical properties of fiber reinforced concrete [24, 25]. Structural shape, mix constituents, weather, and other aspects are determinants in choosing the type of the curing method employed [26]. Many researchers have indicated that heat curing improves the mechanical properties of RPC. Authors in [27] studied the effects of using magnetized water in RPC. The results demonstrated some improvements in the compressive, flexural, and splitting tensile strength for the RPCs cured with different curing methods.

II. EXPERIMENTAL PART

A. Materials

1) 1) Ordinary Portland Cement (OPC)

OPC type IQS 5 CEM I 52.5 R was utilized. Its physical and chemical compositions are presented in Tables I and II. These values indicate that the cement used met IQS no.5/2019 [28] requirements.

TABLE I. PHYSICAL CHARACTERISTICS OF THE OPC

Property	Value	Requirements [28]
Specific surface area (m^2/kg)	398.9	≥ 280
Soundness by autoclave (%)	0.17	≤ 0.8
Setting time (Vicat′s method) initial	130 min	≥ 45
Setting time (Vicat′s method) final	269 min	≤ 600
Compressive strength, 2 days (MPa)	25.55	≥20
Compressive strength, 28 days (MPa)	45.48	≥45

TABLE II. CHEMICAL COMPOSITION AND MAIN COMPLEXES OF OPC

Oxide composition	Abbreviation	Result	Requirements [28]
Insoluble Residue	IR	0.64	Max (1.5)
Magnesia	MgO	2.78	Max (5)
Loss on ignition	LOI	2.68	Max (4)
Sulfate	SO_3	2.45	2.8 if C_3A>3.5
*Main compounds of cement			
Tricalcium aluminate	6.8	C_3A	--

* Bogue equations calculation according to ASTM C150

2) Fine Aggregates

The physical and sulfate content tests for the sand employed are provided in Table III, which confirms their compliance with IQS 45 1984 for zone 4.

TABLE III. PHYSICAL AND CHEMICAL PROPERTIES OF THE USED SAND.

Physical and chemical characteristics	Result	Requirements [31]
Fineness modulus	1.612	------
Sulfate content (%)	0.21	Max.0.50
Specific gravity	2.56	-------
Absorption (%)	1.02	--------

3) Fibers

Carbon Fibers (CF) type sika wrap-300C from Sika Middle East Company were deployed as observed in Figure 1. The specifications and characteristics of the utilized fibers over are listed in Table IV. The Wavy Steel Fibers (WSF) put into service were manufactured by Hongu, China (Table V, Figure 1). The Micro Steel Fibers (MSF) used were manufactured by the Ganzhou Daye Metallic Fibers Co., Lt, China (Table VI, Figure 1).

TABLE IV. CF PROPERTIES

Description	Specifications
Dry fiber density	1820 kg/m^3
Dry fiber thickness	0.167 mm (based on fiber content)
Dry fiber tensile strength	4000 N/mm^2
Aspect ratio (L/D)	0.176

TABLE V. WSF PROPERTIES

Description	Specifications
Material	Cold-draw steel wire
Tensile strength	750 MPa - 1200 MPa
Fiber length	25 mm

TABLE VI. MSF PROPERTIES

Description	Specification
Tensile strength	2600 MPa
Density	7860 kg/m^3
Diameter	0.20 mm ± 0.05 mm
Avg. length	13 mm
Aspect ratio (L/D)	65

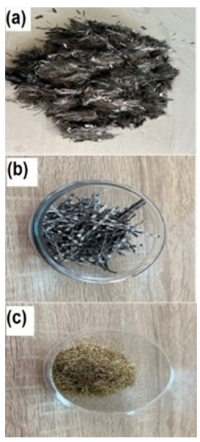

Fig. 1. Fibers used in RPC reinforcement: (a) CF, (b)WSF, (c) MSF.

B. Reactive Powder Concrete Design and Mixing Procedure

1) Mixing

The RPC was constructed based on the recommendations of [11, 27] and several trial mixes. Table VII presents the adopted material and its content. The density of the developed concrete was tested at the age of 28 days and was found to be 2510 kg/m^3 for the reference mix.

TABLE VII. REACTIVE POWDER CONCRETE MIX DESIGN

Mix	M1
OPC, kg/m^3	850
FA, kg/m^3	1050
Silica Fume (SF), kg/m^3	250
Water, kg/m^3	231
W/C	0.22
SP, lt/100 kg	180
Fiber content (MSF, WSF, or CF)	2%

According to the ACI 234R-96 specifications, the SF was added to the RPC mixture, which has been mixed in a small mixer (0.1 m^3). The mixing procedure was conducted as recommended in [11, 27].

2) Sample Preparation

To achieve the objectives of this study, three different molds were prepared:

- Cubic molds with dimensions of 100 × 100 × 100 mm
- Cylindrical molds with 100 mm diameter and a height equal to 200 mm
- Prism molds with dimensions of 100 × 100 × 400 mm.

3) Curing

The effects of four curing techniques on RPC strength were investigated in this study. Consequently, after casting, all specimens were subdivided into groups to be cured.

a) Ordinary Curing (OC)

The RPC samples were cured according to ASTM C192. They were immersed in room temperature (lab conditions) water until testing at 7, 28, or 90 days.

b) Autogenous Curing (AC)

As per ASTM C684-99 specifications, the RPC specimens were immediately covered by burlap and polythene (PE) after casting in room temperature and after 2-days they were forwarded to the water tank as in the first curing technique (Figure 2).

c) Warm Water Curing (WC)

The samples were cured according to ASTM C684-99. One day after casting, the samples were put in a curing water path from 8 am to 2 pm and this process was repeated for 7 days. After that, the samples were removed from the curing water path and were put in a normal curing tank until the age of 28 and 90 days. Figure 3 portrays the process of warm WC.

d) Coating Curing (CC)

In this method, the concrete specimens were pulled out from the molds after 24 hours, and Antisol-WB was sprayed to the newly laid concrete. A thin film of Antisol-WB (Table VIII) was applied to the surface with a hand operated spray gun. The samples were coated in room temperature as depicted in Figure 4. This coating reduces the evaporation of the mixing water from the concrete.

Fig. 2. Autogenous curing.

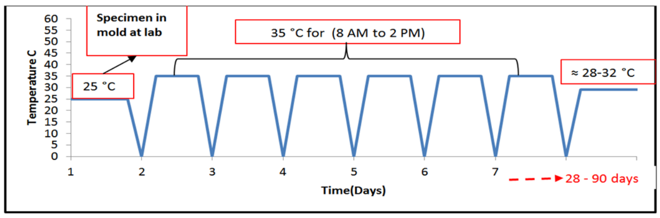

Fig. 3. Curing cycle of warm water curing.

Fig. 4. Coating curing.

TABLE VIII. PROPERTIES OF ANTISOL 51 SUPERPLASTASTICIZER*

Color	Light brown
pH	6.6
Form	Viscous liquid
Subsidiary effect	Hardening
Relative density	1.082 - 1.1 kg/liter
Viscosity	128 ± 30 cps at 20°C
Transport	Not classified as dangerous
Structure	Carboxylic ether polymer-based

*Given by the manufacturer

4) Specimen Testing

The compressive strength of RPC cubes was tested according to BS EN 12390-3 specifications. The splitting tensile test was performed on group concrete cylinders, affirming to ASTM C496 / C496M-17. The one point flexural strength test was used to test the samples, according to ASTM C-78-09.

III. RESULTS AND DISCUSSION

A. Compressive Strength

Figures 5-8 and Table IX illustrate the effect of different types of curing methods on the compressive strength of RPC. As the curing system changes, the compressive strength changes as well.

TABLE IX. COMPRESSIVE STRENGTH OF RPC MIXES

Sample	7 days (MPa)	28 days (MPa)	90 days (MPa)	Increase in 7 days (%)	Increase in 28 days (%)	Increase in 90 days (%)
1. Fixed fiber and different curing methods						
Reference mix						
OC	76.78	91.3	100.4	-	-	-
AC	84.22	100.1	110.2	9.77	10.40	11.61
CC	88.67	102.8	113.1	15.51	16.87	17.02
WC	93.11	113.8	125.2	21.38	24.64	24.78
CF mix						
OC	93.7	109.8	121	-	-	-
AC	103.0	120.7	132.8	9.92	10.83	11.40
CC	107.7	128.2	141.5	14.94	16.75	17.44
WC	113.3	137.2	151.9	20.91	24.95	25.53
MSF mix						
OC	96.7	111.1	123.2	-	-	-
AC	106.3	122.2	137.9	9.96	10.07	11.93
CC	111.2	126.8	144.1	14.95	15.13	16.96
WC	117.0	138.9	154.7	20.94	24.02	25.56
WSF mix						
OC	82.7	96.7	107	-	-	-
AC	91.1	107.4	119.8	10.2	11	12
CC	95.1	112.1	125	15	16.82	17
WC	100.1	120.8	134.3	21	25.01	25.57
2. Fixed curing method and different fiber reinforcement						
Autogenous curing						
Ref.	82.7	96.7	106.4	-	-	-
WCF	89.3	105.4	116.5	8	9.02	9.50
CF	101.7	120	133	23	24	25.06
MSF	105.0	123.7	136.8	27	28	28.60
Coating curing						
Ref.	93.7	109.8	121.2	-	-	-
WCF	101.1	119.6	132.7	7.89	8.92	9.48
CF	115.2	136.1	151.5	22.94	23.95	25.06
MSF	118.9	140.5	155.8	26.89	27.95	28.54
Warm water						
Ref.	96.7	111.1	122.3	-	-	-
WCF	104.4	121.3	133.8	7.96	9.18	10.40
CF	119	137.8	152.8	23.06	24.03	24.93
MSF	122.8	142.2	157.2	26.78	27.94	28.59

For the reference mix, the compressive strength for samples cured for 28 days was 91.3, 100.1, 102.8, and 113.8 MPa for OC, AC, CC, and WC, respectively. While for the CF mix, it was 109.8, 120.87, 128.27 and 137.25 MPa, accordingly. For the MSF mix (Figure 5), the compressive strength for 28-days cured samples was 111.13, 122.24, 126.82, and 138.91 MPa for OC, AC, CC, and WC, correspondingly. For the WSF mix, the compressive strength for 28-days cured samples was 96.7, 107.4, 112.17, and 120.87 MPa for OC, AC, CC, and WC, respectively.

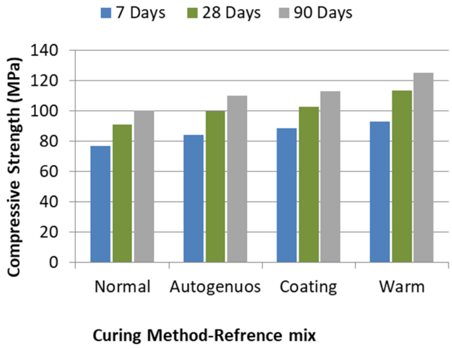

Fig. 5. Compressive strength of RPC mix of the reference samples and different curing methods.

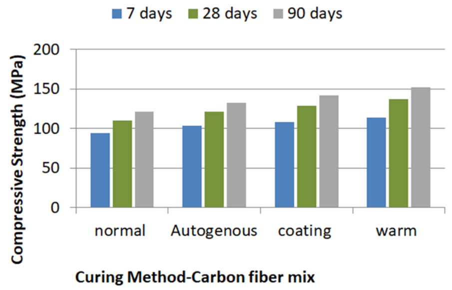

Fig. 6. Compressive strength of CF-reinforced RPC mixes and different curing methods.

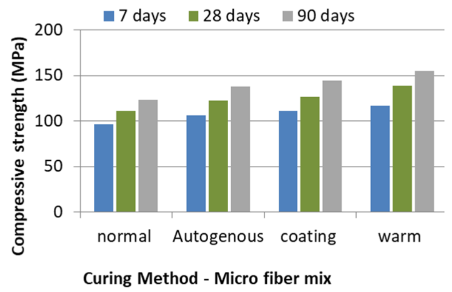

Fig. 7. Compressive strength of MSF-reinforced RPC mixes and different curing methods.

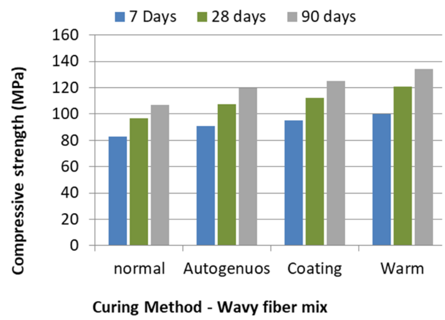

Fig. 8. Compressive strength of WSF-reinforced RPC mixes and different curing methods.

From the above discussion, it can be concluded that each curing regime has an independent effect on the strength development of RPC. Among the four different curing regimes, the WC regime exhibited the highest compressive strength. For WC, the strength development is the highest possibly due to the continuous development of the C-S-H chain under a hot or warm environment, which is in agreement with [29].

For the reference mix, the percentage of change in the compressive strength for 28 days-cured samples was 10.4, 16.87, and 24.64 % for AC, CC, and WC, respectively. For CF, MSF, and WSF RPC mixes, the increase percentage in the compressive strength was almost the same with the reference mix for all the curing systems regardless of the fiber reinforcement deployed. Figures 9-11 manifest the effect of different fibers on the compressive strength of RPC.

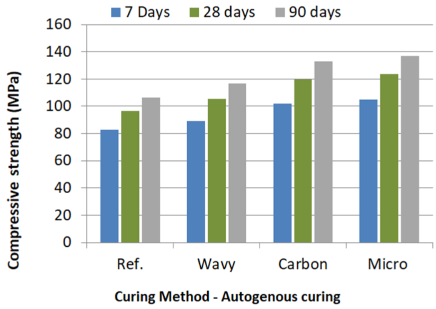

Fig. 9. Compressive strength of reference RPC, WF-RPC, CF-RPC, and MF-RPC mixes in AC.

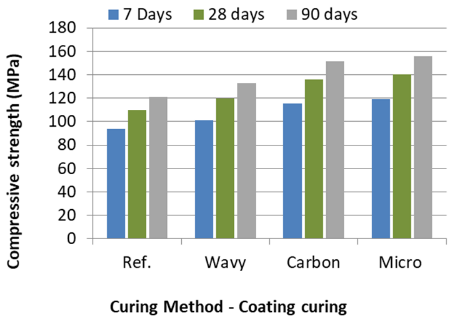

Fig. 10. Compressive strength of reference RPC, WF-RPC, CF-RPC, and MF-RPC mixes in CC.

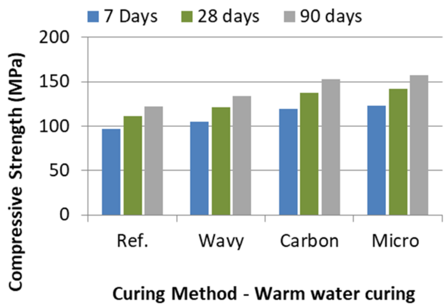

Fig. 11. Compressive strength of reference RPC, WF-RPC, CF-RPC, and MF-RPC mixes in WC.

The increase percentage of the WSF-reinforced RPC is 8, 9, and 9.50% for the age of 7, 28, and 90 days, respectively, and it is almost the same for all the kinds of curing. The percentage of the increase of CF-reinforced RPC is 23, 24, and 25% after 7, 28, and 90 days, respectively, and it is again almost the same for all the kinds of curing. In MSF-reinforced RPC, the increase percentage is 27, 28, and 28.6% for 7, 28, and 90 days, accordingly, and once again it is almost the same for all the kinds of curing.

The best results were acquired for WC of MSF-reinforced RPC, and were 122.8, 142.2, and 157.2 MPa for 7, 28, and 90 days of curing.

B. Flexural Strength

Figures 12-15 and Table X display the flexural test results of the RPC samples for the considered curing methods. The flexural strength increases when the curing method changes from AC to CC and increases anew when shifting to WC. This proves that the curing method has a considerable effect on the flexural strength of the RPC. The increase in the flexural strength of the reference samples was 20.32, 23.7, and 39.57 % for AC, CC, and WC, respectively (for 28 days of curing).

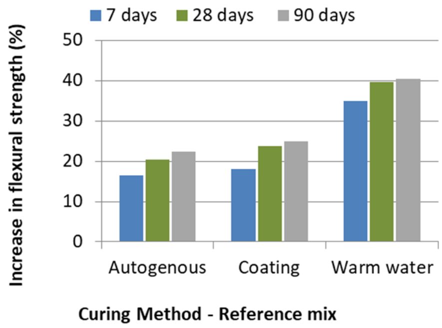

Fig. 12. Flexural test of reference RPC samples for different curing methods.

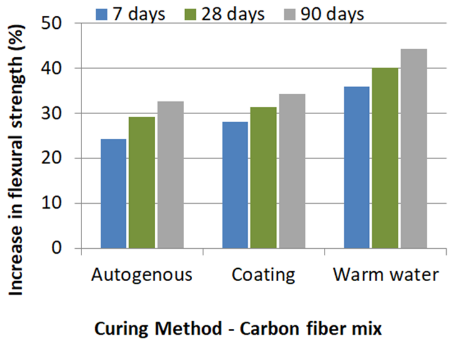

Fig. 13. Flexural test of CF RPC samples for different curing methods.

The increase in the flexural strength of CF-reinforced samples (Figure 13) was 29.1, 31.3, and 40.03% for AC, CC, and WC, respectively (after 28 days curing). These results comply with the findings of [24]. The rise in the flexural strength was less pronounced in MSF-reinforced RPC (Figure 14). The increase was 21.27, 23.76, and 38.91 % for AC, CC, and WC, respectively (after 28 days curing). For WSF-reinforced RPC (Figure 15), the flexural strength changed by 22.23, 27.27, and 39.1 % for AC, CC, and WC, correspondingly (after 28 days of curing). The results comply with the findings of [25].

TABLE X. FLEXURAL STRENGTH OF RPC MIXES

Sample	7 days (MPa)	28 days (MPa)	90 days (MPa)	Increase in 7 days (%)	Increase in 28 days (%)	Increase in 90 days (%)
1. Fixed fiber and different curing methods						
Reference						
OC	10.59	11.2	12.3	-	-	-
AC	12.32	13.9	15.3	16.43	20.32	22.34
CC	12.4	14.2	16.3	17.97	23.7	24.83
WC	14.2	15.9	17.3	34.84	39.57	40.35
CF						
OC	12.4	13.8	15.3	-	-	-
AC	15.5	17.9	19.8	24.27	29.1	32.54
CC	15.9	18.1	20.5	28.12	31.3	34.32
WC	17	19.5	22.1	35.89	40.03	44.34
MSF						
OC	12.4	16.6	17.9	-	-	-
AC	16.6	18.9	21.3	16.39	21.27	23.05
CC	17	19.3	22.4	18.71	23.76	29.4
WC	19.3	22.4	24.9	34.82	38.91	42.01
WSF						
OC	12.3	13.4	14.9	-	-	-
AC	14.4	16.4	19.2	17.28	22.23	27.78
CC	15.6	16.9	19.3	24.02	27.27	29.25
WC	17.8	18.7	22.6	36.44	39.1	44.35
2. Fixed curing methods and different fiber reinforcement						
AC						
Ref.	12.3	13.49	14.9	-	-	-
WCF	14.6	16.3	18.3	18.91	21.2	22.31
CF	15.7	18.6	21.4	27.84	38.47	43.21
MSF	18.37	21.69	23.21	39.34	55.86	58.77
CC						
Ref.	12.4	13.8	15.3	-	-	-
WCF	15.8	18.1	20.3	27.16	30.65	32.98
CF	16	19	21.7	28.44	39.14	42.15
MSF	17.97	19.8	22.7	33.81	36.59	39.37
WC						
Ref.	14.27	15.65	17.31	-	-	-
WCF	16.61	18.98	21.17	16.39	21.27	22.29
CF	17.87	20.51	22.78	25.22	29.22	31.65
MSF	19.81	22.84	24.86	31.81	39.55	41.3

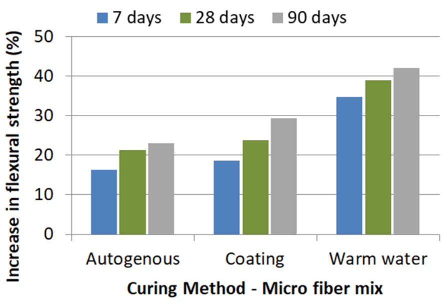

Fig. 14. Flexural test of MSF RPC samples for different curing methods.

Flexural strength is an indirect measure of tensile strength, but it can also be taken as a direct representative of true flexural capacity of cement-based materials. The flexural strength of RPC as compared to RM-RPC increased by 21.2, 38.47, and 55.86% for WF-RPC, CF-RPC, and MF-RPC, respectively in AC. This change was 30.65, 39.14, and 36.59% for WF-RPC, CF-RPC, and MF-RPC, respectively in CC and for WC, it was 21.27, 29.22, and 39.55%, respectively as illustrated in Figures 11 and 12. The results indicate that the optimum flexural values were mainly for MF-RPC regardless of the curing method used. CF-RPC almost achieved the same results as MF-RPC with slightly lower values. The results of the flexural strength comply with and even exceed the results of other works, e.g. [24].

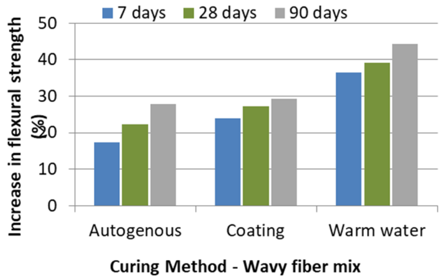

Fig. 15. Flexural test of WSF RPC samples for different curing methods.

C. Splitting Strength

Figures 16-19 and Table XI display the impact of different curing methods on the splitting strength of RPC. An increase of the splitting strength of the reference mix (after 28 days of curing) of about 24.8, 15.62, and 24.25% was obtained for AC, CC, and WC, accordingly as compared to the normal sample (Figure 16).

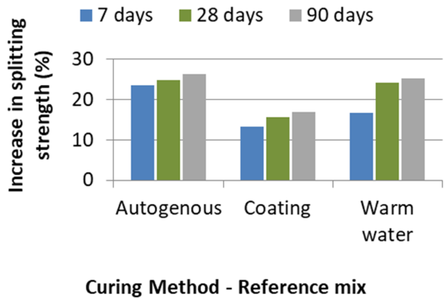

Fig. 16. Splitting strength test results of the reference RPC samples for different curing methods.

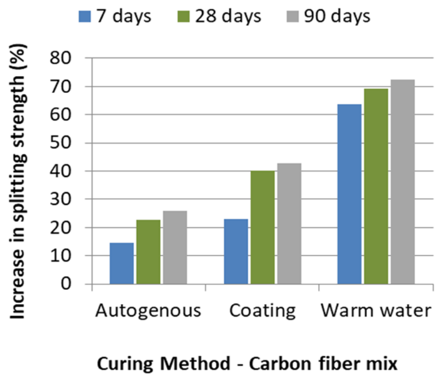

Fig. 17. Splitting strength test results of CF RPC samples for different curing methods.

TABLE XI. SPLITTING STRENGTH OF RPC MIXES

Sample	7 days (MPa)	28 days (MPa)	90 days (MPa)	Increase in 7 days (%)	Increase in 28 days (%)	Increase in 90 days (%)
1. Fixed fiber and different curing methods						
Reference						
OC	9.53	11.13	13.35	-	-	-
AC	11.78	13.18	16.82	23.6	24.8	26.3
CC	10.8	12.83	15.75	13.32	15.62	17.02
WC	11.13	13.83	16.73	16.78	24.25	25.32
CF						
OC	11.78	12.1	13.72	-	-	-
AC	13.48	14.84	17.23	14.43	22.64	26.02
CC	14.48	17.08	19.59	22.92	40.15	42.85
WC	19.64	20.46	23.5	63.72	69.09	72.41
MSF						
OC	11.13	13.83	15.23	-	-	-
AC	14.35	17.89	19.94	28.93	29.6	31.22
CC	15.75	18.83	21	34.91	36.21	37.93
WC	19.15	20.89	23.87	49.52	51.4	55.26
WSF						
OC	12.3	13.4	14.9	-	-	-
AC	14.4	16.4	19.2	17.28	22.23	27.78
CC	15.6	16.9	19.3	24.02	27.27	29.25
WC	17.8	18.7	22.6	36.44	39.1	44.35
2. Fixed curing method and different fiber reinforcement						
Autogenous curing						
Ref.	10.81	11.43	13.85	-	-	-
WCF	12.71	14.26	16.87	17.57	24.75	27.85
CF	13.98	15.93	18.52	29.32	39.37	42.21
MSF	16.63	19.91	24.91	51.38	71.19	77.3
Coating curing						
Ref.	11.78	12.1	13.72	-	-	-
WCF	13.41	16.25	19.05	13.83	34.29	38.92
CF	15.06	18.32	20.93	27.84	50.4	55.23
MSF	17.29	19.33	22.25	46.51	59.75	63.2
Warm water curing						
Ref.	12.13	13.83	15.23	-	-	-
WCF	15.81	18.38	21.51	25.06	32.89	41.25
CF	19.71	22.44	24.58	58.03	61.33	69.58
MSF	22.54	25.67	28.83	81.33	87.25	89.55

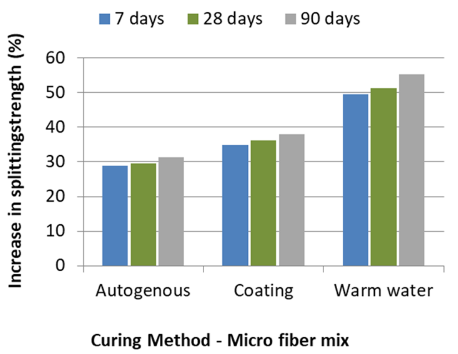

Fig. 18. Splitting strength test results of MSF RPC samples for different curing methods.

Regarding the CF mixes (Figure 17), the increase in splitting strength (after 28 days of curing) was much more pronounced with 22.64, 40.15, and 69.09% for AC, CC, and WC, respectively, due to the transmission of loads from the RPC matrix to the CF. These results comply with those of [11]. For MSF and WSF mixes (Figure 18), the results were almost convergent with the MSF mix results being a little higher due to the higher surface area offered by the MSF, which increases the attached surfaces and the Interfacial Transition Zone (ITZ) and hence augments the resistance to the tensile loads by effectively transferring loads from the matrix to the fibers. The results are in accordance with [20-22].

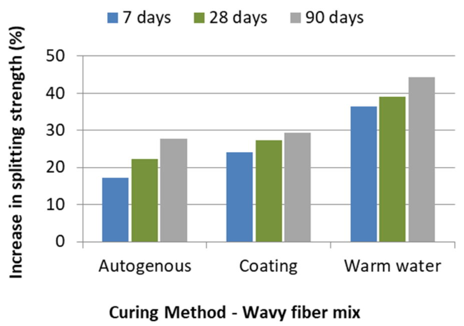

Fig. 19. Splitting strength test results of WSF RPC samples for different curing methods.

Regarding the effect of different fibers on the splitting strength of RPC, the increase after 28 days of curing for AC was 24.75, 39.37, and 71.19% for WF-RPC, CF-RPC, and MF-RPC, respectively, while for CC it was 34.29, 50.4, and 59.75% for WF-RPC, CF-RPC, and MF-RPC, correspondingly, and for WC it was 32.89, 61.33, and 87.25%, respectively.

IV. CONCLUSIONS

This study investigated the influence of curing methods and fiber types on the mechanical properties of Reactive Powder Concrete (RPC). Warm water curing consistently yielded the highest compressive and flexural strengths, likely due to an enhanced C-S-H chain development. Microfibers provided the optimal flexural strength across all the curing methods, closely followed by the carbon fibers. The splitting strength was significantly improved by the inclusion of fibers, with carbon fibers exhibiting the most pronounced increase due to the effective load transfer. These findings offer valuable insights for optimizing the performance of RPC through a targeted selection of the curing method and fiber reinforcement. The following conclusions can be drawn from the experimental results:

The increase percentage in compressive strength for 28 days-cured samples was 10.57, 16.39, and 24.65% for autogenous curing, coating curing, and warm water curing respectively. The increase percentage of wavy fiber-RPC was 8, 9, and 9.50% after 7, 28, and 90 days, respectively, and regardless of the curing method. The latter outcome stands for all the mixtures. The best results were acquired for warm water curing of micro steel fiber-RPC, which were 122.8, 142.2, and 157.2 MPa after 7, 28, and 90 days curing. The flexural strength of the RPC in different curing methods indicates an optimum value for the warm water curing method for all the mixes. The results of the flexural strength of the fiber reinforced RPC indicate that the optimum flexural values were mainly for the micro steel fiber-RPC.

The splitting strength results of the micro fiber- and wavy fiber- RPC across all the curing methods were almost convergent with the micro fiber mix results being a little higher. Regarding the splitting strength results of the fiber reinforced RPC, the increase in splitting strength after 28 days of curing for autogenously cured RPC was 24.75, 39.37, and 71.19% for wavy fiber-RPC, carbon fiber-RPC, and micro fiber-RPC, respectively, while for coating cured RPC, the increase was 34.29, 50.4, and 59.75%, and lastly for warm water cured RPC, the increase was 32.89, 61.33, and 87.25%, respectively.

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