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Effect of zeolite and microsilica on the strength of SCC concrete containing PP fibers

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Abstract

Recent advances in concrete technology have resulted in the development of self-compacting concrete (SCC), a highly flowable concrete capable of consolidating under its own weight without the need for external vibration. Pozzolanic materials containing reactive silica (SiO_2) possess limited intrinsic cementitious properties; however, when incorporated as finely divided particles into cementitious systems, they react with calcium hydroxide (CH) generated during cement hydration, producing additional cementitious compounds that enhance the microstructure and overall performance of concrete. The present study investigates the combined influence of natural zeolite, microsilica, and polypropylene (PP) fibers on both the fresh and hardened properties of SCC. Concrete mixtures were proportioned according to established mix design procedures and prepared under controlled laboratory conditions. Natural zeolite was used as a partial cement replacement at levels ranging from 0 to 20% by weight of cement, while PP fibers were incorporated at volumetric contents between 0 and 0.2%; microsilica was maintained at 6.25% of the total binder content in all mixtures. Fresh concrete performance was assessed through slump flow, T_{500}, V-funnel, and L-box tests to evaluate flowability, viscosity, and passing ability. The hardened properties were examined using compressive strength, splitting tensile strength, flexural strength, and water absorption tests. The experimental results demonstrated that mixtures without PP fibers consistently exhibited the lowest compressive strength at all curing ages. The highest compressive strength was obtained with a PP fiber dosage of 0.1% by volume, resulting in an average improvement of approximately 11% compared with fiber-free mixtures. In addition, replacing 10% of cement with natural zeolite provided the optimum performance, increasing compressive strength by nearly 13% relative to the control mixture.

Keywords:

1. Introduction

Concrete is a heterogeneous composite material consisting of cement, water, and aggregates of different sizes, each contributing distinct physical, chemical, and mechanical properties. The hydration reaction between cement and water produces calcium silicate hydrate (C-S-H) and calcium hydroxide (CH), which are primarily responsible for the mechanical performance, porosity, and other characteristics of concrete [1]. Continuous advancements in concrete technology have led to the introduction of self-compacting concrete (SCC), a type of concrete capable of flowing under its own weight and achieving complete compaction without segregation or the use of mechanical vibration. The concept of SCC was first proposed

in 1988, followed by pioneering investigations at the University of Tokyo in 1989 and 1993 to evaluate its performance [2, 3]. Owing to its ability to achieve adequate consolidation without internal or external compaction energy, SCC can considerably reduce both construction time and associated costs [4, 5]. The fundamental properties defining SCC include filling ability, passing ability, and resistance to segregation. These characteristics are commonly assessed through tests performed on fresh concrete to verify its self-compacting capability [6–8].

The fresh-state performance of concrete is generally influenced by several parameters, including water content, cement dosage, aggregate grading and physical characteristics, as well as the type and amount of mineral and chemical admixtures. The influence of these factors on SCC performance is commonly evaluated using tests such as the slump flow and L-box tests. During the past two decades, SCC technology has been further advanced through the incorporation of supplementary cementitious materials, including fly ash (FA), ground granulated blast-furnace slag (GGBS), and metakaolin (MK) [9–14]. The incorporation of these pozzolanic materials significantly affects both the fresh and hardened properties of concrete. Although pozzolans possess little or no inherent cementitious properties, they exhibit pozzolanic activity and generally have particle sizes equal to or finer than Portland cement (PC). When finely divided and exposed to moisture, they react with calcium hydroxide (CH) at ambient temperature to produce additional cementitious compounds [15, 16]. In general, the incorporation of finely divided pozzolanic materials enhances the performance of mortars and concrete irrespective of their reactivity. Their fine particles fill the spaces between cement grains, resulting in a denser matrix, reduced capillary pore size, lower bleeding, and potentially lower water demand due to the ball-bearing effect associated with rounded particles [17].

Natural zeolite (NZ) is a pozzolanic material rich in SiO_2 and Al_2O_3 and consists primarily of hydrated aluminosilicates with a strong affinity for ammonium and other cations. Ahmadi and Shekarchi [18] reported that incorporating 5, 10, 15, and 20% NZ into concrete with a water-to-binder (W/B) ratio of 0.40 increased the compressive strength by 14, 16, 23, and 25%, respectively. Likewise, Mola-Abasi et al. [19] demonstrated that the incorporation of NZ improved both the peak axial stress and shear strength of concrete. Uysal and Tanyildizi [20] observed that satisfactory self-compatibility properties were achieved only when 5% of the cement was replaced with NZ.

Lau and Anson [21] reported that the incorporation of fibers improves the mechanical performance of concrete while enhancing its resistance to impact loading. Among the available fiber types, polypropylene fibers provide several benefits and also contribute to sustainability when incorporated into concrete mixtures. For example, their addition has been shown to improve crack resistance [22, 23]. Polypropylene fibers are cost-effective, possess favorable mechanical properties, and exhibit excellent corrosion resistance. The incorporation of an appropriate dosage of polypropylene fibers can improve both the mechanical performance and crack resistance of hardened concrete [24, 25]. Previous studies have shown that adding 0.1–0.3% polypropylene fibers reduces plastic shrinkage by 12–25%. Furthermore, the tensile and flexural strengths of concrete increase, while the tensile-to-compressive strength ratio improves by approximately 46% [26]. In recent years, the application of fibers in SCC has attracted increasing research interest. Fiber-reinforced SCC has received considerable attention because of its suitable viscosity, improved durability, enhanced mechanical properties—including shrinkage behavior and compressive, tensile, and flexural strengths—and greater plasticity. Consequently, this material has been widely used in repair and rehabilitation applications [27–34]. Owing to these advantages, fiber-reinforced SCC is considered an innovative and economical construction material that has

significantly contributed to the advancement of concrete technology. Accordingly, numerous recent studies have investigated SCC reinforced with different types of fibers [35–37].

The present study investigates the combined effects of natural zeolite, microsilica, and polypropylene fibers on the fresh properties of self-compacting concrete and the mechanical performance of hardened SCC. Concrete mixtures were proportioned according to established mix design procedures, and the corresponding specimens were prepared for testing. Natural zeolite was incorporated at replacement levels ranging from 0 to 20% by weight of cement, while polypropylene fibers were added at volumetric contents of 0–0.2%. The hardened properties of the concrete were evaluated through compressive strength, splitting tensile strength, flexural strength, and water absorption tests.

2. Material

2.1. Zeolite

The zeolite used in this study is of mineral type and an equal mixture of #800 and #1500 meshes. The zeolite used is extracted from the zeolite mines of of Semnan province in Iran. Zeolite is a natural pozzolan that is divided into two categories: mineral and sedimentary. The mineral type is generally a part of igneous or volcanic rocks, and sedimentary zeolite is its industrial type, which has a higher silicon content than the volcanic type. Zeolite is a rich source of silica oxide, which reacts with calcium hydroxide in cement to produce aluminate gel with amorphous properties. This pozzolan is abundant in Iran and can be easily harvested and processed [38, 39]. The physical and chemical characteristics of the zeolite used in this study are as described in Tables 1.

Table 1. Properties of used Zeolite

property	Sio2	Al2O3	CaO	MgO	Na2O	So3	Fe2O3	K2O
Weight %	63.8	11.3	3.2	0.96	2.55	0.22	0.44	3.24

2.2. Microsilica powder

Microsilica used in this study was supplied as a light-gray powder with a high silicon dioxide (SiO_2) content, making it an effective supplementary cementitious material for improving concrete performance. Owing to its high pozzolanic reactivity and ultrafine particle size, microsilica contributes to reduced permeability, enhanced resistance to freeze–thaw deterioration, and improved mechanical properties of hardened concrete. The physical characteristics and chemical composition of the microsilica employed in this investigation are summarized in Tables 2 and 3.

Table 2. Properties of micro silica powder

Name	Particle size (μm)	Bulk density (kg/m3)	*Degree of fusion* (C)
Micro Silica	0.45~0.61	552~655	1255

Table 3. Chemical analysis of used micro silica powder

Property	Sio2	Al2O3	CaO	MgO	Na2O	MnO	Fe2O3	K2O
Weight %	96.2	1.42	0.47	0.99	0.32	0.31	0.87	1.21

The incorporation of microsilica into concrete in appropriate proportions improves its electrical resistance and decreases its susceptibility to chloride ion penetration. Microsilica can also be used in high-strength concrete to mitigate thermal-related problems. To ensure the formation of a uniform slurry free from agglomerated particles, microsilica should be thoroughly mixed before use. Its incorporation refines the pore structure of concrete, thereby reducing permeability. By improving the bond at the interface between the cement paste and aggregates and reducing the water demand, microsilica contributes to enhanced concrete strength. Proper mixing is essential to obtain a homogeneous slurry without particle agglomeration. In addition, the high viscosity associated with microsilica improves adhesion but may also increase its tendency to participate in alkali-related reactions that could be detrimental.

2.3 Polypropylene fibers

Polypropylene fibers play a significant role in enhancing the strength and durability of concrete mixtures. Their incorporation improves the concrete's resistance to abrasion as well as tensile, shear, and flexural stresses. Unlike many other additives, polypropylene fibers neither increase the weight of the concrete nor settle within the mixture. These fibers are commonly used in concrete applications with lengths ranging from 12 to 18 mm. In the present study, polypropylene fibers with a length of 12 mm were utilized. The detailed properties of the fibers are presented in Table 4.

Table 4: *Characteristics of polypropylene fibers.*

Density (g/cm³)	*0.95*1
Diameter (μm)	*38*.2
Elongation at break (%)	*3.55*
Length (mm)	*12*.1
Melting point (°C)	*164.5*
Water absorption (%)	*0*
Tensile strength (MPa)	*405*

2.4. Aggregates

Iran Standard No. 4977 has been fulfilled by the aggregate used in this research [40]. The concrete's coarse and fine aggregates were crushed limestone and their specific gravity was 2.56. Fineness modulus of fine sand was 2.7. The coarse aggregates used in self-compacting concrete mixes is with a maximum size of 20 millimeters .Figure 1 displays the granulation diagram utilized in the test.

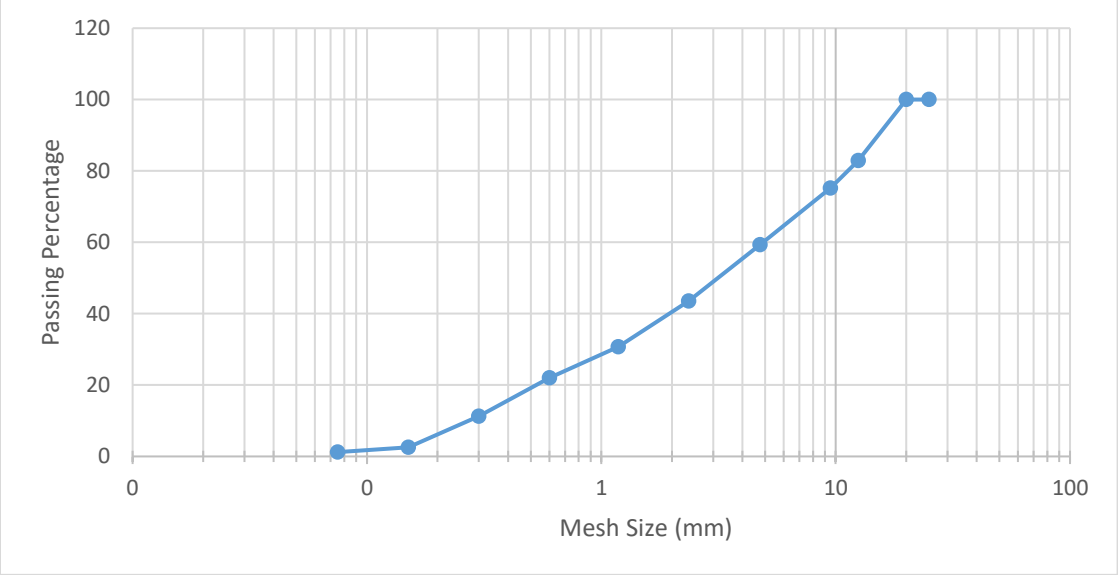


Fig. 1. Particle Size Distribution Used in This Study

2.5. Water-reducing admixture

The powerful lubricant product successfully prevents aggregate separation and meets ASTM C494 standards. Third-generation naphthalene acts as the basis for this neutral water-reducing admixture [41]. After all the elements have been mixed together, or with water, this product can be added to the concrete mixture. The amount of water-reducing admixture used was 2 percent of the weight of the cementitious material.

3. Tested matrix

Natural zeolite was incorporated at replacement levels of 0, 5, 10, 15, and 20% by weight of cement, while polypropylene fiber contents of 0, 0.05, 0.1, and 0.2% by volume of the concrete mixture were considered. The detailed mix proportions are presented in Table 5. A total of sixteen concrete mixtures were prepared and evaluated in this study. Microsilica was first mixed with water to form a slurry before being incorporated into each mixture. After thorough mixing, the

polypropylene fibers were introduced, followed by the addition of the aggregates. The cement was then gradually added while the mixer was operating, after approximately five minutes of mixing. Finally, the superplasticizer was incorporated, and the mixture was blended for an additional two minutes before casting into the molds.

Table 5. Mix Proportions of Concrete Mixtures

Water-reducing admixture	PP Fibers	Microsilica	zeolite	limestone powder	aggregate	sand	cement	water	Mix No.
Kg/m3	**Kg/m3**	**Kg/m3**	**Kg/m3**	**Kg/m3**	**Kg/m3**	**Kg/m3**	**Kg/m3**	**Kg/m3**	
8.0	0.0	25.0	0.0	200.0	408.0	1218.0	400.0	172.2	1
8.0	0.0	25.0	20.0	200.0	408.0	1218.0	380.0	172.2	2
8.0	0.0	25.0	40.0	200.0	408.0	1218.0	360.0	172.2	3
8.0	0.0	25.0	60.0	200.0	408.0	1218.0	340.0	172.2	4
8.0	0.8	25.0	0.0	200.0	408.0	1218.0	400.0	172.2	5
8.0	0.8	25.0	20.0	200.0	408.0	1218.0	380.0	172.2	6
8.0	0.8	25.0	40.0	200.0	408.0	1218.0	360.0	172.2	7
8.0	0.8	25.0	60.0	200.0	408.0	1218.0	340.0	172.2	8
8.0	1.6	25.0	0.0	200.0	408.0	1218.0	400.0	172.2	9
8.0	1.6	25.0	20.0	200.0	408.0	1218.0	380.0	172.2	10
8.0	1.6	25.0	40.0	200.0	408.0	1218.0	360.0	172.2	11
8.0	1.6	25.0	60.0	200.0	408.0	1218.0	340.0	172.2	12
8.0	4.4	25.0	0.0	200.0	408.0	1218.0	400.0	172.2	13
8.0	4.4	25.0	20.0	200.0	408.0	1218.0	380.0	172.2	14
8.0	4.4	25.0	40.0	200.0	408.0	1218.0	360.0	172.2	15
8.0	4.4	25.0	60.0	200.0	408.0	1218.0	340.0	172.2	16

4. Fresh Concrete Tests

The freshly created concrete mixtures were examined using ASTM, ACI 237R, and EFNARC [42, 43] standards. Each concrete mix's flowability, passing ability, and segregation resistance were assessed. A summary and example of the test conducted on fresh concrete are provided below.

4.1 Slump Flow and T500 Test

The SCC mix's horizontal free flow properties in the absence of obstruction are measured using the slump flow test. Figure 2 depicts the slump flow test. Additionally, slump values can be used to assess a mix's segregation, and bleeding in a mixture. Allowable slump values range from 650 mm at the minimum to 800 mm at the maximum. When there is no obstruction, the SCC flow rate can be ascertained using the T50cm test. This test is also used to measure the viscosity of the SCC mixture. The T50cm test has a minimum of 2 seconds and a maximum of 5 seconds.



Fig 2. Actual test of the fresh SCC test

4.2. L-Box Test

The L-box test is used to evaluate SCC's ability to flow through the three reinforcing bars that are placed in front of the movable gate without becoming blocked. Figure 3 shows the value derived from the ratio of H2/H1, where H1 is the height of the concrete left in the vertical section and H2 is the height of SCC at the end of the horizontal section. This value indicates the outcome of the L-box test. The blocking ratio's lowest and maximum values, or H2 / H1, are 0.8 and 1, respectively. If an SCC mix's blocking ratio is near 1, it indicates good passing ability. If the blocking ratio is less than 0.8, the SCC mixture is highly viscous.

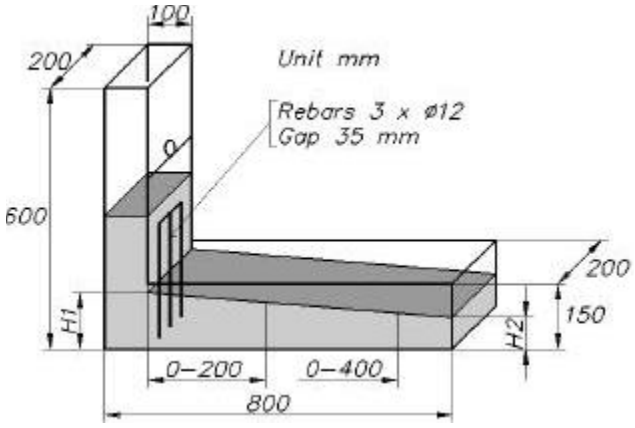


Fig.3. Specifications of the L-box test apparatus [43]

4.3. V-Funnel Test

The purpose of this test is to evaluate a fresh SCC mix's filling capacity and flowability. The duration of the v-funnel can range from 6 to 12 seconds. Using a V-funnel, the viscosity and segregation resistance of a freshly made SCC mix were assessed at T5min. For this test, fresh concrete was poured into the V-funnel, and the discharge time was measured by opening the trap door five minutes later.

4.4. Workability of fresh mix

In accordance with the EFNARC guidelines, the SCGC mixtures' flowability was evaluated using slump flow and V-funnel tests; their passing-ability was evaluated using the L-box and their viscosity was evaluated using V-funnel. The results from fresh SCC concrete tests are presented in table 6.

Table 6: Fresh SCC concrete test results

V funnel sec	L Box Ratio (h2/h1)	T500 - Slump Flow sec	Slump Flow Cm	Mix No.
6.42	0.99	2.25	855	1
6.83	0.94	2.71	846	2
7.12	0.93	3.45	821	3
8.68	0.91	3.75	803	4
6.63	0.97	2.66	832	5
7.10	0.94	2.98	815	6
8.11	0.92	3.62	757	7
8.71	0.87	4.12	720	8
7.32	0.93	3.45	732	9
7.90	0.90	3.92	691	10

9.01	0.86	4.14	672	11
9.43	0.85	4.78	640	12
8.62	0.92	4.12	657	13
9.15	0.84	4.17	622	14
9.93	0.82	4.75	592	15
10.68	0.80	4.88	561	16

5. Comparison of compressive strength test results

Following the guidelines of ASTM C31 (2012) and ASTM C511 (2013), cubic, cylindrical, and prismatic samples were cast. Samples were cast, covered with two layers of plastic sheets, and then kept in a temperature-controlled room for twenty-four hours at 22 ± 2 °C. To stop any potential Ca(OH)2 leaching from these specimens, all samples were demolded after 24 hours and cured in a saturated lime solution until they were old enough to be tested (see Fig. 4). A 2,000 kN universal testing machine (UTM) operating under displacement-control conditions performed the compression test on the specimens. Based on the stroke movement speed, the uniaxial loading rate was regulated at 0.3 MPa/s. The compressive capacity values shown for each mixture are the average of three cubic specimens that were replicated.

Eq. (1) is used to determine the compressive strength of the mix design based on the test results.

$$S = P/A \quad (1)$$

Where P is the load and A is the cross-section of the loaded area.



Fig. 4. Molded concrete

5.1 Compressive strength with zero percent polypropylene fibers

When the compressive strength was evaluated at 7, 28, and 90 days after the incorporation of various percentages of zeolite alone—without polypropylene fibers—it was observed that using 10% zeolite yielded the most favorable outcomes for all three intervals (Fig.5). The minimum compressive strength recorded at 28-day samples, with no zeolite use, was 53 MPa; however, when the optimal quantity of zeolite was used, the compressive strength increased to 60.3 MPa. Incorporating 10% zeolite into concrete usually leads to a 13% enhancement in strength.

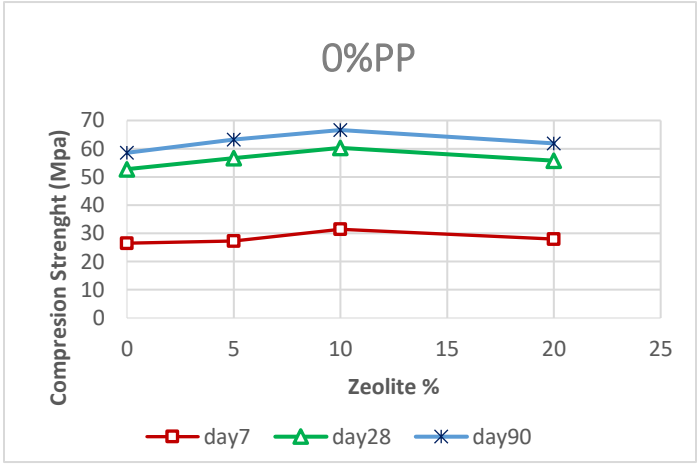


Fig. 5. Compressive strength with zero percent polypropylene fibers

5.2 Compressive strength with 0.2 percent polypropylene fibers

Figure 6 shows the compressive strength of the tested samples containing 0.05 percent polypropylene fibers. Comparing the samples with and without fibers, the compressive strength increases when polypropylene fibers are used. A proportion of 10% zeolite proved to be optimal for all age groups. The corresponding compressive strength after 28 days is 63.7 MPa.

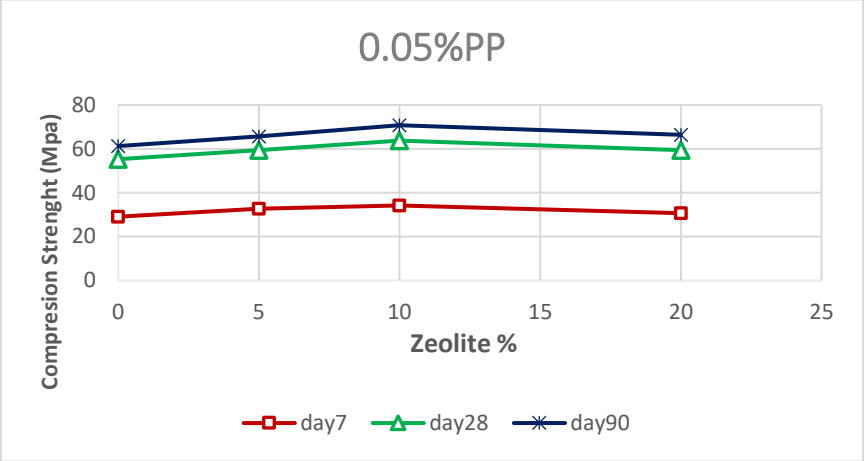


Fig. 6. Compressive strength with 0.2 percent polypropylene fibers

5.3 Compressive strength with 0.4 percent polypropylene fibers

The compressive strength of samples with 0.1% fibers by volume exceeds that of samples with 0.05% by volume of polypropylene fibers (refer to Fig. 7). The compressive strengths for the 28-day sample are 76.9 MPa, with the ideal zeolite percentage being 10%.

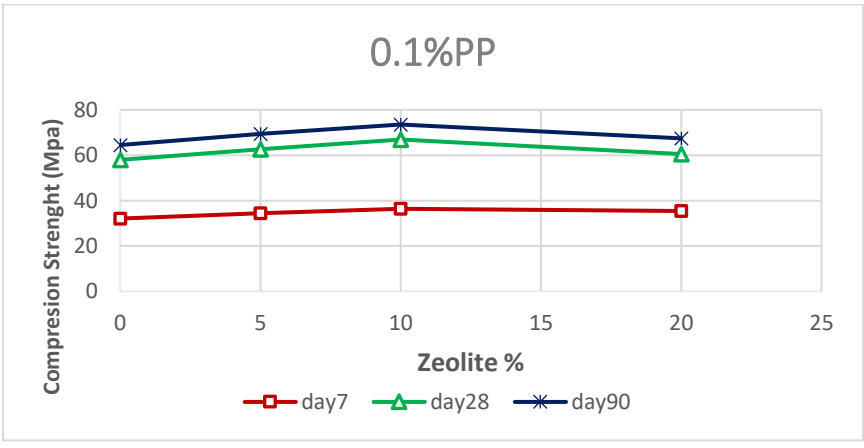


Fig. 7. Compressive strength with 0.4 percent polypropylene fibers

5.4 Compressive strength with 0.8 percent polypropylene fibers

Figure 8 shows the compressive strength of the samples tested containing 0.2 percent polypropylene by volume. The findings indicated that raising the fiber usage to this level resulted in a reduction of compressive strength compared to samples with 0.1%. The optimal zeolite levels for a 28-day sample are 10%, resulting in compressive strengths of 65.4 MPa.

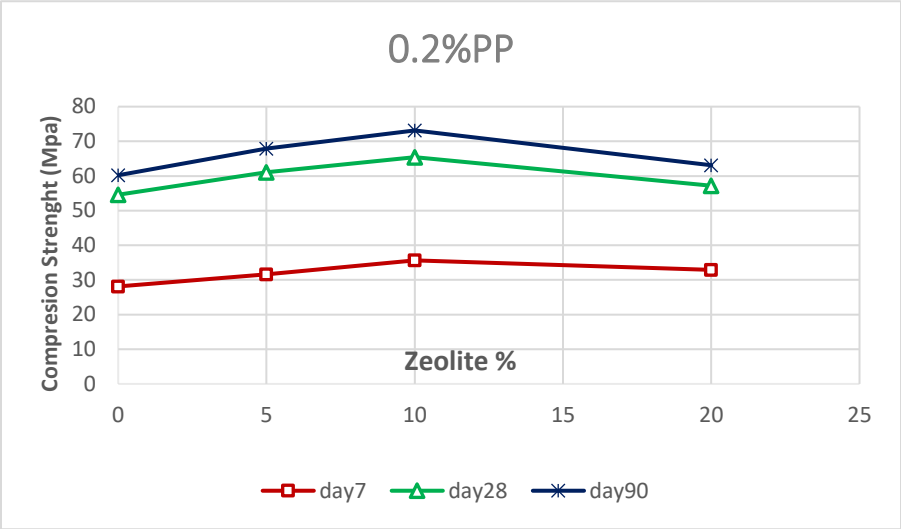


Fig. 8 Compressive strength with 0.8 percent polypropylene fibers

5.5 The effect of different amounts of fibers on compressive strength

According to the compressive strength outcomes for all levels of polypropylene fiber and zeolite usage, Fig. 9 indicates that the minimum compressive strength was recorded for all evaluated ages when polypropylene fibers were absent. The peak compressive strength was achieved with polypropylene fibers constituting 0.1% by volume. Implementing this quantity of fibers enhances the compressive strength of concrete by approximately 11 percent on average.

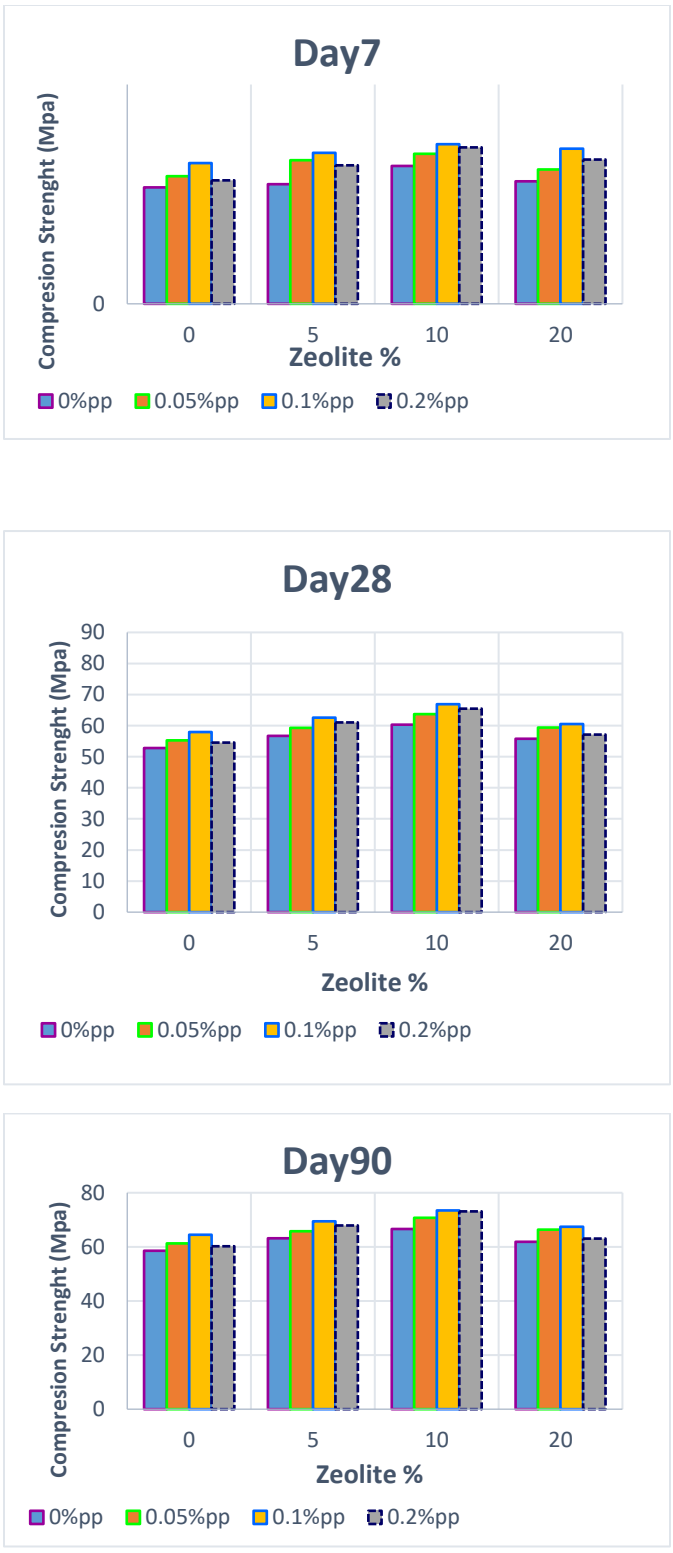


Fig. 9. Effect of zeolite and PP fibers on the compressive strength.

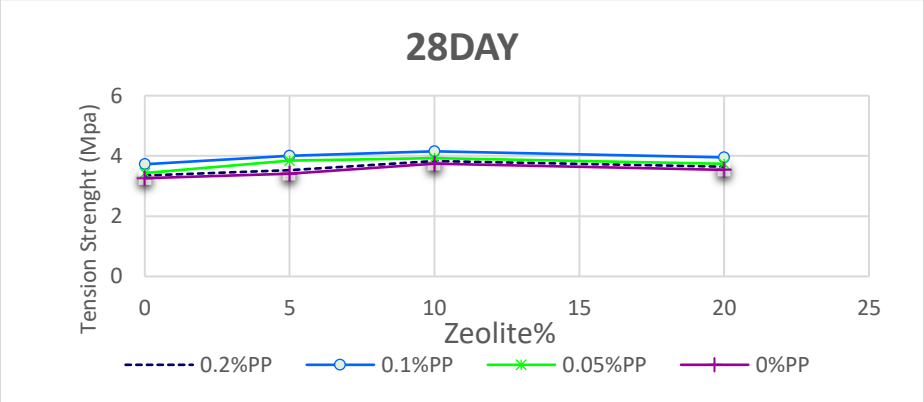
6. Splitting tensile strength

In the current study, cylindrical specimens were cast, cured, and assessed in accordance with ASTM C496 (ASTM 2011) procedures in order to determine the Splitting tensile strength of all mix compositions. A compressive digital test machine with a 2,000 kN capacity was used to determine the STS. Three replicated samples were used to calculate the reported values. Concrete's tensile splitting strength is usually assessed using cylindrical specimens in accordance with established standards. By using compressive equipment to apply a compressive force transversely to the cylindrical samples, the tensile strength of the concrete sample is evaluated.

$$Fct=\frac{2p}{\pi DL} \qquad (2)$$

The concrete's tensile strength is represented by the symbol Fct, while the sample's diameter, length, and maximum test load are represented by the symbols D, L, and P, respectively. Tensile splitting tests were performed on cylindrical samples with dimensions of 15 cm in diameter and 30 cm in length, aged 7, 28, and 90 days, using the Brazilian method. When the samples reached each of these ages, they were taken out of the water, dried, and then split in half using side pressure in a pressure jack. After that, the tensile strength was calculated using the appropriate formula.

Figure 10 presents the graph obtained from the results of the split tensile tests with various amounts of fiber and zeolite. It is evident that regardless of the quantity of analyzed fibers, the best splitting tensile strength can be achieved through the use of 10% zeolite. The ideal fiber content is 0.1% based on the volume of the mix. This applies to all ages of 7, 28, and 90 days. Generally, the ideal quantity of zeolite boosts the splitting tensile strength by almost 15% in comparison to the sample lacking zeolite. Moreover, the splitting tensile strength of the samples rises by an average of almost 11% at the ideal fiber content.



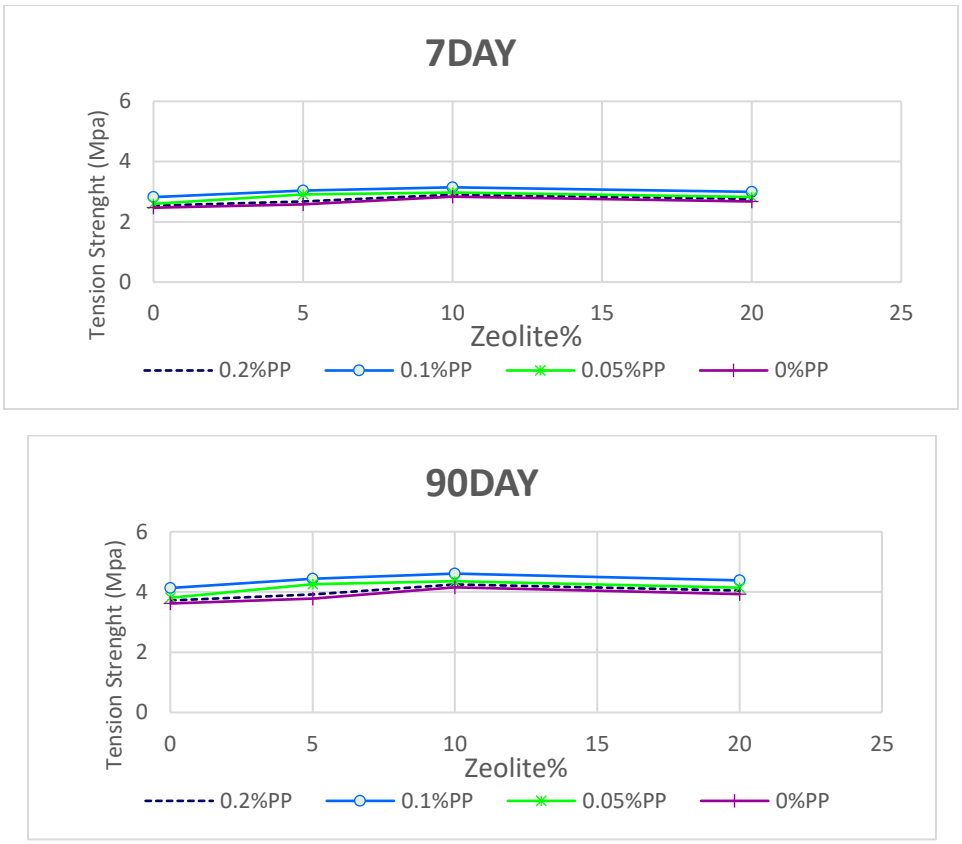


Fig. 10. Results of split tensile test with different amounts of zeolite and fibers.

7. Flexural strength test

For each mix, prismatic specimens were created in accordance with ASTM C293 (ASTM 2016a) to measure the flexural strength. Every sample was used in displacement-controlled mode with monotonic loading. The mean results for the three tested replicates were used to obtain the reported values.
A vertical load is applied at the midspan of the concrete beam, which is supported by two supports, in order to determine the specimens' flexural tensile strength. Samples of failure loads are captured. The following formula is used to determine the flexural strength:

$$ft = Fl/bh2 \qquad (3)$$

The symbol for concrete flexural strength is ft, where F is the failure load of the specimen and l is the distance between supports. B and h represent the width and height of the beam specimen cross-section, respectively.

Figure 11 illustrates the outcomes of the flexural test with different ratios of zeolite and fiber. It indicates that by incorporating 10% zeolite, the highest flexural strength can be achieved regardless of the fiber quantity. This is consistent across all age categories studied, such as 7, 28, and 90 days.

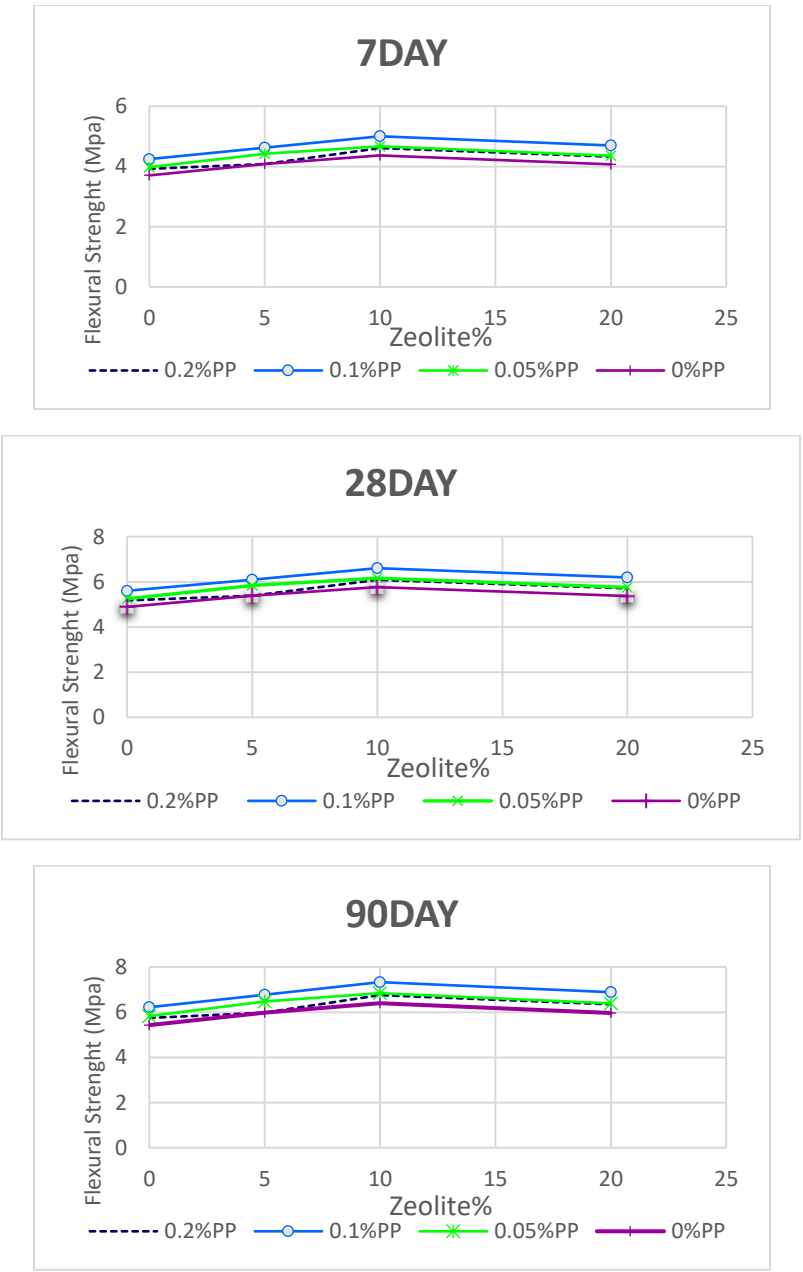


Fig. 11. Flexural test results with different amounts of zeolite and fibers.

8. The water absorption

The water absorption of cured concrete was assessed using the ASTM C642-06 [44] criteria. The concrete sample was weighed (m0) and dried in an oven set to 100–110 °C for 24 hours after being submerged in water for 28 days during the curing process. The sample's weight (m) was once more measured after a full day of submersion in water. Using equation 2-3, the long-term water absorption is computed.

$$(4) Water\ absorption = \frac{m - m_0}{m_0} \times 100$$

m =Wet sample weight

m0= Dry sample weight

Concrete samples' water absorption reveals that water absorption decreases as the proportion of zeolite in the concrete rises (see Fig. 12). This issue arises in a minor manner. For instance, the water absorption in the fiber-free and zeolite -free samples is approximately 4.31%; however, when zeolite is added from 0% to 15%, the water absorption drops to approximately 4.15%. More water is absorbed when polypropylene fibers are used; the least amount of water is absorbed when polypropylene fibers are not used. Water absorption rises by 6% on average when the fiber content is increased from 0% to 0.2% by volume.

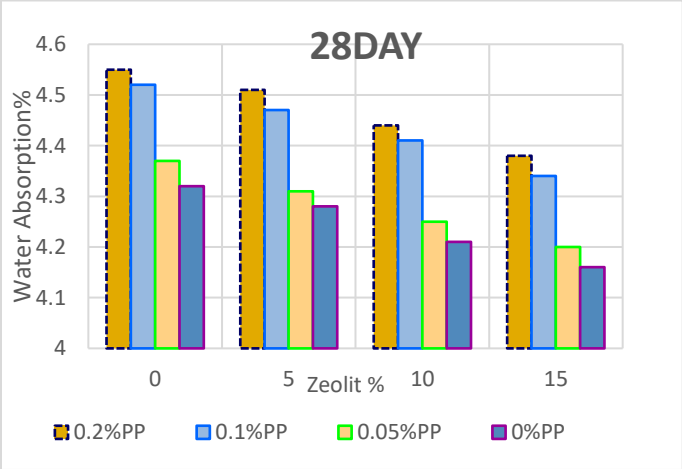


Fig. 12. Results from water absorption test for 28 day samples.

9. Compressive and tensile strength relation

Fig. 13 shows the correlation between the examined specimens' compressive strength and splitting tensile strength. The following is the best-fitting formula:

$$f_{sp} = 0.078 f_c \text{^} 0.94$$

Where f_{sp} is splitting tensile strength of specimens and f_c is compressive strength all in Mpa.

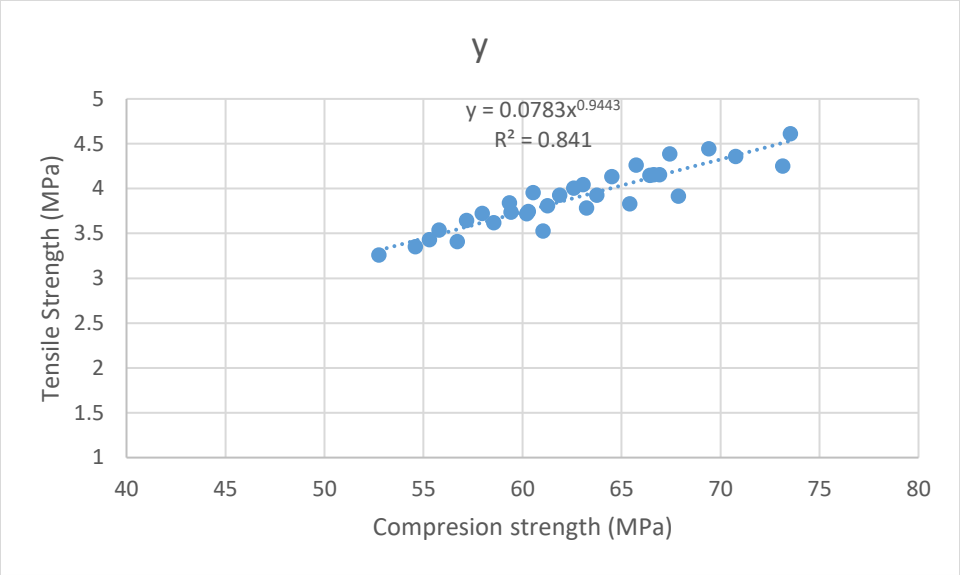


Fig. 13. Correlation between the compressive strength and splitting tensile strength

10. Conclusion

Self-compacting concrete (SCC) is a new type of concrete in construction industry. This research deals with the simultaneous effect of natural zeolite and microsilica as well as polypropylene fibers on the characteristics of fresh SCC concrete and the mechanical characteristics of hardened concrete. For this purpose, the mixing ratio of concrete samples is prepared according to valid methods and the concrete samples are molded. The percentages of zeolite vary from zero to 20% of cement weight and the percentage of polypropylene fibers from zero to 0.2% of concrete by volume and microsilica is 6.25% of the binder. Flowability of examined SCC concrete was evaluated using slump flow and V-funnel tests; their passing-ability was evaluated using the L-box and their viscosity was evaluated using V-funnel. Compressive, tensile splitting and flexural strength test as well as water absorption test is uses to evaluate hardened concrete characteristics. According to the compressive strength outcomes for all levels of polypropylene fiber and zeolite usage, the minimum compressive strength was recorded for all evaluated ages when polypropylene fibers were absent. The peak compressive strength was achieved with polypropylene fibers constituting 0.1% by volume. On average, implementing this quantity of fibers enhances the compressive strength of concrete by approximately 11 percent on average. Also, best recommendation for zeolite incorporation is 10% by weight of cement and approximately leads to a 13% enhancement in strength. Concrete samples' water absorption reveals that water absorption decreases as the proportion of zeolite in the concrete rises. More water is absorbed when polypropylene fibers are used; the least amount of water is absorbed when polypropylene fibers are not used. Water absorption rises by 6% on average when the fiber content is increased from 0% to 0.2% by volume.

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