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Study on the mechanical properties and behavior of reactive powder concrete under various conditions and curing

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Abstract

In this Study, the mechanical and behavioral characteristics of reactive powder concrete under different percentages of microsilica, quartz, and steel fibers under different temperature and pressure curing conditions were studied. In this research, the amount of microsilica was 10, 15, 20%, quartz powder was 10, 15, 20%, steel fibers were 1, 1.75, 2.5%, and for curing conditions, three temperatures of 25, 50, and 75 degrees Celsius for water were considered. Also, all experimental specimens were tested once in conditions without pre-pressure and a second time in conditions with a pre-pressure of 10 MPa. In these specimens Stress-strain diagram, compressive strength, tensile strength, ductility, energy absorption, cracking pattern, and SEM electron image of the experimental specimens were investigated. The results of this Study showed that increasing quartz powder, microsilica, steel fibers, water temperature and pre-pressure increased compressive and tensile strength by about 10, 15, 20 and 30 percent, respectively. Increased energy absorption by about 10, 35, 50, and 85 percent, respectively, and the combination of the above factors improved the mechanical properties of concrete by about 100 to 140 percent. Fracture images and SEM showed an increase in cracking and more adhesion and ductile fracture with extensive fine cracks in the specimens.

Keywords: reactive powder concrete, heat curing and pre-pressure, microsilica, quartz, steel fiber
2020 MSC: 74L10, 74E30, 74R20

1 Introduction

RPC reactive powder concrete is a type of high-performance capable concrete that is helped by improving microstructure, removing coarse aggregates, using cement pozzolani materials, tensile steel fibers, improving the curing method, and using pressure and heat during concrete hardening, etc. and increasing resistance, durability, ductility, energy absorption, etc. It is a result.

The performance of reactive powder concrete was cured under different temperature conditions in Chang, T., et al. in [2]. The results showed that increasing the water temperature increases the compressive strength and flexural strength of reactive powder concrete (RPC).

Yazıcı, H., et al. in [13], investigated the mechanical properties of reactive powder concrete under different treatment conditions. The results of this Study showed that experimental specimens With Processing in an Autoclave and water vapor system had Greater compressive strength and Lower flexural strength and strength than the specimens With Standard Processing.

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The effect of pre-pressure and increasing the curing temperature on the properties of reactive powder concrete was investigated in Helmi, M., et al. [4]. The results of this Study show that rising temperatures and pressure cause the compressive strength of experimental specimens to increase by up to 40%.

Yao, Y., et al. in [12] investigated experimental investigation of the effect of comprehensive hydraulic pressure on the reaction concrete stress-strain diagram powder acceptable. Results show that as the all-round hydraulic pressure increases, the stress-strain diagram improves and the failure pattern of the specimens changes.

Shen, L., et al. in [10], investigated the factors affecting the shear behavior of reactive powder concrete, among them were steel fibers. The results of the experiment showed that the use of a lower ratio of water to cement can Steel Fiber Connection with improve the constituent materials of concrete.

Experimental studies of the water vapor curing method with different durations on the impact resistance of reactive powder concrete were conducted by Wang, X., et al. in [11]. The results of this Study showed that by increasing the exposure time of the specimens to water vapor, the resistance of the experimental specimens to impact load improved.

Ge, L., et al. in [3], investigated experimental investigation of mechanical and microstructural properties of reinforced steel reactive powder concrete, under hot water. The results of this Study showed that the use of hot water and then exposure to water vapor significantly improved the mechanical properties of reactive powder concrete by about 240 percent.

Hendi and Aljalawi in [5], conducted an Experimental study of the effect of curing temperature on the mechanical properties of reactive powder concrete. The results showed that specimens cured in hot water had better mechanical properties than standard cured specimens.

Therefore, according to previous research, in the present Study, using the simultaneous combination of microsilica, quartz powder, steel fibers, and heat and pressure treatment, an attempt has been made to improve the mechanical properties of reactive powder concrete.

2 Materials and methods

The materials used in the preparation of specimens, the granulation of aggregates, as well as the size of the specimens, were selected according to the criteria of ASTM standards.

Table 1: Physical and Mechanical Characteristics of Steel Fibers

Diameter (mm)	**Length(mm)**	**Length/Diameter**	**Density**(kg/m^3)	**Tensile strength (MPa)**	**Ultimate strain (%)**
0.2	14	70	7850	2850	1.3

The quartz powder used has a volumetric density of about 1.5 g/cm^3 and a diameter of 0.08 to 0.7mm.

The microsilica used is based on the ASTM-C1240 standard with a diameter of about 0.1 $\mu m$and a specific surface area of 20 m^2/gr and a specific gravity of 2.2, and its chemical characteristics are according to Table 2.

Table 2: Chemical Characteristics of Cement and Microsilica

	CaO(%)	SiO_2 (%)	Al_2O_3(%)	Fe_2O_3(%)	SO_3(%)	Na_2O(%)	K_2O(%)	MgO(%)	$L.O.I$(%)
Cement	63.02	20.05	4.26	2.82	3.15	0.38	1.24	3.8	2.3
Microsilica	0.27	97.8	0.34	0.17	–	0.23	0.15	0.21	2

The polycarboxylic ether superlubricant is EUNIFLOW 260 with a specific gravity of 1/1 g/cm^3. Silica soot (10 to 20 percent), quartz aggregate (10 to 20 percent), and steel fibers (1 to 2.5 wt.%) of concrete were used. The amount of water in the cement was considered to be 35% and the amount of superlubricant was added to the extent that the slump was in the range of 12. The density of all specimens was about 2400 kg/m^3. With the help of the Taguchi method, the number of specimens was reduced, and the mixing plan for the specimens is according to Table 3.

Table 3: Mixing plan for one cubic meter of experimental specimens (S=Silica Fume, Q=Quartez Powder, F=Steel Fiber, C=Cement, W=Water, FA=Fine Aggregate, SP=Super Plasticizer)

Specimen name	**C(Kg)**	**W/C**	**FA (Kg)**	**S/C(%)**	**Q/C(%)**	**F(%)**	**SP/C(%)**
S10Q10F1.0	882	0.35	934	10	10	1.0	1.15

To make the specimens, first ordinary sand, quartz powder, steel fiber, cement, and microsilica were mixed dry for 6 minutes at 60 RPM, and then the mixture of water and superlubricant was gradually sprayed into the mixture for 4

S10Q15F1.0	882	0.35	884	10	15	1.0	1.1
S10Q20F1.0	882	0.35	832	10	20	1.0	1.14
S15Q10F1.0	833	0.35	936	15	10	1.0	1.13
S15Q15F1.0	833	0.35	884	15	15	1.0	1.1
S15Q20F1.0	833	0.35	832	15	20	1.0	1.2
S20Q10F1.0	784	0.35	936	20	10	1.0	1.3
S20Q15F1.0	784	0.35	884	20	15	1.0	1.1
S20Q20F1.0	784	0.35	832	20	20	1.0	1.15
S10Q10F1.75	882	0.35	936	10	10	1.75	1.15
S10Q15F1.75	882	0.35	884	10	15	1.75	1.1
S10Q20F1.75	882	0.35	832	10	20	1.75	1.14
S15Q10F1.75	833	0.35	936	15	10	1.75	1.13
S15Q15F1.75	833	0.35	884	15	15	1.75	1.1
S15Q20F1.75	833	0.35	832	15	20	1.75	1.2
S20Q10F1.75	784	0.35	936	20	10	1.75	1.3
S20Q15F1.75	784	0.35	884	20	15	1.75	1.1
S20Q20F1.75	784	0.35	832	20	20	1.75	1.15
S10Q10F2.5	882	0.35	936	10	10	2.5	1.15
S10Q15F2.5	882	0.35	884	10	15	2.5	1.1
S10Q20F2.5	882	0.35	832	10	20	2.5	1.14
S15Q10F2.5	833	0.35	936	15	10	2.5	1.13
S15Q15F2.5	833	0.35	884	15	15	2.5	1.1
S15Q20F2.5	833	0.35	832	15	20	2.5	1.2
S20Q10F2.5	784	0.35	936	20	10	2.5	1.3
S20Q15F2.5	784	0.35	884	20	15	2.5	1.1
S20Q20F2.5	784	0.35	832	20	20	2.5	1.15

minutes at a speed of 100 RPM. Also, according to the algorithm of Table 4, the specimens were cured in conventional water at 25 degrees, curing under pressure of 10 MPa in the first hour or with hot water from the second to the fifth day.

Table 4: Specification of the types of processing modes

Type of Curing	**Specifications**				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
T25	1 day in mold	28 days in 25° water			
T50	1 day in mold	1 day in 25° water	3 days in 50° water	23 days in 25°C Water	
T75	1 day in mold	1 day in 25° water	3 days in 75° water	23 days in 25°C water	
T50P	Pressure (10MPa-60Min)	1 day in mold	1 day in 25° water	3 days in 50° water	23 days in 25° water
T75P	Pressure (10MPa-60Min)	1 day in mold	1 day in 25° water	3 days in 75° water	23 days in 25° water

For example, in the T75P type curing, in the first step, after the specimens were poured into the mold, they were subjected to a pre-pressure of 10 MPa. In the second step, they were kept in the mold for one day. In the third step, the specimens were placed in water at 25 degrees Celsius for one day. In the fourth step, the specimens were placed in water at 75 degrees Celsius for three days. In the fifth step, the specimens were placed in water at 25 degrees Celsius for 23 days.

3 Results and discussion

3.1 Stress-strain diagram and rupture pattern

In Figures 1, the stress-strain diagram of the experimental specimens under different processing conditions is shown.

According to Figure 1, in experimental specimens with one percent of steel fibers, in the case where only hot water has been used for curing, with the increase in the temperature of hot water from 25 to 75 degrees Celsius, the yield limit strain, the stiffness and the descending branch of the graph have not changed much. Still, the moment of rupture strain has increased from about 0.01 to 0.016, and the rupture limit strain has increased from 0.012 to about 0.02. In other words, the shape of the specimens has been improved. In addition, in these specimens, the average energy absorption in specimens cured in 75°C water is about 2.67 times that of specimens cured in 25°C water.

Also, in experimental specimens with 1% steel fibers, if the specimens are first exposed to a pressure of 10 MPa and then placed in hot water, they have less stiffness, ductility and toughness than specimens that have been placed only in hot water. The percentage of their increased ductility and toughness depends on the temperature of the water. In such a way that with an increase from 25 to 75 degrees Celsius, the experimental specimens have become more

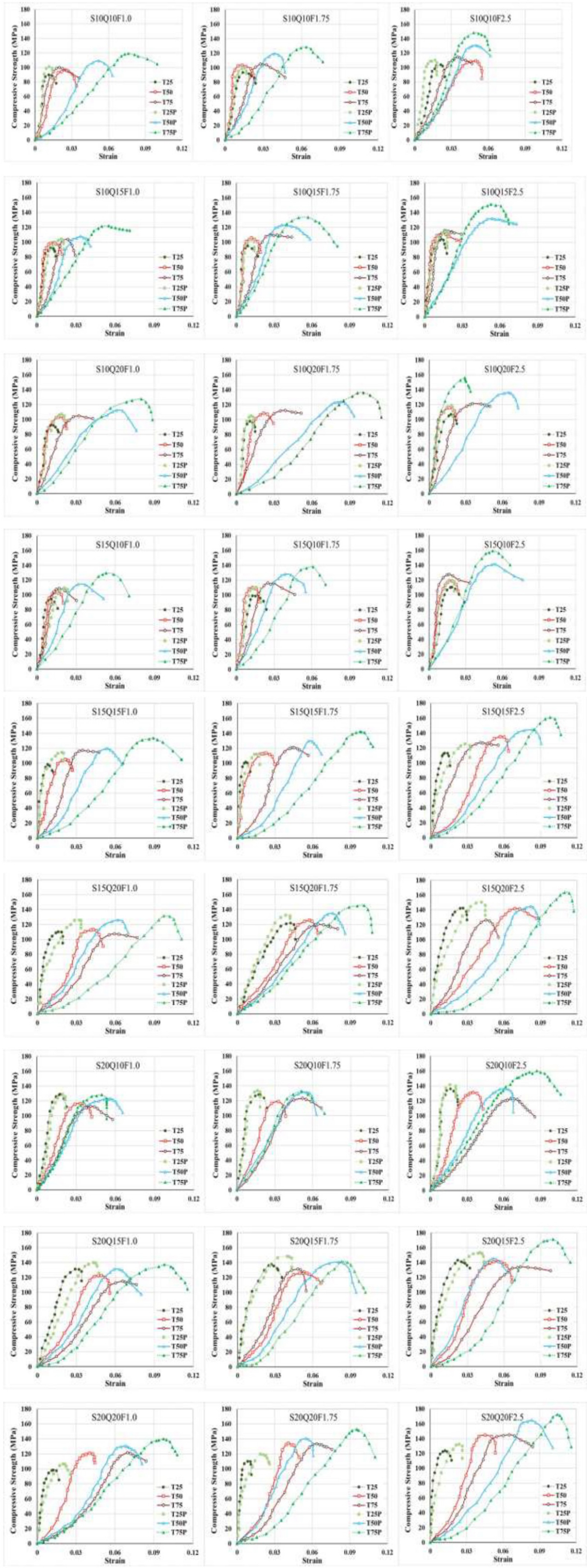


Figure 1: Stress-strain diagram of experimental specimens under different curing conditions

malleable. Also, in these specimens, which were first pressurized and then in hot water, the energy absorption in the specimens that were first subjected to pre-pressure and then in water of 75 ˚C, was about 3.67 times the energy absorption of similar specimens but cured in 25-degree water.

According to Figure 1, in the specimens containing 1.75% steel fibers, while the specimens were in the hot water processing stage, the increase in water temperature from 25 to 50 ˚C had no significant effect on the stiffness and the descending branch. Still, the rise in temperature from 50 to 75 degrees Celsius has a substantial impact on the stiffness and yield limit strain of the experimental specimens. In such a way that by increasing the water temperature from 25 to 50 degrees Celsius, the strain equivalent to the final resistance decreased from about 0.012 to 0.01. The moment of rupture strained from 0.015 to 0.011, but the increase in the water temperature from 50 to 75 degrees Celsius increased the strain equivalent to the maximum resistance, from 0.01 to about 0.03, and caused the strain of the moment of rupture from about 0.011 to about 0.032. An increase of about 3 times the absorption of energy.

Also, in specimens with 1.75% steel fibers, if a pressure of 10 MPa has been used in the processing stage, before the specimens are placed in hot water, compared to the specimens that have been placed in hot water, the use of pressure at 25 degrees Celsius has increased stiffness. Still, at 50 and 75 degrees Celsius, the stiffness has decreased. Whereas in all experimental specimens, the use of pressure has increased the final strength, ductility and energy absorption, the percentage of which increases depending on the temperature of the hot water, so that with increasing the temperature of the water, the percentage of their increase.

Also, according to Figure 1, in the experimental specimens with 2.5% steel fibers, the experimental specimens that were placed in hot water only, while the experimental specimens were placed in hot water only, the increase in water temperature had a negative effect on the final strength, and at 25 and 50 degrees Celsius, the stiffness did not change much, but at 75 degrees Celsius, the stiffness and with the increase in temperature, the strain of the moment of final resistance and energy absorption increased, so that, at 25, 50 and 75 degrees Celsius, the strain equivalent to the final resistance was about 0.017, 0.02 and 0.038, respectively, and the energy absorption at 50 and 75 degrees Celsius was 1.93 and 2.52 times the temperature of 25 degrees, respectively. But in the specimens that were exposed before the exposure in hot water, under pressure of 10 MPa, increasing the temperature from 25 to 50 ˚C reduced the stiffness and increased the equivalent strain of the final strength from 0.02 to 0.032 and increasing the water temperature from 50 to 75 ˚C increased the stiffness and final strength and decreased the moment strain of the final resistance from 0.07 to 0.03. In addition, the energy absorption at 50 and 75 degrees is about 2.76 and 3.16 times that of 25 degrees on average.

According to Figure 1 and from the comparison of the diagrams related to specimens with 1, 1.75 and 2.5% steel fibers, with increasing the percentage of steel fibers, the yield limit strain, the breakage strain, ductility, and energy absorption of the experimental specimens increased with increasing the percentage of steel fibers in general. In other words, with the increase in the percentage of steel fibers, the experimental specimens behaved more softly, and their rupture occurred later.

Among all the experimental specimens, by applying a pre-pressure of 10 MPa in the curing stage, the hardness has been reduced compared to the case in which only hot water has been used in the curing stage. Still, the strain of the final resistance limit has increased significantly; in other words, the specimens have become more ductile, and their energy absorption has increased. It seems that the reason for this is the adhesion of the materials to the steel fibers due to the application of pressure, and the more the adhesion of these materials to the steel fibers, the higher the strain of the final resistance limit. In other words, it can be said that the application of pre-pressure has improved the behavior of the strain stress diagram, because the final strength, ductility, and energy absorption of the specimens have increased, and these two parameters have a significant effect on reducing seismic damage to the structure. Also, the amount of increase in the final strength and ductility parameters due to pre-pressure depends on the water temperature.

As can be seen from the stress-strain curve of the preparation specimens in Figure 1, after the concrete reaches the maximum compressive strength, the experimental specimens can tolerate less deformation under lower loads and are destroyed. This situation creates more brittle behavior conditions for powder-reactive concrete in the range of providing maximum loads close to the final failure conditions.

Also, based on Figure 1, the strain stress diagram of the experimental specimens is also affected by the amount of microsilica and quartz powder. In such a way, with increasing the percentage of micro-silica and increasing the quartz powder, the ductility and final strength of the experimental specimens have increased, and energy absorption has increased by 10 to 30 percent, depending on the treatment conditions.

In Figure 2, cracking and fracture of a experimental sample in the last loading stage are shown. It was observed that in specimens with 2.5% steel fibers, ductile fracture occurred. Steel fibers resist the spread of cracks and distribute stresses within the concrete, thereby improving tensile strength, flexural strength, and ductility.

Also, the failure pattern of the specimens has changed with the change in the processing conditions, so that in the experimental specimens made under the T75P curing conditions, it took a long time to rupture after the first crack was observed.

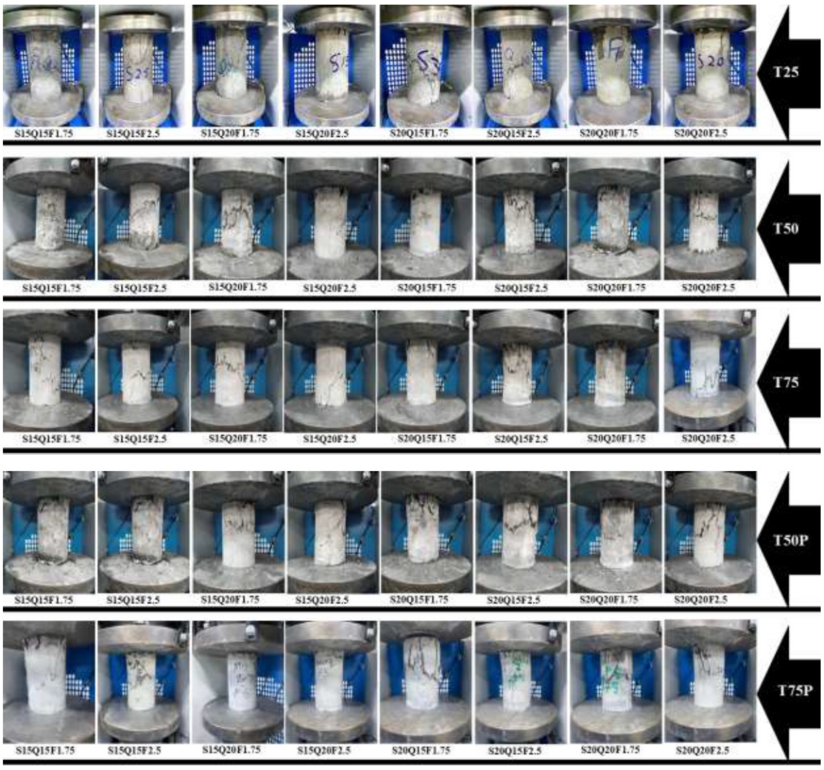


Figure 2: Crack and rupture pattern of experimental specimens

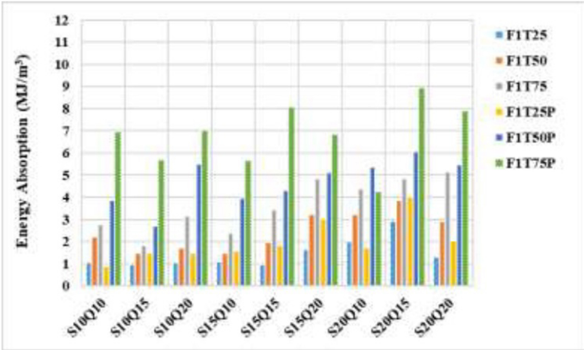
3.2 Energy absorption

The energy absorption capability of concrete is one of the important parameters in the design of structures against dynamic loads. In Figure 3, the energy absorption of the experimental specimens is shown as equal to the area under the stress-strain diagram.

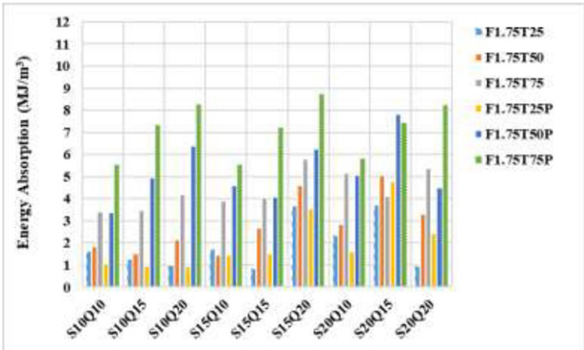
According to Figure (3–a), in specimens that contain 1% steel fibers and are placed in hot water only at 50 and 75 degrees in the curing stage, the average energy absorption is about 1.75 and 2.67 times that of the specimens with standard curing (That is, the specimens contain 1% steel fibers and are cured in water at a temperature of 25 degrees and conditions without pre-pressure). Also, in this group of experimental specimens that have been tested in the curing stage, they have been pre-pressurized, and if the water temperature is 25, 50 and 75 degrees Celsius, the average energy absorption is about 1.42, 3.54 and 5.35 times the standard specimens of this group, respectively.

According to Figure (3–b), in the specimens that contain 1.75% steel fibers and are placed in hot water only at 50 and 75 degrees in the curing stage, the average energy absorption is about 1.77 and 2.98 times that of the specimens with standard curing in this group (That is, a specimen containing 1.75% steel fibers, a water curing temperature of 25 degrees, and tested under conditions without pre-pressure), respectively. Also, in this group, the experimental specimens that have been pre-pressurized during the processing stage, if the water temperature is 25, 50 and 75 degrees Celsius, the average energy absorption is about 1.18, 3.43 and 5.03 times the standard specimens of this group, respectively.

According to Figure (3–c), in specimens that contain 2.5% steel fibers and are placed only in hot water at 50 and 75 degrees in the curing stage, the average energy absorption is about 1.93 and 2.52 times that of the standard processing specimens of this group(That is, a specimen containing 2.5% steel fibers, a water treatment temperature of 25 degrees, and tested under conditions without pre-pressure), respectively. Also, in this group of experimental specimens that



(a)



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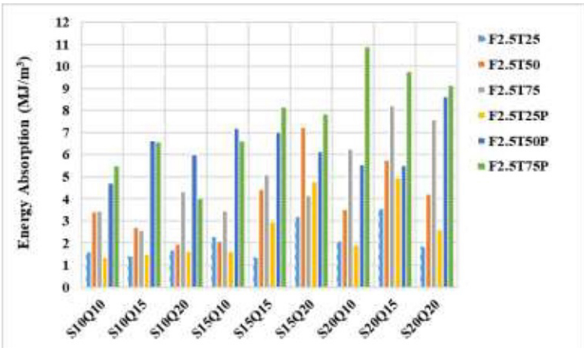


(c)

Figure 3: Energy absorption of experimental specimens with (a) 1% (b) 1.75% (c) 2.5% steel fibers

have been prepressurized in the curing stage, if the water temperature is 25, 50 and 75 degrees Celsius, the average energy absorption is about 1.23, 3.39 and 3.88 times the standard specimens of this group, respectively.

From the comparison of Figures (3–a), (3–b) and (3–c), it can be said that the increase in the percentage of steel fibers has increased energy absorption. In addition, in all experimental specimens, the specimens that have been pre-pressurized during the curing stage have more energy absorption than similar specimens, and the increase in the processing temperature has increased energy absorption.

3.3 Compressive strength

In Figure 4, the compressive strength of the experimental specimens is shown.

According to Figure 4, the increase in microsilica from 10 to 20 percent increased compressive strength by about 15 percent on average. In other words, it seems that increasing micro-silica from 10 to 20% increases the reaction with calcium hydroxide produced during the cement hydration reaction and improves the mechanical properties of concrete by creating a fine and dense structure of C-S-H.

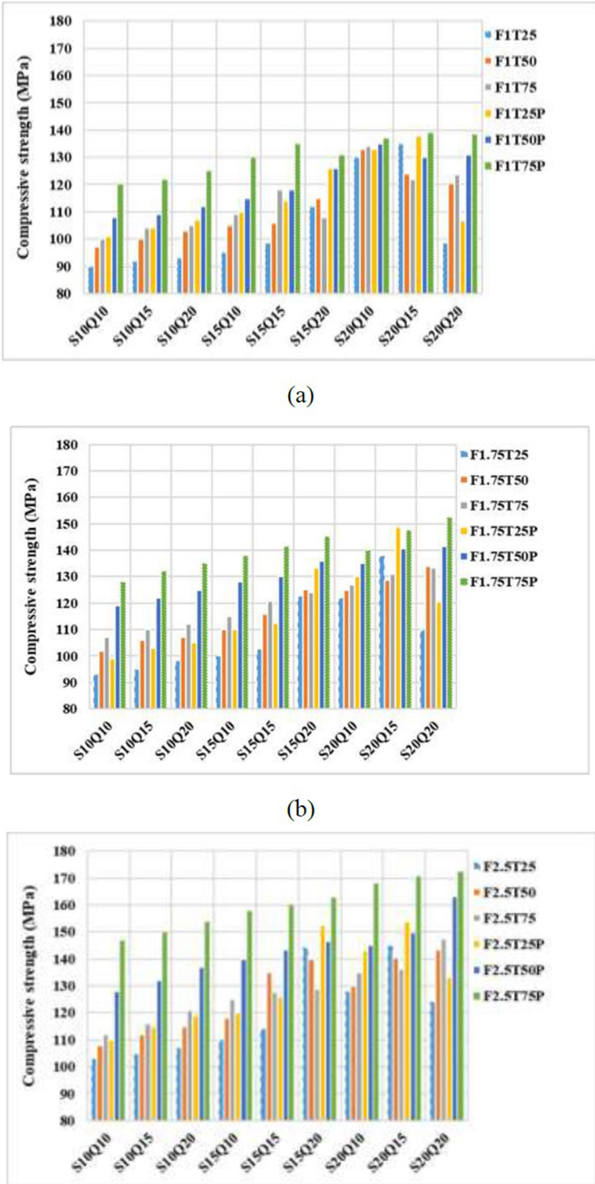


Figure 4: Compressive strength of experimental specimens with (a) 1% (b) 1.75% (c) 2.5% steel fiber

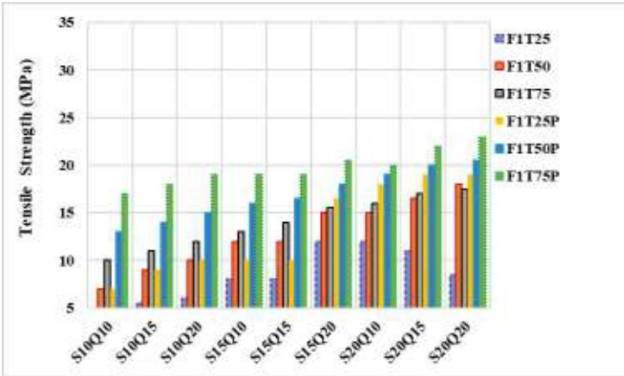
Also, according to Figure 4, the increase in quartz powder from 10 to 20 percent, on average, increased the compressive strength by about 10 percent. However, the rise in steel fibers from 1 to 2.5 percent increased the compressive strength by about 20 percent.

According to Figure 4 and from the comparison of the compressive strength of the experimental specimens, it can be said that the use of hot water and the application of pre-pressure in the Processing of reactive powder concrete will increase its compressive strength and as the water temperature increases, the compressive strength will increase. It seems that the reason for this is the increase in the adhesion of the materials to steel fibers.

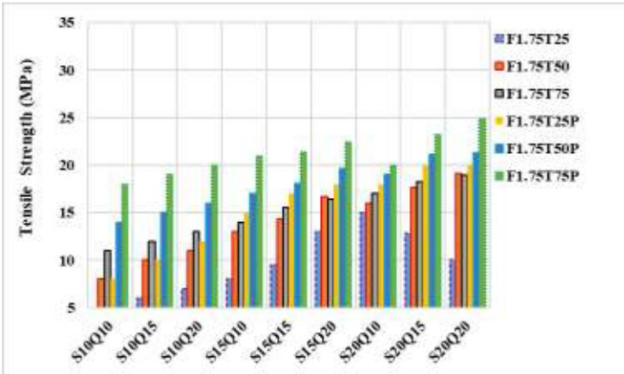
As can be seen in Figure 4, increasing microsilica solitude from 10 to 20 percent increased the compressive strength by 15 percent, but more than that, it decreased the compressive strength. However, with the increase in temperature above 50 degrees, this increase simultaneously increased the compressive strength increased by 25 percent, and with the increase in temperature and pre-pressure, it increased by about 35 percent. In other words, other increases in temperature and pre-pressure have increased the role of micro-silica and quartz powder.

3.4 Tensile strength

In Figure 5, the tensile strength of the experimental specimens is shown.



(a)



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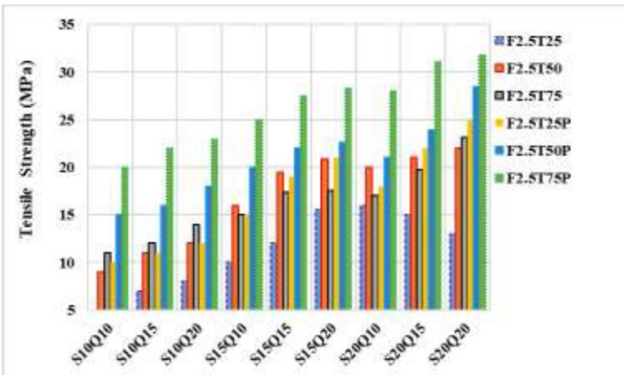


(c)

Figure 5: Stress-strain diagram of experimental specimens under different curing conditions

As shown in Figure 5, for water specimens with 1 and 1.75% steel fibers, in the case of the hot water only curing method, increasing the water temperature from 25 to 50 ˚C significantly increased the tensile strength of the specimens, but increasing the water temperature from 50 to 75 ˚C slightly increased the tensile strength of the test specimens.

Also, according to Figure 5, in test specimens with 2.5% steel fibers, increasing the water temperature from 50 to 75 ˚C significantly increased the tensile strength, but in these specimens, increasing the water temperature from 50 to 75 ˚C greatly reduced the tensile strength of the test specimens.

Therefore, in hot water curing, 1.75% fiber percentage improved the tensile strength, but using 2.5% steel fibers reduced the tensile strength of the test specimens.

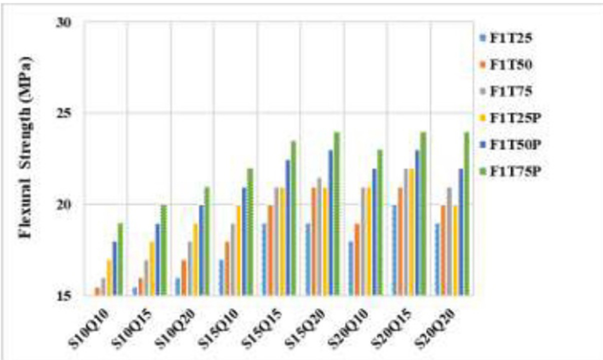
Based on the above figure, applying pre-pressure before placing the specimens in hot water increases the tensile strength of the experimental specimens, and, with increasing the percentage of steel fibers, the rate of tensile strength increases. It seems that the reason for this is the adhesion of the materials to the steel fibers due to the application of pressure.

Based on the above figure, increasing the percentage of microsilica alone, increasing the rate of quartz powder alone, and increasing the percentage of microsilica and quartz powder simultaneously increased the tensile strength of concrete.

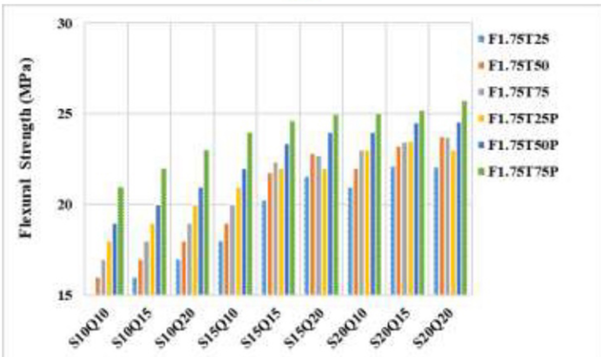
Therefore, the highest and lowest tensile strengths were related to the experimental specimens S15Q15F1-T25 and S20Q20F2.5 -T75, with values of 8 and 31.75 MPa, respectively.

3.5 Flexural strength

In Figure 6, the flexural strength of the experimental specimens is shown.



(a)



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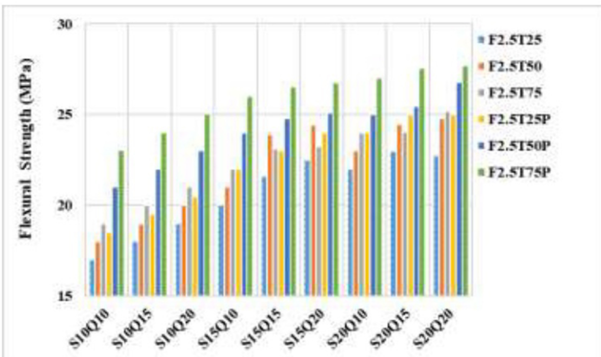


(c)

Figure 6: Flexural strength diagram of experimental specimens with (a) 1% (b) 1.75% (c) 2.5% steel fibers

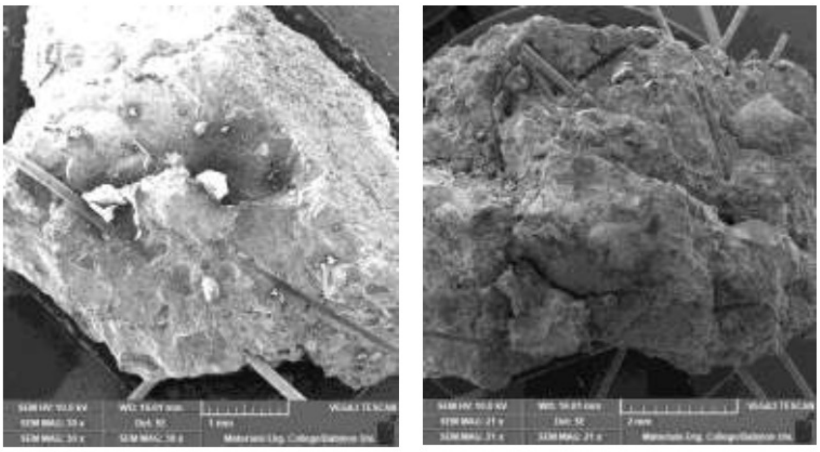
As shown in the figure above, in a case where only hot water was used in the curing stage, in specimens with 1 and 1.75% steel fibers, the increase in water temperature increased the flexural strength, but in the specimens with 2.5% steel fibers, the increase in water temperature from 25 to 50 degrees Celsius increased the tensile strength, while the rise in water temperature from 50 to 75 degrees Celsius has reduced tensile strength. In all experimental specimens, the lowest flexural strength is related to the specimens that used only water at 25 °C in the curing stage and the highest flexural strength is related to the specimens that were first subjected to 10 MPa pre-pressure and then in hot water at 75 °C.

Also, in the case of applying pre-pressure and then settling the experimental specimens in hot water, increasing the water temperature has always increased the flexural strength of the experimental specimens compared to the case in which only hot water has been used in the processing stage.

In all experimental specimens and in all processing methods, increasing the percentage of steel fibers, increasing the rate of microsilica and increasing the percentage of quartz powder have increased the flexural strength of the experimental specimens.

3.6 Microstructure analysis

Due to the necessity of investigating the microstructure of reactive powder concrete, in the following figures, the microstructure photographs of the experimental specimens S20Q20F2.5-T75 and S20Q20F2.5-T75P are shown, the main purpose of which is to compare and investigate the microstructure of concrete specimens in a state in which the maximum amount of micro-silica and quartz powder is used. They are made under curing conditions at 75 °C with and without prepressure.



(a) (b)

Figure 7: Scanning microscopy images for experimental specimens in the maximum state of microsilica and quartz powder and curing temperature of 75 °C (a) S20Q20F2.5-T75 (prepressure sample), (b) S20Q20F2.5-T75P (pre-pressure sample)

Based on the microscopic images shown in Figure 7, in concretes with microsilica and quartz powder, the amount of density and pore structure is improved by applying pre-pressure and high temperature. In other words, the higher water temperature during the treatment of reactive powder concrete causes the hydration reaction to be greatly improved and increases the mechanical properties of the concrete by creating a denser microstructure through the formation of calcium silicate hydrate (C-S-H) in addition to reducing the permeability. Also, at temperatures above 50 Degrees Celsius, some materials, such as crushed quartz, are activated and act like pozzolan, reacting with the lime in concrete.

Also, in Figure 8, the microstructure of the experimental specimens S20Q20F1-T25 and S20Q10F1-T25 is shown.

Analysis SEM shows the common surface between steel fibers and cement with crystals $Ca(OH)_2$ fillings that are useful for steel fiber composites and provide hardness and cracking resistance to concrete. Reactivity increases. Also, to the extent that the adhesion of the cement paste to the steel fibers is higher and there are no holes and microcracks around it, the contribution of steel fibers in the tensile tolerance of the transfer area is also increased [6, 9, 14, 15]. Of course, microcracks may occur in the transfer area before loading and during the manufacture and Processing of specimens due to the relative displacement between the cement paste and the aggregates [7, 8]. It seems

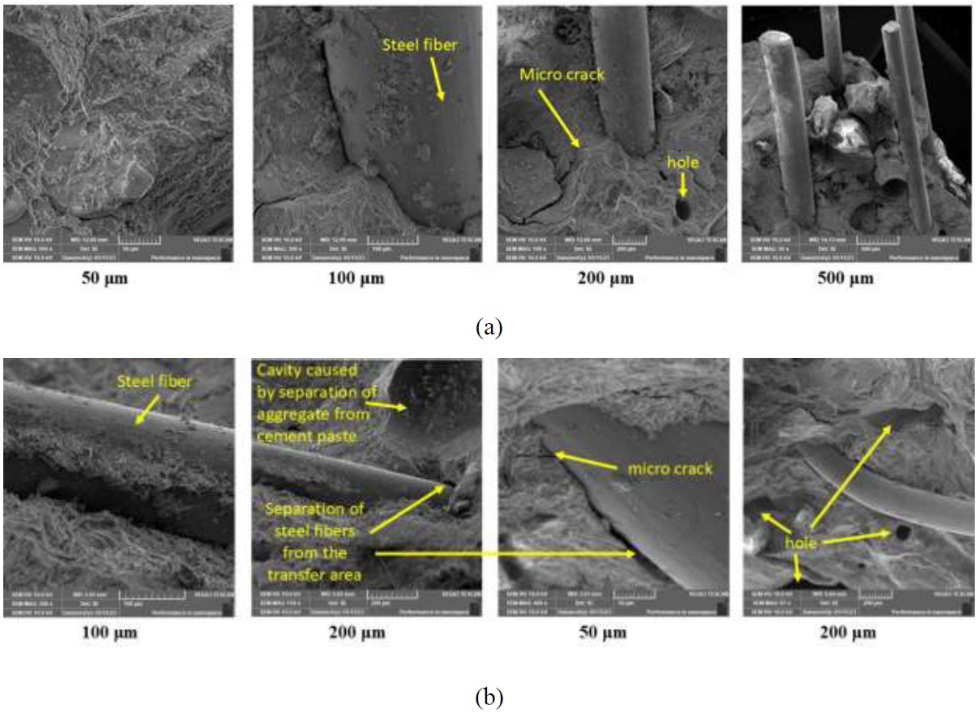


Figure 8: Scanning Electron Microscope (SEM) images for experimental specimens (a) S20Q20F1-T25 (b) S20Q10F1-T25

that in this Study, the amount of quartz powder, microsilica and steel fibers has been effective on microcracks. As shown in Figures (8–a) and (8–b), in the experimental sample, which contains 20% quartz powder (S20Q20F1-T25), the separation of steel fibers from the transmission area has become more evident. This phenomenon may have been caused by the thickening of the layers of water around the quartz powder.

Based on the microscopic images shown in Figure 8, the presence of microsilica and its role in reactive powder concrete are evident in the microstructure of reactive powder concrete due to its high reactivity, high specific area, and consequently increasing the volume of hydrated gel production and reducing cavities. According to past research, Micro-silica reacts with calcium hydroxide produced during cement hydration reaction and produces gels C-H-S. This results in a more dense structure, and thus a more compact structure. Mechanical Specifications Concrete Improves Find [1].

Also, based on the microscopic images shown in Figure 8, by replacing a part of the cement with active additives, the porosity of the reactive powder concrete is reduced, the porous structure is improved, and their structure becomes denser.

4 Conclusion

In this Study, in order to investigate and identify the behavior of reactive powder concrete (RPC), several specimens were subjected to pre-loading in different percentages of quartz sand, microsilica and steel fibers and different temperatures of the cured water. Slump, Density, Compressive Strength, Tensile Strength, Flexural Strength of Cracking Pattern, Ductility, Energy Absorption and SEM Microstructure Photo structure Experimental specimens were examined. The results of this Study showed that quartz fine sand particles, by filling the empty spaces and increasing the density, microsilica particles by hydrating with hydrocalcium ($Ca(OH)_2$) and the formation of hydrated calcium silicate (C-S-H) and increasing the adhesion between the particles, steel fibers by increasing cohesion and energy absorption and creating ductile fracture with wide fine cracks and curing with hot water and pressure with improved curing conditions and better hydration and higher density, have improved the mechanical properties of concrete. Temperature treatment and pre-pressure were observed as the most effective factors in increasing the improvement of the mechanical properties of concrete.

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