The Combined Influence of Polypropylene Fibers[PPF] and Silica Fume[SF]on Concrete Strength

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Abstract:- **This research investigates The combined Influence of PPF and SF on Concrete Strength. key variables Effects such as contents of PPF and SF were studied. An experimental plan was conducted to achieve the required objectives. Concrete mixes having a fixed water/binder ratio equals 0.40 and a constant total binder content equals 500kg/m^{3}are prepared. The % of SF that replaced cement in this study were 0%,6%,12% and 18%. PPF with 12mm length and four volume fractions of 0%, 0.25%,0.5% and 0.75% are used. The results illustrate that SF posses great enhance on the concrete tensile and compressive strengths. The increasing of replacement of SF from 12% to 18% has no approximately significant change on the development of concrete strength. The adding of PPF caused an inverse influence on the strengths of plain and SF concretes**.

Keywords: ***Polypropylene Fibers[PPF] ,Compressive Strength And Silica Fume[SF]***

I. INTRODUCTION

SF consists of extremely fine particles approximately 100 times lower than the average particles of cement, the great fineness of particles of the SF allows it to fill the tiny voids between cement particles . SF is among one of the important pozzolanic materials presently used in concrete. It was initial used in 1969 in Norway but only began to be systematically employed in Europe and North America in 1980. Since then, the SF using in concrete has been growing rapidly , it has been used either as a cement partial replacement or as an additive when special properties are desired [1]. The quick growth in the SF using is attributed to its positive effects on the cementitious composites mechanical properties . Trough the last decade considerable attention has been given to the SF using as a cement partial replacement to produce high-strength concrete[HSC]. the adding of SF to cement concrete marginally decreased the concrete workability but significantly enhanced its mechanical properties[2] . Bhanja et al. checked the SF influence on concrete and suggested the optimum SF content with view of the concrete compressive strength [3]. However, many of researches show that SF growths the concrete brittleness. Ductility improvement is a main aim in concrete science and must be taken into consideration by researchers [4,5] . For several centuries fibers have been used to reinforced brittle materials such as masonry bricks . Now, there are a many of fiber types available for commercial use, the main types being glass, steel ,synthetic materials, and some natural fibers [6-10]. Because PPF has low elastic modulus, high strength, low price, excellent ductility, and excellent durability, many of experimental works related to the PPF using in concrete and cement matrix have been published.[11-12] The polypropylene fibers effect on the hardened concrete properties changes depending upon the fiber length , fiber volume fraction , the design of mixture, and the concrete materials used nature . The common results indicate to abrasion resistance, permeability, and impact resistance are all considerably enhanced by the PPF addition [13] The PPF effect on compressive ,flexural, and tensile strengths in addition to toughness and Young modulus is not quite obvious. Most researches show either no effect or modest enhance in these properties. However, in some cases the PPF addition has been decreased the hardened concrete ultimate strength . The PPF using combined with SF can be recommended to decrease early age cracks and enhancing the durability. The combination of 0.07% PPF and 10%SF volumetric fraction mitigated early age cracks and much decrease carbonation depth and water permeability [14]. However, little information is presently recognized regarding to the combined effect of SF and PPF on the concrete mechanical properties . Therefore, the present study investigates SF, and PPF using an wide range of mixes : SF (by mass) from 6% to 18 % , and PPF (by volume) from 0.25% to 0.75% .

II. MATERIALS

in all concrete mixes, Local materials were tested and used according to ASTM [American Standard of Testing Materials] and ESS [Egyptian Standard Specifications]to in this study . basalt with maximum size equals to 25mm was used as a coarse aggregate and its particle shape was approximately flaky, in this research, natural sand composed essentially of siliceous materials was used as a fine aggregate .Ordinary Cement was checked to assure its compliance with Specifications . supper-plasticizer was added to maintain the water/ binder ratio =0.40 with slump ranges from 6-11cm. 12mm length PPF was used. For preparing the SF concretes , silica fume from Sika company was used.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

III. CONCRETE MIXES PROPORTIONS

16 concrete mixes were prepared, and the initial one was without SF and PPF[control mix]. There are 3 ratios of PPF by volume [0.25% ,0.5% , 0.75%] were mixed in concrete and 3 ratios with SF by mass [6% , 12% , 18%] replacing the similar quantity of cement. Another 9 proportions were arranged with SF by mass replacing the similar quantity of cement [6% to 18%]with PPF mixed in concrete by volume [0.25% to 0.75%] . 16 mixes are shown in Table (1) .

Table (1) : Concrete Mixes

Mix No.	PPF content %	SF content		Cement (kg/m^3)	Basalt kg/m^3	sand kg/m^3	water kg/m^3	Super plasticizer kg/m^3
		%	(kg/m3)					
1	0	0	0	500	1130	565	200	9.25
2	0.25	0	0	500	1130	565	200	9.25
3	0.5	0	0	500	1130	565	200	9.5
4	0.75	0	0	500	1130	565	200	9.5
5	0	6	30	470	1130	565	200	9.25
6	0	12	60	440	1130	565	200	9.5
7	0	18	90	410	1130	565	200	9.5
8	0.25	6	30	470	1130	565	200	9.5
9	0.5	6	30	470	1130	565	200	10
10	0.75	6	30	470	1130	565	200	10
11	0.25	12	60	440	1130	565	200	9.5
12	0.5	12	60	440	1130	565	200	10
13	0.75	12	60	440	1130	565	200	10
14	0.25	18	90	410	1130	565	200	9.75
15	0.5	18	90	410	1130	565	200	10
16	0.75	18	90	410	1130	565	200	10

IV. DESCRIPTION OF TESTED SPECIMENS

48 cubes of sides15x15x15cm length and 48 cylinders of diameter 15cm and height 30cm were cast for compressive and splitting tensile strengths .Concrete was cast and compacted in the forms. Hydraulic compression machine of 2000KN capacity was used for testing the specimens.

V. TEST RESULTS COMPRESSIVE STRENGTH

Concrete mixes compressive strengths were specified at 28 days of curing. The results are illustrated in Tables 2-7 and Figures 1-6. Table 2 and figure 1 show the change of polypropylene fiber reinforced concrete (PPFRC) compressive strengths. From this results, with increasing of PPF content, the compressive strength is reducing gradually and the reduction is so great at the PPF content equals 0.75%. Compared with plain concrete, the reduction of compressive strength was 20 % , 25 % and 26 % for PPF content equals 0.25% , 0.50% and 0.75% respectively. Table 3 and figure 2 show the change of compressive strength of silica fume concrete (SFC)mixes , from this results ,the compressive strength growths with increasing of SF contents and the different SF contents strengths are bigger than that of control mix. Compared with the control mix, the compressive strength increases of 13% , 45 % and 23 % for SF contents 6% , 12% and 18% respectively. SF acts as a filler because of its tiny particles size and the pozzolanic response of the SF produces extra C-S-H gel , which grows into the capillary spaces that remain after the cement hydration in mortar mixes [15]. Therefore , it would appear that SF acts both physically (as space filler) and chemically (reacting with Ca(OH)2 to form C-S-H) to aid in the improvement of mixes strength .

Tables 4-6 and figures 3-5 show the change of the PPFRC compressive strength at the same ratios of SF contents. It was noticed that with increasing of PPF contents, the SFC compressive strength decreases. At 6% SF, the compressive strength reduces with 26%, 29% and 30% for PPF content equals to 0.25%, 0.5% and 0.75% respectively while at SF content 12% the decrease was 29% , 40% and 41%, also at 18% SF content the decrease was 22%, 32% and 34% respectively

Table (2): Compressive strength results [kg/cm^2] of PPFRC

SF content %	PPF content %	Compressive strength kg/cm^2
0	0	[control]386
0	0.25	[-20%]310
0	0.5	[-25%]291
0	0.75	[-26%]287

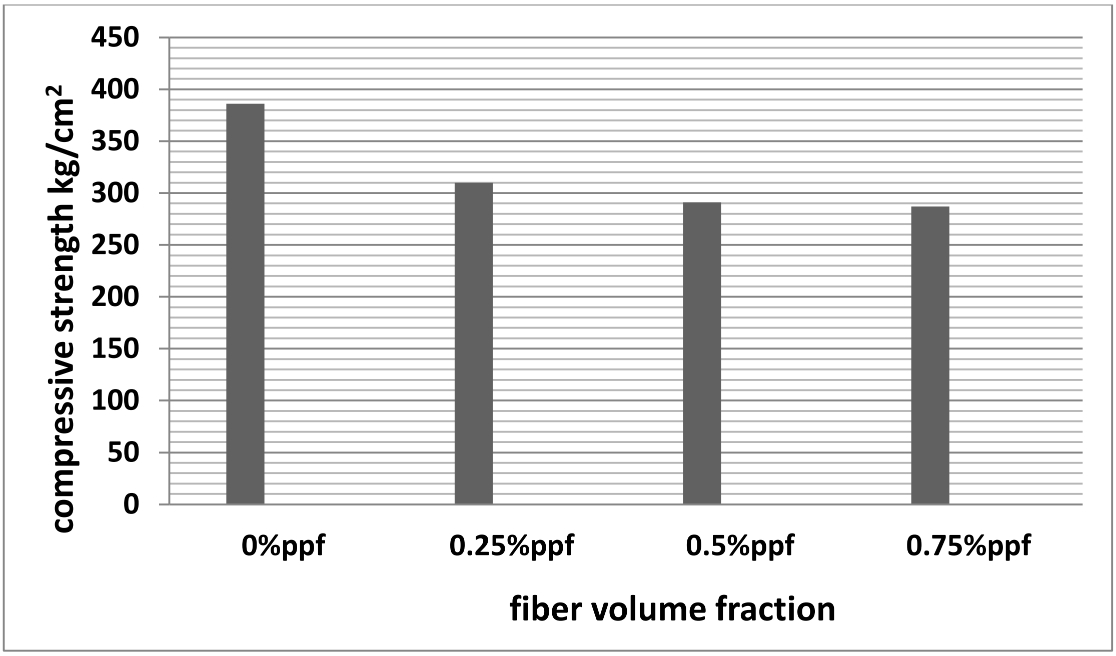

Fig.(1) : The PPFRC compressive strength (kg/cm2)

Table (3): Compressive strength results [kg/cm^2] of SFC

SF content %	PPF content %	Compressive strength kg/cm^2
0	0	[control]386
6	0	[+13%]436
12	0	[+45%]560
18	0	[+23%]475

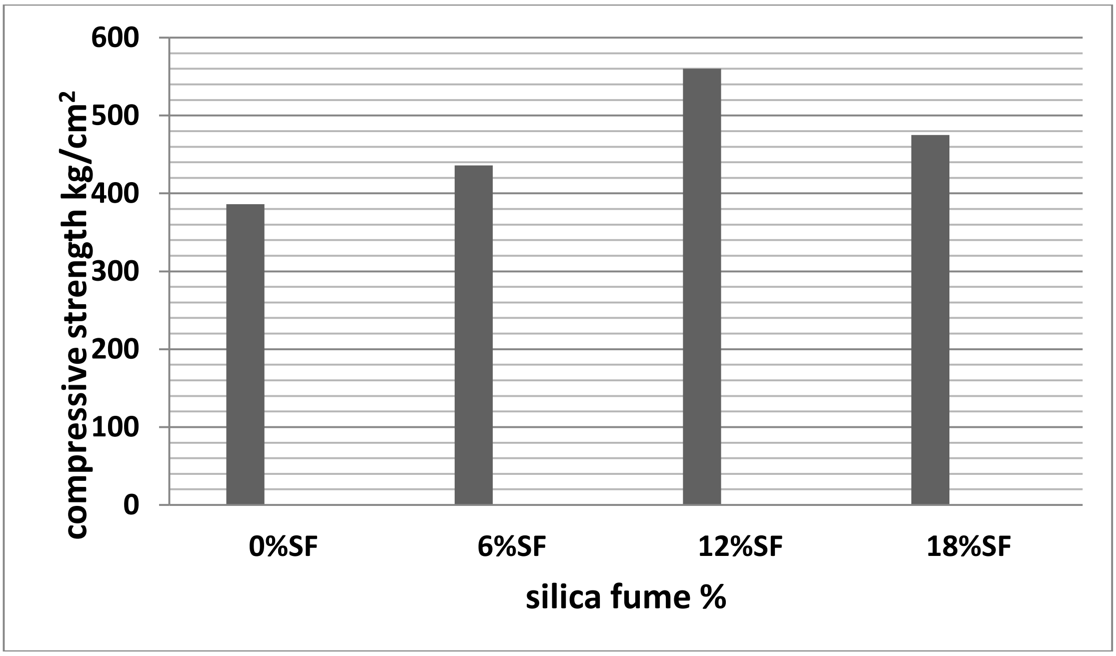

Fig.(2) : The SFC compressive strength (kg/cm^2)

Table (4): PPFRC with SF content =6% compressive strength results [kg/cm^2]

SF content %	PPF content %	Compressive strength kg/cm^2
6	0	[control]436
6	0.25	[-26%]324
6	0.5	[-29%]308
6	0.75	[-30%]304

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

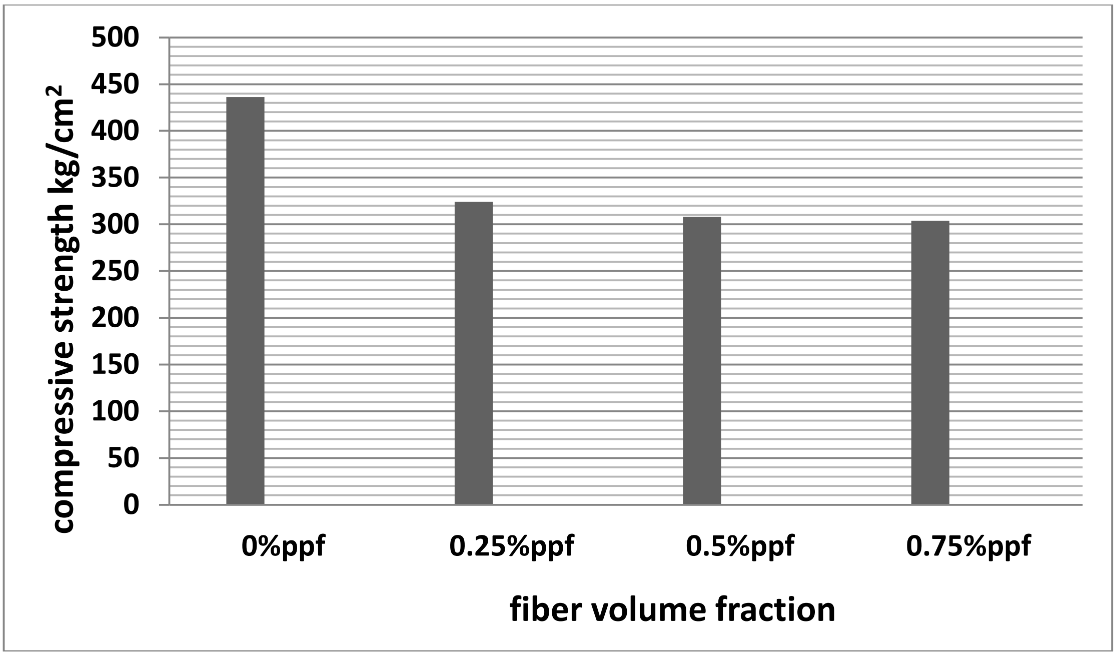

Fig.(3) : PPFRC with SF content =6% compressive strength results [kg/cm^2]

Table (5): PPFRC with SF content =12% compressive strength results [kg/cm^2]

SF content %	PPF content %	Compressive strength kg/cm^2
12	0	[control]560
12	0.25	[-29%]400
12	0.5	[-40%]338
12	0.75	[-41%]328

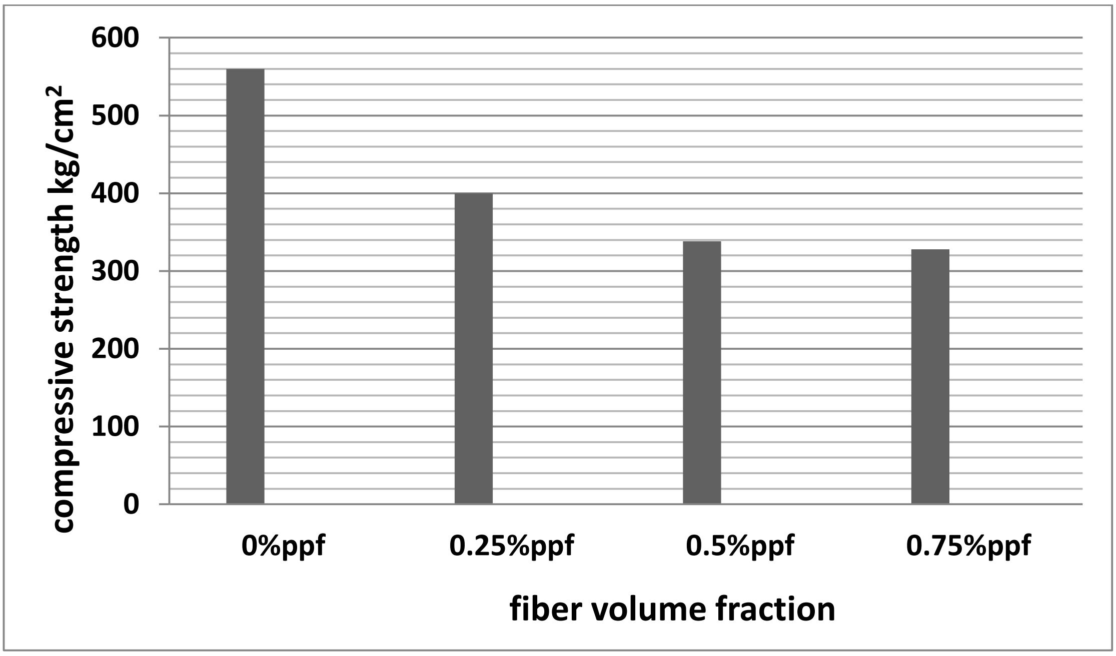

Fig.(4) : PPFRC with SF content =12% compressive strength results [kg/cm^2]

Table (6): PPFRC with SF content =18% compressive strength results [kg/cm^2]

SF content %	PPF content %	Compressive strength kg/cm^2
18	0	[control]475
18	0.25	[-22%]370
18	0.5	[-32%]322
18	0.75	[-34%]315

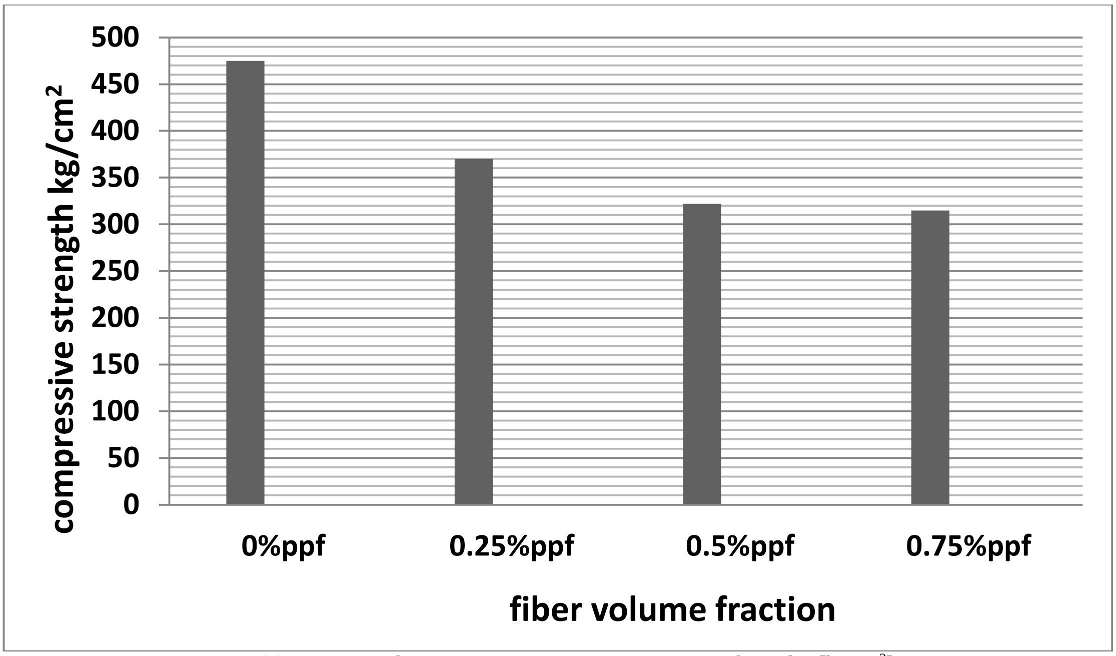

Fig.(5) : PPFRC with SF content =18% compressive strength results [kg/cm^2]

Table (7): Summary of compressive strength results [kg/cm^2]

PPF content%	the compressive strength (kg/cm^2) at SF content			
	0%	6%	12%	18%
0	[control] 386	[+13%l]436	[+45%l]560	[+23%]475
0.25	[control]310	[+5%]324	[+29%]400	[+19%]370
0.5	[control]291	[+6%]308	[+16%]338	[+11%]322
0.75	[control]287	[+6%]304	[+14%]328	[+10%]315

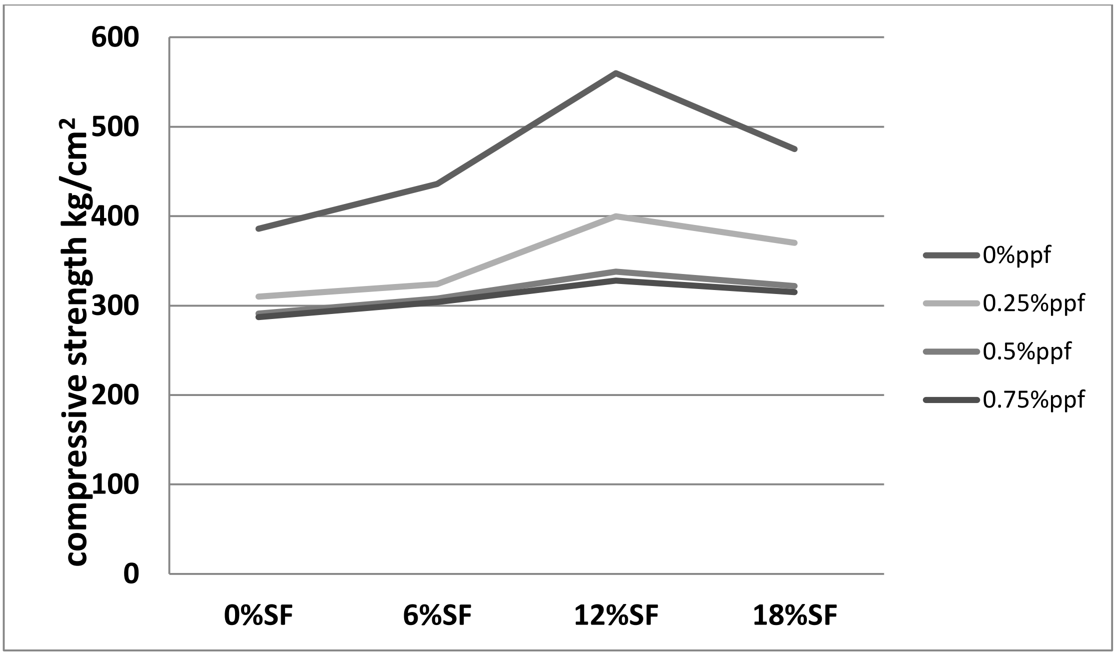

Fig.(6) : The compressive strength (kg/cm^2) of all concrete mixes

Tensile strength

Splitting tensile strengths of all mixes were specified after 28 days curing. The results are given in Tables 8-13 and Figures 7-12. Table 8 and figure 7 show the change of PPFRC tensile strength. From this results, with increasing of fiber content, the tensile strength is reducing regularly . Compared with plain concrete ,the decrease of tensile strength were 10 % , 18% and 16 % for 0.25% , 0.50% and 0.75% PPF content respectively. Table 9 and figure 8 show the change of SFC tensile strength , from these results ,the tensile strength growths with increasing of SF contents and the strengths of different SF contents are larger than that of control mix. Compared with the control mix, the tensile strength increases of about 11 % , 25 % and 22 % for SF

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 08, August - 2017

contents 6% , 12% and 18% respectively. Tables 10-12 and figures 9-11 show the variation of the tensile strength of PPFRC at the same ratio of SF content. With increasing PPF content, the SFC tensile strength decreases. At 6% SF content ,the tensile strength decreases with 10%, 16% and 16% for PPF content 0.25%, 0.5% and 0.75% respectively as for SF content 12% the decrease was 18%,24% and 24%, also for SF content 18% was 20%, 28% and 23% respectively.

Table (8): PPFRC tensile strength results [kg/cm^2]

SF content %	PPF content %	Tensile strength kg/cm^2
0	0	[control]37
0	0.25	[-10%]33
0	0.5	[-18%]30
0	0.75	[-16%]31

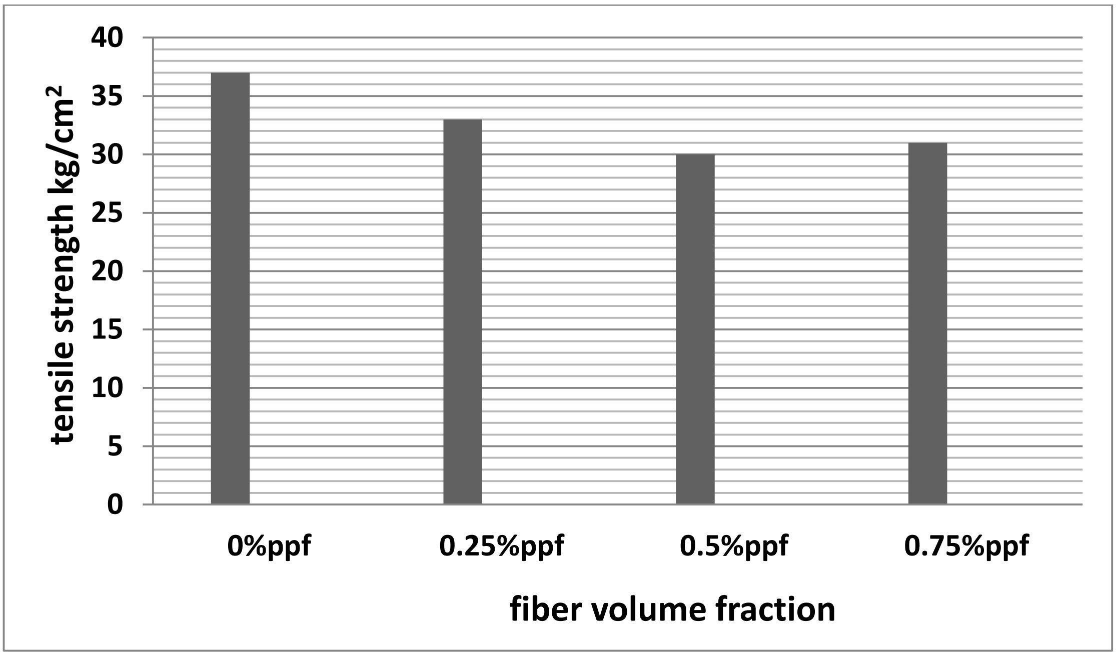

Fig.(7) : The PPFRC tensile strength (kg/cm^2)

Table (9): SFC tensile strength results [kg/cm^2]

SF content %	PPF content %	Tensile strength kg/cm^2
0	0	[control]37
6	0	[+11%]41
12	0	[+25%]46
18	0	[+22%]45

VI. CONCLUSIONS

1. SF has an inverse effect on the fiber concrete workability.
2. SF has great enhance on the concrete compressive strength and concrete splitting tensile strength , the splitting tensile strength and compressive strength of concrete increase gradually with increasing the content of SF.
3. The compressive strength increases with increasing in SF compared with normal concrete. The maximum increase in compressive strength was up to 13 %, 45 % and 23 % for 6% , 12% and 18% of SF replaced by cement respectively.
4. The tensile strength increases with increasing in SF compared with normal concrete. The maximum increase in strength was 11 %, 25 % and 22 % for 6% , 12% and 18% of SF replaced by cement respectively.
5. The increase of replacement levels of SF from 12% to 18% has not large change on the development of tensile and compressive strengths. Therefore the replacement optimum dosage of SF in the concrete in this paper was considered 12%.
6. The adding of PPF caused an inverse influence on the tensile and compressive strengths of normal concrete and SFC.
7. However , the adding of PPF resulted in a large decrease in compressive strength than tensile strength.
8. the reduction in compressive and tensile strengths are directly relative to the content of fibers.

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