Evaluation of Reactive Powder Concrete Strength using Various Curing Methods

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ABSTRACT

This study examines the strength development of Reactive Powder Concrete (R-P-C) under various curing methods. The R-P-C mixture was prepared using a ratio of 1:0.25:1.11 by weight of high-quality ordinary cement, Silica Fume (S-F), and fine Sand (S), along with 2% by concrete volume of micro steel fibers. In addition to Normal Curing (R-N) utilized as a control approach, three alternative curing methods were evaluated: Autogenous + Normal Curing (R-AN), Steam + Normal Curing (R-S), and coating with a Water (W)-based liquid curing compound (R-C). The results indicated that R-S significantly enhanced the compressive strength of R-P-C as the curing duration increased from 1 to 3 days. The strength improvements at 7, 28, and 90 days were measured at 13.99%, 15.97%, and 16.47% for 1 day of R-S; 15.42%, 17.44%, and 18.48% for 2 days; and 17.52%, 18.49%, and 20.04% for 3 days. This method accelerated chemical reactions within the cement matrix, having promoted stronger bonds and higher early-age strength, making it the most effective technique for maximizing the strength gain. R-AN for 2 days, followed by 26 days of W immersion, also proved beneficial, having increased compressive strength by 10.85%, 11.05%, and 12.2% at 7, 28, and 90 days, respectively. This method effectively retained moisture, having facilitated optimal chemical reactions and steady strength development. Similarly, (R-C) improved compressive strength by 12.55%, 12.71%, and 13.82%, having minimized evaporation and maintained internal moisture. Furthermore, improvements in compressive strength were accompanied by proportional increases in flexural and splitting tensile strengths across all curing methods.

Keywords-reactive powder concrete; normal curing; autogenous curing; coating curing; steam curing; micro steel fibers; silica fume

I. INTRODUCTION

Ultra-High-Performance Concrete (UHPC) is distinguished for its superior durability and workability [1, 2]. UHPC has gained significant scientific interest owing to its exceptional strength (exceeding 100 MPa) and superior toughness compared to Ultra-High Strength Concrete (UHSC), attributed to fiber inclusion [3, 4]. The application of UHPC in the construction of bridges and buildings is common [5, 6]. R-P-C is classified within the group of UHPC [7]. The term "reactive powder" indicates that all powdered constituents in the R-P-C exhibit chemical reactivity [8]. R-P-C consists of extremely fine powders, including S, S-F, Portland cement, and quartz powder. Steel fibers are occasionally utilized; however, Superplasticizers (SPs) are consistently applied to lower the W/C ratio, below 0.2, enhancing R-P-C workability [9, 10]. Its tightly packed micro-structure offers R-P-C ultra-high strength and long-term durability [11]. The R-P-C cementitious compositions result in tension or compression brittle failure. For this reason, fiber reinforcements are incorporated [12, 13].

The incorporated fibers can enhance concrete performance under dynamic and static loads [14]. As mentioned earlier, the R-P-C has a dense micro-structure and is often reinforced with fibers, contributing to its exceptional mechanical properties. However, these properties are sensitive to curing conditions. Therefore, optimizing the curing methods and understanding their impact on R-P-C performance is crucial. Authors in [15] examined fiber-reinforced R-P-C compressive strength. The findings indicated a compressive strength 33% greater than that that of the non-fiber reinforced R-P-C, making it appropriate for utilization in structural components requiring higher early compressive strength. Authors in [9] investigated the steel fiber reinforced R-P-C. The steel fiber incorporation resulted in a significant tensile strength enhancement, but in a minor enhancement in compressive strength as the fiber volume percentage increased from 0 % to 3 %. The improvement of the mechanical properties is influenced by several factors, including fiber shape, fiber length, and curing conditions [16, 17]. Proper curing plays a crucial role in achieving the desired characteristics of concrete, such as durability and strength. This is especially important in the early stages of concrete development, as it enhances cement hydration [18].

Various curing procedures substantially influence the concrete strength. Numerous studies indicate that curing techniques, including autoclaving, steam curing, and W curing can improve the mechanical properties of fiber-reinforced concrete [19, 20]. The structural form, mixed elements, weather conditions, and other factors influence the selection of the curing process utilized [21]. Several investigations have demonstrated that the mechanical characteristics of R-P-C can be enhanced by heat curing. Authors in [22] examined the impact of magnetized W on R-P-C, and the results revealed enhancements in the splitting tensile, flexural, and compressive strength of the R-P-Cs subjected to various curing processes. Authors in [23] investigated the effect of normal hot W curing on the properties of locally produced R-P-C. The results showed improvements in compressive, flexural, and tensile strength with the use of S-F, fly ash, and the addition of steel and glass fibers. Hot W curing further enhanced the compressive strength. An experimental study [24] explored the effect of hot W and hot steam curing on the mechanical properties of R-P-C. The findings exhibited that hot W curing at 90°C significantly enhanced the mechanical properties. However, despite the advancements in R-P-C, limited research has compared the influence of different curing methods on its mechanical properties. While individual methods, like R-S, R-AN, and R-C have shown positive results, a thorough evaluation of their effectiveness in enhancing early and long-term strength development is still needed. The current study aims to evaluate the influence of various curing methods on the compressive, flexural, and splitting tensile strength of R-P-C, providing valuable insights for optimizing curing strategies in practical applications.

II. EXPERIMENTAL INVESTIGATION

- Ordinary Cement (OC): The Ordinary Portland Cement (OPC) was utilized within the specification limits provided in [25], with CEM 1-42.5R grade.
- S-F: Amorphous sub-micron powder S-F was utilized, with 120% strength activity index, complying with [26].
- S: Sika S, finer than 0.6 mm was used, conforming with [27]. Its fineness modulus, absorption, and bulk density were 1.9%, 1.2%, and 1500 kg/m^3, respectively. The SO_3 contents equaled to 0.2%, and so were within the IQS limits (≤ 0.5%). The main properties of OC, S-F, and S are listed in Tables I and II.
- Superplasticizer (SP): SikaViscocrete-180GS-type F&G conforming to [28], was used in this study. It is a light-brownish aqueous solution of modified-polycarboxylates with a PH value and density equal to (4-5) and 1.07 kg/L, respectively.
- Micro Steel Fiber (SF-M): Hongu Steel Fiber with 0.2 mm nominal diameter and 13 mm length was utilized, resulting in an aspect ratio (L/D) equal to 65.
- Water (W), complying with [29], was used.

TABLE I. PHYSICAL PROPERTIES OF INGREDIENTS

Constituents	Physical properties		
	Specific surface area (m^2/kg)	Specific gravity	Compressive strength (MPa)
OPC	287 m^2/kg	3.15	2 days: 21, 28 days: 44.7
Limits of [25]	≥ 280 m^2/kg	-	2 days ≥ 20, 28 days ≥ 42.5
S-F	16 m^2/kg	2.21	-
Limits of [26]	≥15 m^2/kg	-	-

TABLE II. CHEMICAL COMPOSITION

Constituents	Chemical composition (%)							
	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	SO_3	Moisture content	LOI
OPC	63	20	5.1	3	3.3	2.2	-	2.8
Limits of [25]	-	-	-	≤ 5%	-	2.8% if C_3A > 3.5%	-	≤ 4
S-F	0.11	92.5	0.21	0.12	0.10	-	0.7	3
Limits of [26]	-	≥ 85	-	-	-	-	≤ 3	≤ 6

III. DESIGN AND PREPARATION

A. Design

The R-P-C mixture was designed based on [9, 22], and several trial mixes were performed. Table III outlines the selected materials and their proportions. The measured fresh density of the concrete was 2110 kg/m³, and the flow table test yielded a result of 112 mm, aligning with the specified range of 110 ± 5 mm [30].

TABLE III. MIXTURE PROPORTIONS BY (kg/m^3)

C	S-F	S	W	W/Cm	SF-M	SP
900	225	1000	230	0.204	156	28.5

B. Mixing and Casting

The adopted mixing program was conducted according to [22]. Three types of molds were prepared to reach the goals of this study, as depicted in Table IV and Figure 2.

TABLE IV. DETAILS OF CASTING AND MOLDS

Mold type	Dimensions (mm)	Casting specification	Strength test	Testing specification
Cube	100 × 100 × 100	[31]	Compressive	[32]
Prism	75 × 75 × 300	[33]	Flexural	[34]
Cylinder	100 × 200	[33]	Splitting tensile	[35]

Fig. 1. Constituent materials used in the mixture.

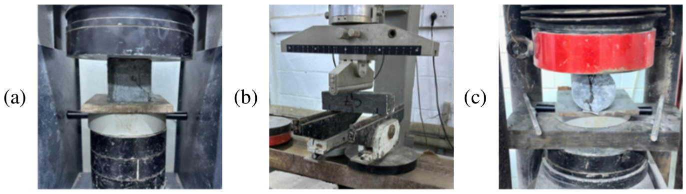


Fig. 2. (a) Compressive strength test for cubic specimens, (b) flexural strength test for prismatic specimens (one-point load), (c) splitting tensile strength test for cylindrical specimens.

C. Curing

Different curing methods were selected to achieve various objectives related to enhancing concrete performance and adapting to environmental conditions. R-N ensures optimal hydration and strength development, while R-S accelerates hardening and an early strength gain. The R-C with W-based liquid curing compound reduces moisture loss by evaporation, prevents cracking in dry environments, and eliminates the need for other costly curing methods. Additionally, R-AN minimizes self-shrinkage and improves the long-term properties of concrete, enhancing material quality and durability. The curing procedure involves:

1. R-N: R-P-C specimens were cured according to [33], which involves immersing the specimens in W at room temperature (laboratory conditions) until the age of testing at 7, 28, and 90 days, as portrayed in Figure 3(a).
2. R-C: The top surfaces of the specimens were sprayed with a W-based liquid curing compound, commercially known as Sika-Antisol WB IQ two hours after casting. The remaining surfaces were sprayed one day later, following the removal of the molds, as shown in Figure 3(b).
3. R-S: The R-P-C specimens were cured in high-temperature W at 50 ± 2 °C, as proposed in [36], for several days, as depicted in Figure 3(c):

- R-SN1: 1-day in mold + 1-day in hot W + 27-days R-N.
- R-SN2: 1-days in mold + 2-days in hot W + 26-days R-N.
- R-SN3: 1-days in mold + 3-days in hot W + 25-days R-N.

4. R-AN: The specimens were cured [37], which involved covering them with plastic wrap at room temperature for the first 2 days after casting. Subsequently, the specimens were submerged in W until the testing ages, as illustrated in Figure 3(d).

IV. RESULTS AND DISCUSSION

A. Compressive Strength

The results of the various curing regimes' influence on the R-P-C compressive strength development are presented in Figure 4. The compressive strength improvement from the lowest to the highest was: R-AN, R-C, and R-S, which increased with an R-S duration from 1 to 3 days.

Fig. 3. (a) R-N, (b) R-C, (c) R-S, (d) R-AN.

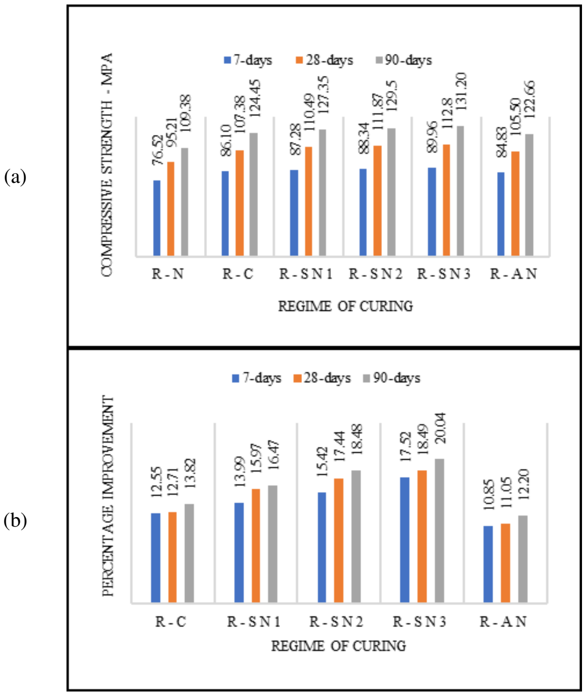


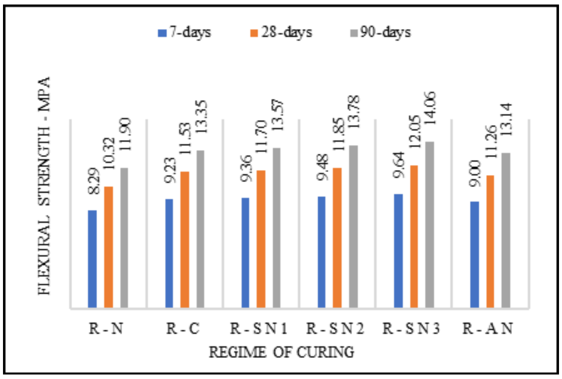
Fig. 4. (a) Compressive strength of the R-P-C mix with different curing methods, (b) percentage improvement in R-P-C mix compressive strength for each curing method.

The improvements of 10.85%, 11.05%, and 12.2% were recorded at 7, 28, and 90 days of curing, respectively, for the R-AN regime, emerging from keeping the maintained W content without loss. Therefore, the proper chemical reactions are compatible with the results of [22]. The R-C technique with the W-based liquid curing compound proved its efficiency with many other types of concrete, such as normal concrete with different levels of strength [38] and roller-compacted concrete [39, 40]. Improvements of up to 12.55%, 12.71%, and 13.82% can be expected owing to its high capacity to retain moisture and minimize evaporation loss. The R-S method, one of the most used techniques, is particularly beneficial in precast concrete production due to its ability to accelerate early strength development. As R-S increased from 1 to 3 days, a corresponding improvement in compressive strength was observed. The strength gains at 7, 28, and 90 days were: 13.99%, 15.97%, and 16.47% for 1 day of R-S; 15.42%, 17.44%, and 18.48% for 2 days and 17.52%, 18.49%, and 20.04% for 3 days. This specific method demonstrated the highest improvements. Several studies [23, 24, 40, 41] also proposed hot W curing as an effective alternative for enhancing concrete strength.

B. *Flexural and Tensile Strength*

The different curing methods' impact on the R-P-C flexural and tensile strength is shown in Figures 5 and 6, respectively. The improvement of flexural and tensile strength can be sorted as compressive strength from the lowest to the greatest is: R-AN, R-C, and R-S, with an increase corresponding to the duration of steam curing from 1 to 3 days. It was noted that these results are similar to the compressive strength findings. The improvement for the R-AN regime was 8.54%, 9.04%, and 10.48% for flexural strength, and 7.55%, 8.86%, and 9.26% for tensile strength at 7, 28, and 90 days of curing, respectively. R-AN relies on internal moisture, but its efficiency is limited compared to other methods. It provides moderate strength improvements, as hydration occurs more slowly. These results agree with [24]. The R-C curing regime improvement was 11.22%, 11.74%, and 12.18% for flexural strength, and 10.255, 9.95%, and 10.95% for tensile strength, at 7, 28, and 90 days of curing, respectively. These improvements can be attributed to the fact that C-R prevents moisture loss, ensuring sustained hydration and gradual strength improvement. Finally, for the R-S regime, the improvement in flexural strength at 7, 28, and 90 days, respectively, was 12.82%, 13.35%, 14.08% for 1 day of curing, 14.24%, 14.75%, 15.81% for 2 days, and 16.225, 16.765, 18.21% for 3 days. For tensile strength, the improvement at 7, 28, and 90 days, respectively, was 11.855% 12.25%, 12.85% for 1 day of curing, 13.25%, 13.96%, 14.56% for 2 days, and 15.25%, 15.85%, 16.95% for 3 days. These improvements are due to R-S accelerated hydration reactions, leading to faster and more significant strength development. Moreover, the longer durations of R-S (1 to 3 days) further enhance microstructure, resulting in higher strength improvement over time. These results agree with [23, 24, 40, 41].

(a)



(b)

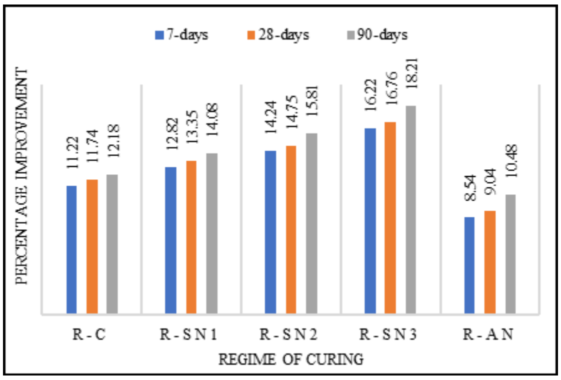


Fig. 5. (a) Flexural strength of the R-P-C mix with different curing methods, (b) percentage improvement in R-P-C mix flexural strength for each curing method.

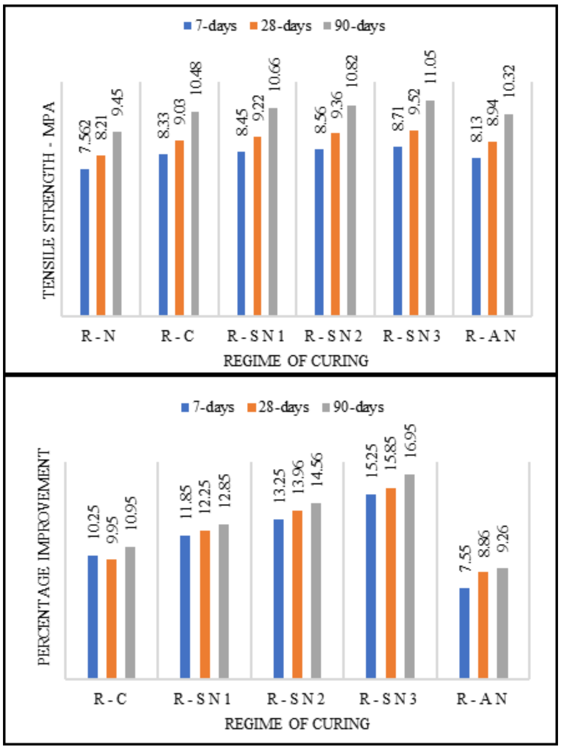


Fig. 6. (a) Tensile strength of R-P-C mix with various curing methods, (b) percentage improvement in R-P-C mix tensile strength for each curing method.

V. CONCLUSIONS

This study investigates the influence of four different curing methods on the mechanical properties of Reactive Powder Concrete (R-P-C). Its compressive, flexural, and tensile strength was evaluated through experimental testing. Based on the results obtained, the following conclusions can be drawn:

- The autogenous curing (R-AN) method, followed by Water (W) curing, demonstrates effective moisture retention, leading to consistent strength development over time.
- Applying a W-based liquid curing compound (Sika-Antisol WB IQ) was proven to be a reliable technique for

minimizing moisture loss and enhancing concrete strength in challenging environments.

- The highest improvements in mechanical strength (compressive, flexural, and splitting tensile) were achieved in the Steam + Normal Curing (R-S) regime, which increased with a curing time duration from 1-3 days, followed by Normal Curing (R-N) up to 28 and 90 days.
- The correlation between R-P-C strength and the different curing methods indicates that an increase in compressive strength is accompanied by corresponding improvements in flexural and splitting tensile strengths.
- Selecting and implementing appropriate curing techniques plays a crucial role in enhancing the long-term performance and durability of R-P-C across various environmental conditions.

REFERENCES

[1] F. L. Bolina, G. Poleto, and H. Carvalho, "Proposition of parametric data for UHPC at high temperatures," *Journal of Building Engineering*, vol. 76, Oct. 2023, Art. no. 107222, https://doi.org/10.1016/j.jobe.2023.107222.

[2] M. M. Kadhum, "Studying of Some Mechanical Properties of Reactive Powder Concrete Using Local Materials," *Journal of Engineering*, vol. 21, no. 07, pp. 113–135, Jul. 2015, https://doi.org/10.31026/j.eng.2015.07.09.

[3] J. Li, Z. Wu, C. Shi, Q. Yuan, and Z. Zhang, "Durability of ultra-high performance concrete – A review," *Construction and Building Materials*, vol. 255, Sep. 2020, Art. no. 119296, https://doi.org/10.1016/j.conbuildmat.2020.119296.

[4] J. Du *et al.*, "New development of ultra-high-performance concrete (UHPC)," *Composites Part B: Engineering*, vol. 224, Nov. 2021, Art. no. 109220, https://doi.org/10.1016/j.compositesb.2021.109220.

[5] M. Elmorsy and W. M. Hassan, "Seismic behavior of ultra-high performance concrete elements: State-of-the-art review and test database and trends," *Journal of Building Engineering*, vol. 40, Aug. 2021, Art. no. 102572, https://doi.org/10.1016/j.jobe.2021.102572.

[6] F. Y. Huang, H. L. Chen, F. F. Yang, C. Lin, and B. C. Chen, "Experimental Study on Bending Capacity and Calculation Method of Ultra-high Performance Concrete Slab," *Journal of Architecture and Civil Engineering*, vol. 36, no. 3, pp. 28–36, May 2019.

[7] H. H. Mohammed and A. S. Ali, "Flexural Behavior of Reinforced Rubberized Reactive Powder Concrete Beams under Repeated Loads," *Journal of Engineering*, vol. 29, no. 08, pp. 27–46, Aug. 2023, https://doi.org/10.31026/j.eng.2023.08.03.

[8] O. A. Mayhoub, E.-S. A. R. Nasr, Y. A. Ali, and M. Kohail, "The influence of ingredients on the properties of reactive powder concrete: A review," *Ain Shams Engineering Journal*, vol. 12, no. 1, pp. 145–158, Mar. 2021, https://doi.org/10.1016/j.asej.2020.07.016.

[9] L. S. Danha, W. Ismail Khalil, and H. M. Al-Hassani, "Mechanical Properties of Reactive Powder Concrete (RPC) with Various Steel Fiber and Silica Fume Contents," *Engineering and Technology Journal*, vol. 31, no. 16, pp. 3090–3108, Sep. 2013, https://doi.org/10.30684/etj.31.16A.8.

[10] M. Soutsos and S. Millard, "Mix Design, Mechanical Properties, and Impact Resistance of Reactive Powder Concrete (RPC)," presented at the Concrete Repair, Rehabilitation and Retrofitting III, UK, 2005, pp. 181–186.

[11] M. Á. Sanjuán and C. Andrade, "Reactive Powder Concrete: Durability and Applications," *Applied Sciences*, vol. 11, no. 12, Jan. 2021, Art. no. 5629, https://doi.org/10.3390/app11125629.

[12] Z. F. Muhsin and N. M. Fawzi, "Effect of Fly Ash on Some Properties of Reactive Powder Concrete," *Journal of Engineering*, vol. 27, no. 11, pp. 32–46, Nov. 2021, https://doi.org/10.31026/j.eng.2021.11.03.

[13] J. Xu *et al.*, "Behaviour of ultra high performance fibre reinforced concrete columns subjected to blast loading," *Engineering Structures*, vol. 118, pp. 97–107, Jul. 2016, https://doi.org/10.1016/j.engstruct.2016.03.048.

[14] J. Abd and I. K. Ahmed, "The Effect of Low Velocity Impact Loading on Self-Compacting Concrete Reinforced with Carbon Fiber Reinforced Polymers," *Engineering, Technology & Applied Science Research*, vol. 11, no. 5, pp. 7689–7694, Oct. 2021, https://doi.org/10.48084/etasr.4419.

[15] H. Al-Jubory and Nuha, "Mechanical Properties of Reactive Powder Concrete (RPC) with Mineral Admixture-ENG," *Al-Rafidain Engineering Journal (AREJ)*, vol. 21, no. 5, pp. 92–101, Oct. 2013, https://doi.org/10.33899/rengj.2013.79579.

[16] A. Hussein, Z. M. R. A. Rasoul, and A. J. Alsaad, "Steel Fiber Addition in Eco-Friendly Zero-Cement Concrete: Proportions and Properties," *Engineering, Technology & Applied Science Research*, vol. 12, no. 5, pp. 9276–9281, Oct. 2022, https://doi.org/10.48084/etasr.5178.

[17] G. K. Mohammed, K. F. Sarsam, and I. N. Gorgis, "Flexural Performance of Reinforced Concrete Built-up Beams with SIFCON," *Engineering and Technology Journal*, vol. 38, no. 5A, pp. 669–680, May 2020, https://doi.org/10.30684/etj.v38i5A.501.

[18] R. P. Memon, A. R. M. Sam, A. Z. Awang, and U. I. Memon, "Effect of Improper Curing on the Properties of Normal Strength Concrete," *Engineering, Technology & Applied Science Research*, vol. 8, no. 6, pp. 3536–3540, Dec. 2018, https://doi.org/10.48084/etasr.2376.

[19] S. S. Raza and L. A. Qureshi, "Effect of carbon fiber on mechanical properties of reactive powder concrete exposed to elevated temperatures," *Journal of Building Engineering*, vol. 42, Oct. 2021, Art. no. 102503, https://doi.org/10.1016/j.jobe.2021.102503.

[20] S. S. Raza, L. A. Qureshi, B. Ali, A. Raza, and M. M. Khan, "Effect of different fibers (steel fibers, glass fibers, and carbon fibers) on mechanical properties of reactive powder concrete," *Structural Concrete*, vol. 22, no. 1, pp. 334–346, 2021, https://doi.org/10.1002/suco.201900439.

[21] P. C. Taylor, *Curing Concrete*. UK: CRC Press, 2013.

[22] S. M. Khreef and Z. K. Abbas, "The effects of using magnetized water in reactive powder concrete with different curing methods," *IOP Conference Series: Materials Science and Engineering*, vol. 1067, no. 1, Oct. 2021, Art. no. 012017, https://doi.org/10.1088/1757-899X/1067/1/012017.

[23] G. I. K, K. M. Elsayed, M. H. Makhlouf, and M. Alaa, "Properties of Reactive Powder Concrete Using Local Materials and Various Curing Conditions," *European Journal of Engineering and Technology Research*, vol. 4, no. 6, pp. 74–83, Jun. 2019, https://doi.org/10.24018/ejeng.2019.4.6.1370.

[24] M. Abdulrahman, A. Al-Attar, and M. Ahmad, "Effect of different curing conditions on the mechanical properties of reactive powder concrete," *MATEC Web of Conferences*, vol. 162, May 2018, Art. no. 02014, https://doi.org/10.1051/matecconf/201816202014.

[25] *Iraqi Specification No. 5 : Portland Cement. Baghdad, Iraq: Central Agency for Standardization and Quality Control, 2019.*

[26] *Standard Specification for Silica Fume Used in Cementitious Mixtures.* USA: ASTM International, 2020.

[27] *Iraqi Specification No. 45. Aggregate from Natural Sources for Concrete and Construction. Baghdad, Iraq: Central Organization for Standardization and Quality Control, 2019.*

[28] *Standard Specification for Chemical Admixtures for Concrete*. USA: ASTM International, 2017.

[29] *Iraqi Specification, No .1703: Water Used for Concrete and Mortar*. Baghdad, Iraq: Central Organization for Standardization and Quality Control, 1992.

[30] *Standard Test Method for Flow of Hydraulic Cement Mortar*. USA: ASTM International, 2020.

[31] *Testing hardened concrete - Part 2: Making and curing specimens for strength tests*. Slovenia: SIST, 2019.

[32] *Testing hardened concrete - Part 3: Compressive strength of test specimens*. Slovenia: SIST, 2019.

[33] *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory*. USA: ASTM International, 2019.

[34] *Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens*. USA: ASTM International, 2011.

[35] *Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading)*. USA: ASTM International, 2016.

[36] *Standard Specification For Tolerances For Accelerated Curing at Atmospheric Pressure*. USA: ACI, 1992.

[37] *Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens*. USA: ASTM International, 2003.

[38] D. M. Hussein and Z. K. Abbas, "Influence of Magnetized Mixing Water on Different Levels of Concrete Strength using Different Curing Processes," *Engineering, Technology & Applied Science Research*, vol. 14, no. 4, pp. 15739–15744, Aug. 2024, https://doi.org/10.48084/etasr.7898.

[39] H. R. Hassoon and Z. K. Abbas, "Analyzing Lab and Field Compaction Methods for designing Roller Compacted Concrete Pavements (RCCP) with Different Curing Processes: Articles," *Engineering, Technology & Applied Science Research*, vol. 14, no. 5, pp. 17488–17493, Oct. 2024, https://doi.org/10.48084/etasr.8614.

[40] M. Seffo, N. S. Ismaeel, and A. hussain Ali, "Influence of Curing Regimes on the Compressive Strength of the Reactive Powder Concrete (RPC) Used in Rigid Pavements," *Journal of Techniques*, vol. 25, no. 3, 2012.

[41] S. I. Hendi and N. M. Aljalawi, "Effect of Various Curing Regimes on Some Properties of Reactive Powder Concrete RPC," *Journal of Engineering*, vol. 30, no. 11, pp. 21–38, Nov. 2024, https://doi.org/10.31026/j.eng.2024.11.02.