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Effect of Silica Fume and Polypropylene Fibers on the Mechanical Properties of Pervious Concrete

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Pervious Concrete, polypropylene Fibers, Silica Fume, compressive strength, permeability coefficient, voids content.

ABSTRACT
In this paper, Silica Fume (S.F.) be used for reinforce pozzolanic cement paste and the effect of using many weight percentages as (0%, 5%, 10%, 15%, and 20%) to lessening the concrete weight as a cement replacement in concrete mixtures on the mechanical properties was studied. High range water reducing added to decrease the water demand of the concrete, when silica fume added. Moreover, (0.025%, 0.05%, 0.1%, and 0.15%) are the proportions of polypropylene Fibers (P.P.F.) by volume, which used to improve the pervious concrete mechanical properties, physical, and mechanical properties of hardened concrete containing voids ratio, compression strength, and flexural strength and, splitting tensile strength investigated. The density of reference pervious concrete that was get through the experimental work was(1835 Kg/m3) at (28) days ,it permeability coefficient (K) and voids content was(0.324) cm/s, and (30.21%) successively, The results shown important increase in compression, splitting tensile and flexural strengths of pervious concrete containing silica fume and (P.P.F.) comparison with reference pervious concrete. The mixture of (10%) of (SF) and (0.1%) of (P.P.F.) gave optimum increased in the compressive, flexural, and splitting tensile strengths compared with the reference mix and the results (47.8%, 29.21%, and 24.41%) respectively.

تأثير غبار السليكا والياف البولي بروبلين على الخواص الميكانيكية للخرسانة النافذة

الخلاصة
في هذه البحث، تم أستخدم غبار السليكا لتقوية البوزولانية لعجينة الأسمنت وباستخدام عدة نسب وزنية وهي (٠٪، ٥٪، ١٠٪، ١٥٪، و٢٠٪) من وزن الاسمنت لتقليل الوزن الكلي للخرسانة النافذة من خلال استخدامها كبديل عن الاسمنت وتأثيرها على الخواص الميكانيكية للخلطات الخرسانية النافذة. استخدمت مخفضات المياه عالية المدى لتقليل الطلب على المياه من الخرسانة، عند إضافة غبار السليكا. وعلاوة على ذلك، تم استخدام عدة نسب هي (٠,٠٢٥٪، ٠,٠٥٪، ٠,١ %، و٠,١٥٪) والتي تمثل نسب ألياف البولي بروبلين الحجمية المستخدمة لتحسين الخواص الميكانيكية للخرسانة النافذة و تم اختبار الخصائص الفيزيائية والميكانيكية للخرسانة النافذة المتصلبة بما في ذلك نسبة الفراغات واختبار النفاذية ومقاومة الانضغاط وقوة الشد الانشطاري ومقاومة الانحناء. بينت النتائج ان كثافة الخرسانة النافذة المرجعية (١٨٣٥) كغم/ م ٣ في (٢٨) يوما، والمحتوى الفراغي ومعامل ال نفاذية كان (٠,٣٢٤) سم / ث، و (٣٠٪) على التوالي، كذلك كانت هناك زيادة كبيرة في مقاومة الانضغاط وقوة الشد الانشطاري ومقاومة الانحناء من الخرسانة النافذة التي تحتوي على غبار السليكا والياف البولي بروبلين مقارنة مع الخلطة المرجعية. خليط من (١٠٪) من (غبار السليكا) و (٠,١٪) من (الياف البولي بروبلين) أعطى أكبر زيادة في مقاومة الانضغاط وقوة الشد الانشطاري ومقاومة الانحناء مقارنة مع الخلطة المرجعية وكانت النتائج (٤٧,٨٪، ٢٩,٢١٪، و٢٤,٤١٪) على التوالي.

الكلمات المفتاحية
الخرسانة النافذة، الياف البولي بروبلين، غبار السيلكا، مقاومة الانضغاط، معامل النفاذية، محتوى الفراغات

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Introduction

The expression "pervious concrete" (PC) describes a no slump, no fine materials, open-material fabricated of Portland cement, not more than 10% of the maximum single sized coarse aggregate, admixtures, and water, The not present or little amount of fine aggregate leads to open voids between cement-covered aggregate with correlated pores ranging in size of (2 to 8 mm) [1]. The pervious concrete mechanical properties changed in the design pavements thickness of pervious concrete. Pervious concrete regarded a special type of porous concrete. In this type of concrete, a covering of thin surface of cement paste surrounds the coarse aggregates, consequently, utilization of silica fume to reinforce the transition zone between coarse aggregate and cement past [2]. Pervious concrete used in pavement of the roads due to decreasing of their runoff and absorption of noise. Polypropylene fibers (P.P.F.) is one of the most successful commodity fibers, reaching a world production capacity of four million tons a year, because of its depressed density, high stiffness and excellent chemical/bacterial resistance [3]. Polypropylene fibers is widely used in many industrial performances such as furnishing products, and industrial cables. The use of fiber reinforced concrete to strengthen the tensile strength, toughness, and flexural strength, as well as the failure mode of concrete. The addition of fibers in concrete has few influence on the modulus of elasticity and Compression strength [4].

Literature Review

There are many studies have dealt with improved pervious concrete characteristics:

Jing Yang, et al. in (2003) [5]. Investigated the influence of silica fume (SF), and super plasticizer (SP) in the previous concrete. The results shown that using (SP) and (SF) at previous concrete can reinforce the strength of pervious concrete greatly, the Compression strength of the composite can reach (50) MPa and the flexural strength (6) MPa and the unit weight between (1900 –2100) kg/m3.

An Cheng et al. in (2011) [6]. Investigated the recycled aggregate (RA) obtained at the construction waste with cement paste and styrene-butadiene latex modified paste as binder, and The three nominal diameters of the aggregate were (7.2) mm and (11.1) mm .The results show that mechanical strength decreases as permeability increases The natural aggregate and styrene-butadiene latex would produce pervious concrete at more Compression strength and lower permeability properties.

Max. Strength and permeability in pervious concrete with recycled coarse aggregate was (w/b=0.35), and diameter of (11.1) mm for the recycled aggregate.

Wen-Ten Kuo., et al. in (2013) [7]. Washed municipal solid waste incinerator bottom ash (MSWIBA) was used as a substitute for natural aggregate at pervious concrete. Results indicated that the fresh pervious concrete unit weight made with MSWIBA was about (1653–2080) kg/m3 and gain with the ratio of cement paste filling. The bending and split tensile strengths were roughly (1/9) and (1/4) of the Compression strength, respectively.

Saeid Hisami et al. in (2014) [8]. Studied the influence of(0.3%) of polypropylene sulfide (PPS) fibers, (0.2%) of fiber glass, and (0.5%) fiber steel, by volume, on the pervious concrete, with rice husk ash(RHA), the influence of(0%, 2%, 4%, 6%, 8%, 10%) and (12%) weight percentages as a cement equivalent at concrete mixtures. The results indicated that for(8–10%) replacement of (RHA) and w/c of (0.33), the pervious concrete Compression strength containing fibers and RHA increases by (34%, 37% and 36%) for glass, steel and (PPS) fibers, respectively. Concrete flexural test grading raises with Polypropylene fiber.

Materials

1. Cement

Type I, ordinary Portland cement used in this study from Al- Douh refectory. Test results shown the cement identified with Iraqi specifications No. 5/1984 [9] .The properties of cement shown in the table(1)and(2).

Table (1): Chemical analysis of cement and silica fume.

Oxides percentage	cement	Limit of Iraqi spec.No. 5/1984
CaO	63.2	-
SiO2	18.9	-
Al2O3	3.8	-
Fe2O3	4.6	-
SO3	1.5	≤ 2.5
MgO	1.7	≤ 5.0
L.O.I	1.9	≤ 4.0
L.S.F	0.9	0.66-1.02
I.R.	0.4	≤ 1.5

Table (2): Physical properties of cement

Physical properties	Test results	Limit of Iraqi spec.No. 45/1984
Initial setting time (vicat)	65 min.	≥ 45min.
Final setting time (vicat)	170 min.	≤ 375 min.
Compressive strength of mortar (MPa) 3-days	19.0	≥ 15
Compressive strength of mortar (MPa)7-days	30.5	≥ 21
Specific gravity	3.1	-
Specific surface (cm2/gr)	3000	-

2. Aggregate.

2.1. Coarse Aggregate.

Coarse aggregate properties affect the proportions of all other materials in a previous concrete mixture. Aggregate grading used in pervious concrete are typically grading between (19 and 9.5 mm) [1], with Max. Size (19)mm. Table (3) shows the grading compared with Iraqi specifications No. 45/1984[10], the waterless rodded unit weight and the aggregates void ratio at this work quantified by ASTM C29 [11], and it delimited to be (1585) Kg/m3 and (39.8 %), respectively.

Table (3): Grading of natural coarse aggregates

Sieve size (mm)	Percent Passing	Limit of Iraqi spec.No. 5/1984
37.5	100	100
20	96	95-100
10	42	30-60
5	5.4	0-10
Bulk Specific gravity (ASTM 127-03)		2.64
Void content (ASTM 29-03)		39.8%

2.2. Fine aggregate.

A (4.75) mm maximum size of clean sand is used as fine aggregate. The grading of fine aggregate are listed in Table (4) and compatible to the requirement of Iraqi specifications No. 45/1984 [10].

Table (4): Sieve analysis of fine aggregate.

Sieve size	Passing ratio (%)	Limit of Iraqi spec. No. 45/1984
9.5mm	100.00	100
4.75mm	94.56	90-100
2.36mm	72.45	75-100
1.18mm	68.40	55-90
600μm	53.32	35-59
300μm	16.60	8-30
150μm	2.12	0-10

3. Water

Ordinary water used for curing and mixing for concrete mixes of this study.

4. Polypropylene Fiber (P.P.F.)

A short (12 mm) High execution of polypropylene fiber used in this study shown in Fig. (1-a). Polypropylene fiber complied with requirements of ASTM C1116-02 [12].Table (5) indicated the characteristics of polypropylene fiber

Table (5): Physical and Technical Properties of Polypropylene Fiber (P.P.F.)

Properties	Specifications
Tensile strength	350 MPa
Fiber length	12 mm
Specific gravity	0.91 g/cm3
Young's modulus	5000 MPa
Fiber thickness	18 μm
Elongation	25%
Colour	White

5. Superplasticizer.

Superplasticizer is high range water reducing additives, It meet the requirements of super plasticizer according to ASTM-C494 Type B, D and G [13].Table (6) shows the typical properties of super plasticizer. High range water reducing added to decrease the water demand of the concrete, when silica fume added.

Table (6):Typical properties of super plasticizer

Properties	Specifications
Specific gravity	1.2
Form	Liquid
PH	7-9

6. Silica Fume (SF)

The silica fume used in this work, which shown in Fig. (1-b). Table (7) shown the properties of silica fume according to ASTM C-1240-05[14], the silica fume added in a dry state to the cement and thoroughly mixed with it in order to provide a homogenous mixture. Silica fume have a very high water demand and thus may fail to meet (ASTM C618).[15]requirements.

Table (7): Chemical and physical properties of silica fume.

Oxide composition	Oxide Content %	Physical Properties	ASTM C-1240 Limitations
SiO2	91.4		≥ %85
L.O.I	0.53		≤ 6.0
SO3	0.13		
MgO	1.03		-
Na2O	0.16		-
Percent retained on 45μm(No. 325) sieve ,max ,%	8		≤ 10
Specific gravity		2.21	-
Bulk density		310 kg/m3	-
Specific Surface		20 m2/gm	≥ 15
form		Amorphous	-

(a) (b)

Figure 1: (a) Polypropylene fibers (b) Silica fume.

Mix Proportions

Proportioning pervious concrete mixture is different compared to ordinary concrete; it designed to allow the flow of water through its surface. The first step in proportioning the mixture is to determine the aggregate void ratio, conformity with ASTM C29 [11], the aggregate specific gravity. The void content of aggregate that will be use in a previous concrete mixture changeable and rely on the grading. The target void content range of the pervious concrete mixture should be specify. The reference mixture is made by(ACI 211.3-02). [16] and five concrete mixtures were similar to reference mixture (PC1) but contain Silica fume (SF): there are (0.0%,5.0%, 15%,20% , 10%) for mixes (PC2,PC3,PC4,PC5,PC6) by weight of cement and (0.15%,0.05%,0.025%, 0.00% and 0.1%) of polypropylene fibers by volume of concrete respectively .

Table (8) shows the proportions of mixes of pervious concrete with coarse aggregate. for all mixtures the aggregates was used in saturated surface dry case (S.S.D.) Specific surface area of (S.F.) is greater than the cement, therefore the concrete performance is reduced fundamentally and more water is needed to fix it, because the concrete Performance should not be changed; the amount of superplasticizer is increased. [17].

Permeability Test

The pervious concretes designed based on requirement of permeability, it was one of the major properties of pervious concretes, and a function how pores related to each other [19]. Figure (2) shows the device used to define the pervious concrete penetration, this test made with constant-head method, and the device is typically, used to measure the penetration of cylindrical samples of (100 x 200) mm accordance to ASTM D-2434-68. [20], and the water supply at the inlet neutralized in the same of test period. After establishment a constant flow rate, water collected in a graduated flask for a known duration. Average permeability coefficient (k) calculated according to Eq. (2), where :(k) is the permeability coefficient, (Q) is the water flow discharged, (L) is the length of samples, (A) is a cross-sectional area of sample, (t) the time of discharge, and (h) is the head of water.

$$k = \frac{QL}{Aht} \qquad (2)$$

Figure 2: constructed device for permeability test.

Concrete testing.

Pervious concrete specimens prepared at general according to ASTM C192-02.[21].For each mix, six (150 mm) standard cubic steel molds used for casting specimens and for Compression strength in (7) and (28) days in agreement with ASTM C39-98 [22], the splitting tensile strength used two molds of (100X200) mm cylindrical concrete samples measured conformity to the ASTM C 496- 86[23], two (100X100X400mm) prisms for flexural strength at (28) day, correspond with ASTM(C293–02).[24]. Moreover, in order to calculate the permeability coefficient and porosity, three (100 x 200) mm cylindrical specimens cast as shown in figure (3).

Figure 3:(a)the pervious concrete specimens (b)compressive strength machine(c)specimen of compressive strength(d)flexural strength specimen test.

Table (8): Proportion of pervious concrete mixes.

Mix designation	Cement Kg/m3	Coarse Aggregate Kg/m3	Water/Cement ratio	Fine aggregate Kg/m3	S.F.% Of cement	P.P.F. % by vol.	S.P.% Of cement
PC1	360	1400	0.29	90	0.00	0	-----
PC2	360	1400	0.29	90	0.00	0.15	0.65
PC3	360	1400	0.29	90	5.00	0.05	0.70
PC4	360	1400	0.29	90	15.00	0.025	0.75
PC5	360	1400	0.29	90	20.0	0.00	0.80
PC6	360	1400	0.29	90	10.00	0.10	0.68

Casting and Curing of Pervious Concrete.

The samples cast in three layers by rodding 25 times with applying a vibration for (10) seconds. After mixing, the specimens disposed of the molds and maintained in the water until they will arrive the test age of (7) and (28) days when they are ready to do the experimental tests.

Void Ratio and Densities test.

Void ratio is a measure of the total open space within the pervious concrete. It is a ratio of the volume of voids, to the all volume of cement paste and aggregate. The pervious concrete void ratio of cement paste, which rely on the properties of the elements, how, it are combined and proportioned. ASTM C1754-14. [18].It executant to molded cylinders It was determined in accordance with (method A), at 28 day of age, by taking the difference in weights of an oven dried (100 mm x 200 mm) cylindrical specimens, and when submerged in water, using Equation (1), where: v = void ratio, A = dry specimen mass (Kg), B = mass in water (Kg), Pw= density of water (Kg/m3), and Vol = volume of specimen (m3).Void proportion test performed at three samples for each mix design, every specimen tested three once

$$v = \left[1 - \frac{A - B}{pw * Vol}\right] * 100 \qquad (1)$$

Results and Discussion

1. Bulk density of the mixtures

The control specimen of pervious concrete has a density of (1835) kg/m3, which is about (75%), the weight of the normal concrete [25], and that satisfied the requirement of ASTM 1754-14[18]which state that between (1650 Kg /m3) to (1948 Kg/m3). Table (9) and Fig. (6), presents the test results of unit weight and voids content at (7) and (28) days for all pervious concrete mixtures, the table shows that the unit weight pervious concrete mixtures of (28) days is greater than (7) days duo to the growth of hydration processes products [26]. Adding (SF) in different ratios shows lighter weights of concretes like indicated in the Fig. (5), and the Polypropylene fibers presence does not effect on the density of pervious concrete because the weight is very lighter comparison with other 5%). The lowest density of (1746.72) kg/m3 was from the mix PC5, a Fig. (6), shows that the voids in the all pervious concrete mixes was reduced with increasing the silica fume because of the conversion of hydroxide calcium $Ca(OH)_2$ to calcium silicate hydrate (C-S-H) by silica fume. Reduced voids within the paste also reduces the potential for accumulation of water around aggregate particles [27].

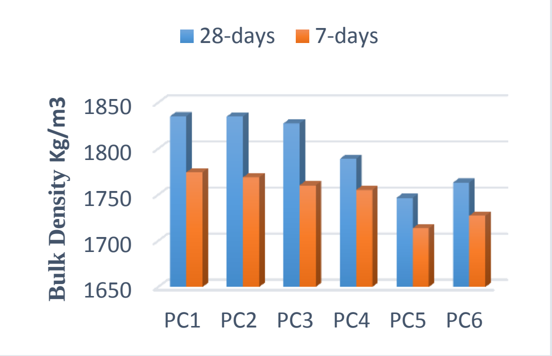

Figure 4: Bulk density kg/m3 of all mixes at (7) and (28) days.

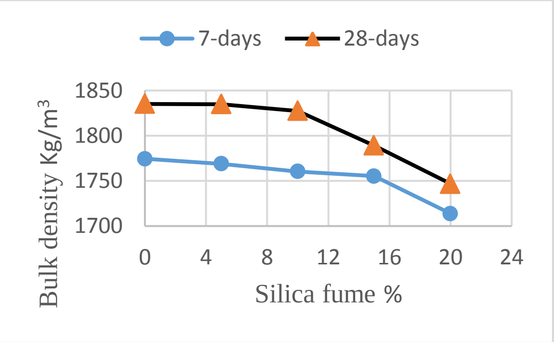

Figure 5: Bulk density with silica fume percentage at (7) and (28) days.

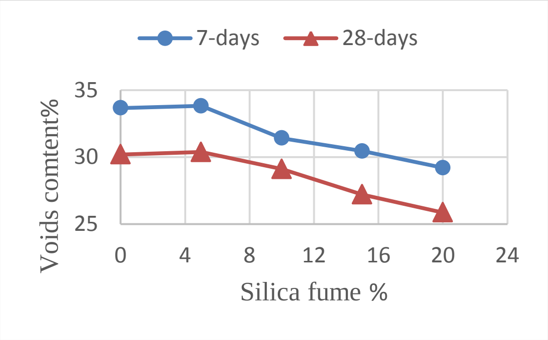

Figure 6: Bulk density with voids content percentage at (7), (28) day.

2. Resultants test of Permeability.

Research results in permeability Test of polypropylene fiber and silica fume pervious concrete samples are indicator in table (10) and Fig. (7).Influence of Silica fume particles with (P.P.F) at the pervious concrete penetration was decreased the pervious concrete penetration coefficient (K), for instance, (K) value of the reference mix (PC1) was 0.324 cm/s which reduced to (0.301%, 0.724%, and 0.243%) in the mixes (PC3, PC4, and PC5) respectively. A 10% silica fume replacement diminished the permeability coefficient by (33.95%) in mix PC6; that primarily because of a significant reduction at cement baste capillary porosity by the conversion of the hydroxide calcium $Ca(OH)_2$ with the pozzolanic silica fume into calcium silicate hydrates which effectively fills up large voids [28]. PC2 mix with (0.15 %) of (P.P.F) and without (S.F) shows that no change in the permeability coefficient (K) this means the fiber does not have considerable effect on the permeability [8].

Table (9): Test results permeability coefficient at (28) days.

Mixes	Permeability coefficient (k) (cm/s)	Percentage of decrease %
PC1- 0.00 % PPF-0.00 % SF	0.324	-----
PC2- 0.150 % PPF-0.00% SF	0.323	0.00
PC3- 0.0 5%PPF-5.00 % SF	0.301	7.1
PC4- 0.025 % PPF-15.0 % SF	0.274	15.43
PC5- 0.00% PPF-20.0 % SF	0.243	25.00
PC6- 0.10 % PPF-10.0 % SF	0.214	33.95

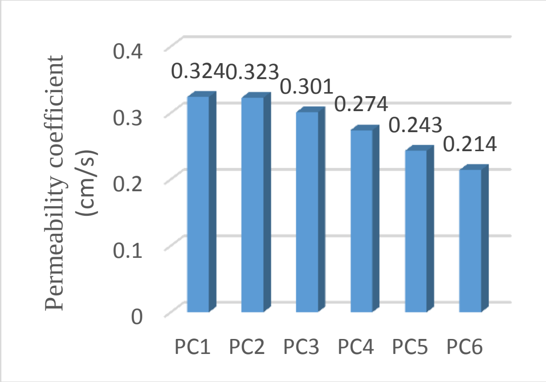

Figure 7: Permeability coefficient of all mixes at (28) days.

3. Results of Compression strength.

Compression strength is that greater significant factor for estimating the concrete mechanical properties. Table (11) apparent the Compression strength test results and figure (8) at (7) and (28) day, it can be found that pervious concrete made with Polypropylene Fibers (P.P.F.) in addition silica fume had more Compression strength than control mix , the raise in the Compression strength at 28 days was more than their conformable Compression strength at (7) days due to the condensation of product of hydration process with silica fume about the Polypropylene fiber and loss the transition zone porous and further improves the mechanical properties of the concrete [29].

Also, Figure (8) shows that Compression strength decreased significantly when increasing the voids ratio content of pervious concrete, due to that voids are weakness points during the loading process, leading to reduce the resistance of concrete. [29].The maximum Compression strength of pervious concrete was (31.87) MPa at (28) days of age founded in the (PC6) mix with 0.1% of polypropylene fibers with 10% of silica fume and the percentage of increased was (47.82%) comperation with control mix.

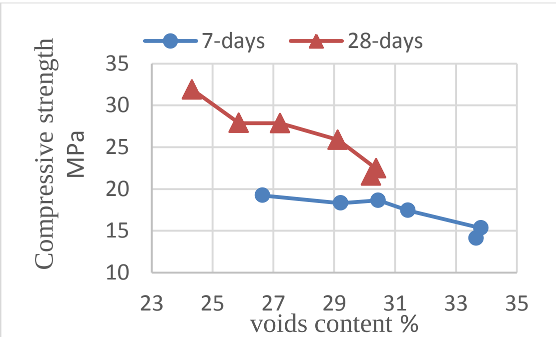

Figure 8:compression strength with voids content percentage for (7), (28) day.

4. Results splitting tensile strength test.

The splitting tensile strength pervious concrete effect of silica fume and Polypropylene fibers for shown at Table (12), the pervious concrete mixes splitting tensile force test results plotted in Fig. (9). after (28) day of treated water, it was discovered that pervious concrete splitting tensile strength mixes with Polypropylene fibers and silica fume increases compared to the reference concrete mix and the increasing was (19.1 %, 10.11%, 4.5%) respectively for (PC2, PC3, and PC4) because of betterment at the mechanical bond force of pervious concrete and the capability to postponement the embody of crack and fixing their procreation [30]. The mix (PC6) with (10%) of silica fume and (0.1%) of (P.P.F) gives the max. percentage of splitting tensile strength

additional was (29.21%) because of the dual effect of S.F. and P.P.F. Also Fig. (9) Shows that Slight improvement at pervious concrete splitting tensile force with just (SF) liked at (PC5).

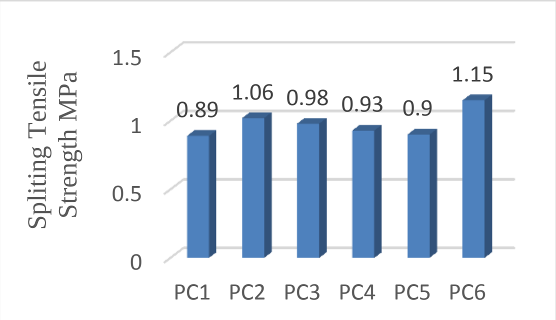

Figure 9: Splitting tensile strength of mixtures for (28)-days.

5. Flexural Strength Resultants.

The flexural strength for the specimens measured with the age of (28) day. From test results given in Table (13), it can be noticed that flexural strength of the mixes made with silica fume and Polypropylene fibers exhibited increases in flexural strength in comparison with control mix, similar to the Compression and tensile strengths trends at presence of fibers with (SF) maximum percentage of increasing was (24.40%) at (PC6) with (10%) Silica fume and 0.1% of (P.P.F) by volume. that can be attributed the increase may be resulted from the fibers intersecting the crack in the tension and providing an additional energy absorbing mechanism [28]. In addition, the strengthened and reduced the transition zone porousness between coarse aggregates and cement past in the presence of (S.F).It can be noticed from Fig. (10), that pervious concrete flexural strength without Polypropylene fibers not change much as in (PC5) mix compared with reference pervious concretes.

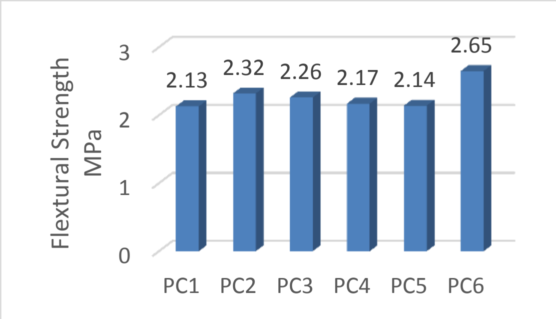

Figure 10:Flexural strength of all mixes at (28)-days

Table (9): Average test result of bulk densities and void ratio at7and 28 days of age

Mixes	Bulk Density Kg/m3 (7days)	Voids Ratio,% (7days)	Bulk Density Kg/m3 (28days)	Voids Ratio,% (28 days)
PC1- 0.00 % PPF-0.00 % SF	1774.43	33.67	1835.34	30.21
PC2- 0.150 % PPF-0.00% SF	1768.93	33.83	1834.95	30.38
PC3- 0.0 5%PPF-5.00 % SF	1760.34	31.43	1827.42	29.12
PC4- 0.025 % PPF-15.0 % SF	1755.22	30.45	1789.11	27.22
PC5- 0.00% PPF-20.0 % SF	1713.70	29.21	1746.72	25.87
PC6- 0.10 % PPF-10.0 % SF	1727.27	26.65	1763.31	24.33

Table (11): Average test result of compressive strength at (7) and (28) days.

Mixes	Compressive strength MPa 7days	Compressive strength MPa 28days
PC1- 0.00 % PPF-0.00 % SF	14.12	21.56
PC2- 0.150 % PPF-0.00% SF	15.34	22.45
PC3- 0.0 5%PPF-5.00 % SF	17.43	25.87
PC4- 0.025 % PPF-15.0 % SF	18.65	27.87
PC5- 0.00% PPF-20.0 % SF	18.32	26.28
PC6- 0.10 % PPF-10.0 % SF	19.23	31.87

Table (12): Test results of splitting tensile strength at (28) days.

Mixes	Splitting Tensile strength MPa -28days	Percentage of increase %
PC1- 0.00 % PPF-0.00 % SF	0.89	-----
PC2- 0.150 % PPF-0.00% SF	1.06	19.10
PC3- 0.0 5%PPF-5.00 % SF	0.98	10.11
PC4- 0.025 % PPF-15.0 % SF	0.93	4.50
PC5- 0.00% PPF-20.0 % SF	0.90	1.12
PC6- 0.10 % PPF-10.0 % SF	1.15	29.21

Table (13) :Test results of flexural strength (MPa) at (28) days.

Mixes	Flexural strength MPa -28days	Percentage of increase in 28-days
PC1- 0.00 % PPF-0.00 % SF	2.13	-----
PC2- 0.150 % PPF-0.00% SF	2.32	4.7
PC3- 0.0 5%PPF-5.00 % SF	2.26	6.1
PC4- 0.025 % PPF-15.0 % SF	2.17	3.76
PC5- 0.00% PPF-20.0 % SF	2.14	0.5
PC6- 0.10 % PPF-10.0 % SF	2.65	8.92

CONCLUSIONS

This study illustrates the influence of silica fume at (5%, 10%15%, and 20%) from weight of cement with Polypropylene fibers of (0.025%, 0.5%, 0.1%, and 0.15%) by volume. On the pervious concrete, the conclusions drawn as follows:

The control pervious concrete has a density of (1835) kg/m^3, and the voids content was reducing with increasing the percentage of silica fume, the lowest density of (1746.72) kg/m^3 was from the mix (PC5) at 28-days. It permeability coefficient (K) and voids content was (0.324) cm/s, and (30.21%) respectively.

The effect of Silica fume particles with (P.P.F) at the pervious concrete presence decreased also, (K) value of the reference mix (PC1) was (0.324) cm/s, which reduced to (7.09%, 15.43%, and 25%) in the mixes (PC2, PC3, and PC4), respectively.

There was an increase in the Compression strength with increasing the fiber volume fraction and silica fume, and maximum Compression strength of pervious concrete was 31.87 MPa at 28 days of age founded in the (PC6) mix with 0.1% of polypropylene fibers with 10% of silica fume and the percentage of increased was 32.3%.comperation with control mix.

The flexural strength and splitting tensile Strength of (0.1%) (P.P.F) and (10%) silica fume of pervious concrete specimens have the higher value of flexural strength and splitting tensile strength compared with other mixes were (2.65) MPa and (1.15) MPa at(28) days respectively with increased of (24.41 %) of flexural strength and (29.21%) of splitting tensile strength compared with reference mix. In general, splitting tensile strength and flexural strength of pervious concrete increase with adding (P.P.F) and silica fume.

There is little reform at the mechanical properties of pervious concrete when added silica fume only like in PC5 mix and were 0.5% and 1.12% at tensile splitting and flexural strengths respectively comparison with the reference mix.

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