Sustainable Structure and Materials, *Vol. 1, No .2, (2018) 36-43*
DOI: https://doi.org/10.26392/SSM.2018.01.02.036

A review on effect of different fiber types on fiber reinforced Concrete behavior

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(Received February 20, 2018, Revised Jun, 05, 2018, Accepted Jun, 08, 2018)

ABSTRACT. *This paper aims at comparing the change in the behavior and properties of concrete after addition of fiber and the effect of type, shape and distribution of fibers in concrete mixture on compressive strength, tensile strength, bending strength, impact resistance, and minimization of cracks in concrete. And the influence of different kinds of fiber on the durability of concrete. For comparison, we relied on a set of previous studies and scientific research on the object of our research.*

Keywords: Concrete, Fiber Reinforced, Concrete behavior, Flexural strength, Durability.

1. INTRODUCTION

Concrete that the fragile material and its strength tension much less strength compression, Steel bars are used to enhance concrete tensile strength and resist energy absorption, the increasing tensile cracks in the Concrete Member might claim failure state. After the seventies of the latest century, Use asbestos to reinforce concrete. In the late 1950s and early 1960s by Batson and Romuald, in 1964 by Romuald and Mandel Research on random scattered sparse fibers. As well Shah and Rangan 1971 began studying anther types of fiber in addition to steel fiber.1971 Nawy et al. Nawy and Neuwerth developed Using fiber glass as the main compound reinforcement in concrete beams and slabs, since the time used steel fiber in reinforced concrete [1]. Concrete fibers consist of composite material consisting of a mixture of cement (mortar or concrete) and appropriate fibers sporadic, Fiber was used as an additive which is uniform, intermittent and randomly distributed, and According by the

American concrete institute ACI committee 544 [2] there are four types of fiber concrete: Steel Fibers, Synthetic Fibers include carbon fiber, Glass Fibers and Natural Fibers. As the chemical and physical monarchy of fiber affect the chemical stability of the concrete, density, fire resistance, surface roughness, of the concrete, each type of fiber has its own properties that differ from other species, these properties include tensile strength, Energy Absorption, Flexural strength, compressive, strength, ductility, elongation to failure etc. In addition to other engineering characteristics that affect the performance of fibers in concrete the cross section of the fiber can be square, circular, rectangular, triangular, polygonal, or any substantially polygonal shape to improve pullout behavior that can be achieved from deforming the fibers.

2. EFFECT OF FIBER ON CONCRETE PROPERTIES

2.1 Workability

The effectiveness of all fiber reinforcement is particularly dependent on achieving a homogenous spread of fiber in concrete, successful casting, spraying and bonding with cement. By increasing the percentage of special fibers with small diameter, they often have an adverse effect on the concrete viability and lead to changes in the mix design. To reduce water permeability of concrete by adding silica fumes, fly ash and PP fibers. **[1]** for the excess in fiber volume, there is a decrease in the freshness of concrete and the cohesion of concrete components, low operational capacity, with the increased volume of steel fiber. **[2]** Checked, different properties of SFRC consist of different aspect ratio and compared with plain concrete. Conclusion With the increase in fiber content in the concrete mix, the workability decreases uniformly. **[12]** Fibers that impede the movement of aggregates, and lead mainly to lack of mobility and its intensity can be reduced by shortening the aspect ratio of fibers. **[5]** Showing of the hooked fiber is better compared to the straight fiber because the baling was prohibiting during mixing. **[6]** Polypropylene fibers have a lower impact on workability, compared to steel fibers, separation of risk in lightweight concrete reduces due to blocking effect of steel and polypropylene fibers. **[15]**

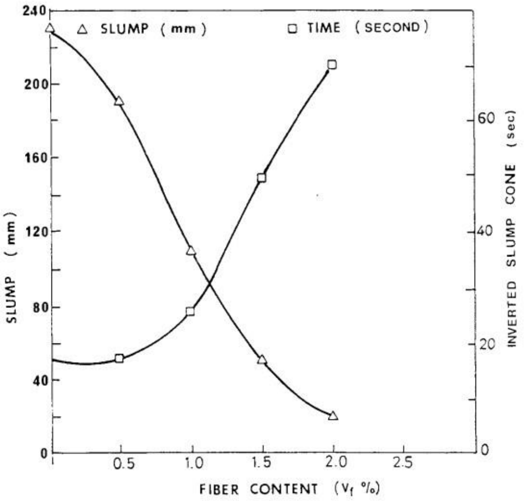

Chart -1: The fiber content in the concrete mixture has an effect on the workability. **[1]**

2.2 Modulus of Elasticity

The modulus of elasticity, also called the constancy coefficient, is taken as the descent of the tendon from the original to some arbitrary points on the stress/strain curve. The concrete containing a fraction of the steel fibers by 0.25% and 0.5% had a marginal higher value of the elastic coefficient contrast to the concrete non-fiber. Elastic modulus of concrete containing 0.05% PP fibers are slightly higher than the elastic modulus of concrete non-fibers. 0.1% and 0.2% of PP fibers the values are reduced from the elasticity coefficient and did not improve it.

2.3 Compressive strength

Fiber has a relatively small effectiveness on the compressive resistance of concrete, adding fiber in the matrix of concrete, compared with the matrix of plain concrete, affects the value of the compressive of peak strength only slightly but affects the response after the peak more effectively. A raise of almost 14.2. % in compressive resistance when using SF in concrete when compared to plain concrete results. 26. %. Maximum increase in compressive load of fracture in concrete when using 2. % volume of steel fibers. **[11]** Lab results on lightweight concrete reinforced with volume fraction. (0%, 0.5%, 1%, 1.5% and 2%) of fiber, and concluded that the compressive strength improved slightly with implication of steel fibers. **[12]** The compressive force decreased up to 31% with the addition of steel fibers, maximum observed when using 1.5% volume fiber. **[14]** When use 1.0 to 10.0% polypropylene fiber reinforced sample Decreased in compressive resistance compared to plain sample. **[13]** The incorporation of too short nylon fibers reduces the compressive resistance up to 37%. **[7]**

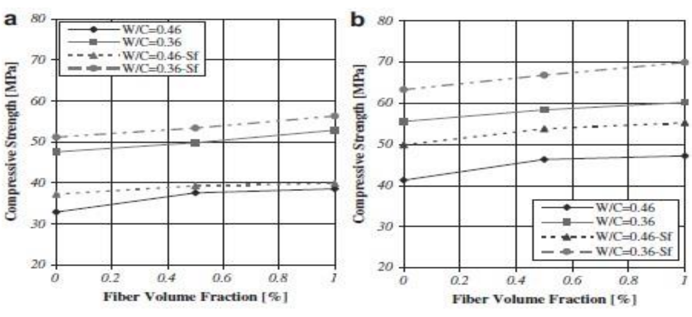

Chart -2: Compressive. Strength (Map) - fiber volume fractions (%) At different ages of concrete of: (a) 7 d, (b) 28 d. **[2]**

2.4 Flexural strength

To characterize the flexural behavior, it is indispensable to measure the stress-strain (load-deflection) curves which reflect influence of the fibers on concrete member beneath flexure loads. Flexural testing is usually obtained in four-point loading, there are Typical specifications are found in ASTM C1018, BS6432. The use of 1.5% volume fractions of SF excess the concrete resistance to flexure loads up to 30-66%. They also noted that there was no important influence on the flexural strength of fractions of low-volume steel fibers of less than 0.5%. **[2]** To improve the bending resistance and to obtain the optimum increase Is included 1.5% volume SF, For about 67% increase in bending strength. Flexure strength are increased reach to 49% when included 3% of SF. SFRC in 1.5% volume fraction and increase the aspect ratio 70% of steel fiber observed an increase of up to 58.65% in the strength of flexural. **[14]** A 32% excess in flexural strength of polypropylene fibers reinforced the sample at 1.0% of the fiber volume fraction. **[8]** No significant influence was spotted on the tensile strength of mortar when polypropylene fibers were incorporated. **[10]** In 1% volume add fiber of glass volume increase up to 75% in the strength of flexural. **[36]**

Table -1: Maximum of flexural loads, first crack loads and congruent deflections. **[3]**

Fibre mix proportion by weight		Fibre volume fraction (%)	Maximum flexural load and corresponding deflection		First crack load and corresponding deflection	
50 mm long fibres (%)	25 mm long fibres (%)		Deflection (mm)[a]	Load (kN)[a]	Deflection (mm)[a]	Load (kN)[a]
0	0	0	0.338	11.88	0.338	11.88
100	0	1.0	0.545	16.68	0.397	13.76
65	35	1.0	0.498	16.92	0.396	14.49
50	50	1.0	0.526	16.56	0.385	14.38
35	65	1.0	0.506	16.64	0.392	14.38
0	100	1.0	0.434	15.92	0.401	14.92
100	0	1.5	0.661	20.98	0.399	15.19
65	35	1.5	0.650	20.12	0.401	15.35
50	50	1.5	0.653	18.75	0.399	15.00
35	65	1.5	0.588	17.73	0.394	15.55
0	100	1.5	0.495	17.17	0.399	15.85
100	0	2.0	0.902	23.83	0.405	15.89
65	35	2.0	0.720	22.32	0.405	16.28
50	50	2.0	0.768	19.81	0.402	16.35
35	65	2.0	0.613	18.75	0.408	16.83
0	100	2.0	0.483	18.01	0.401	17.66

[a] Average of three batches.

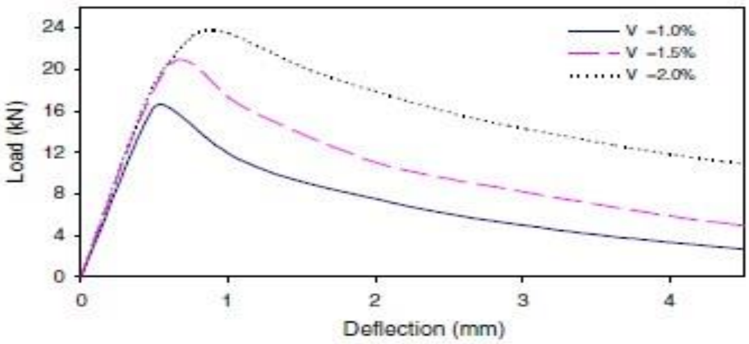

Chart -2: Load deflection curves for fibrous concrete with mixed aspect ratio of fibers [100% 50 mm + 0% 25 mm long fiber] at different fiber volume Fractions. **[3]**

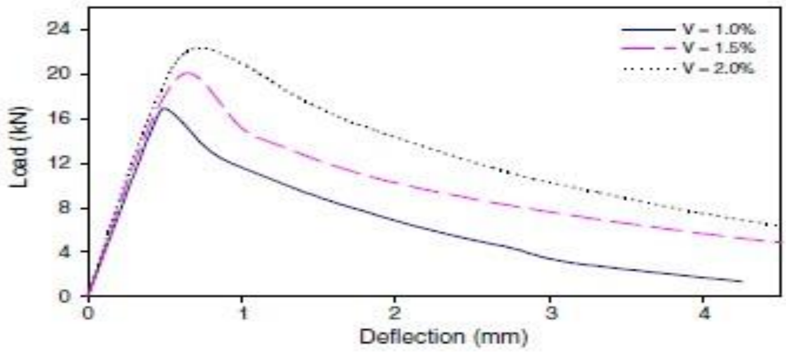

Chart -3: Load deflection curves for fibrous concrete with mixed aspect ratio of fibers [50% 50 mm + 50% 25 mm long fiber] at different fiber volume fractions. **[3]**

2.5 Shrinkage

The shrinkage in concrete is known as volume change due to chemical reaction between cement and water (hydration). The dryness of concrete due to water loss has three types, Shrinkage plastic, Autogenous shrinkage, Drying shrinkage, Factors affecting the shrinkage of concrete are the properties of materials, moisture, and changing of temperature, the disadvantage caused by the shrinkage of concrete are tensile stress and cracks. The effect of shrinkage with the low ratio of water to cement, it was evident in concrete mixtures with steel fibers و where the fracture ratios were 44.6%, 20.8% and 13.5% for mixtures with 0.32, 0.4 and 0.5 respectively of steel fiber**. [14]** The volume of polypropylene fibers increased by 0.12% reduction in shrinkage drying by about 24%. **[1]**

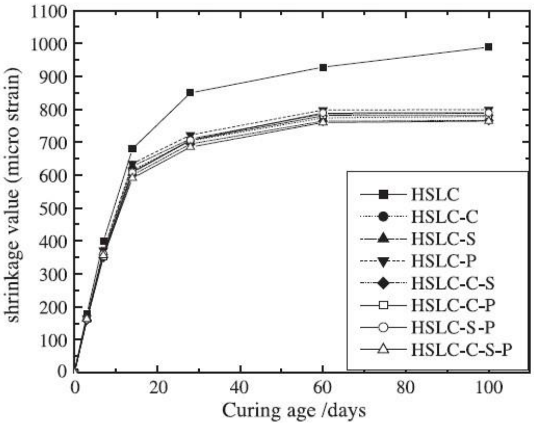

Chart -4: Shrinkage of the fiber reinforced light weight aggregate concretes. **[5]**

2.6 Tensile strength

Ordinary concrete is weak in tensile strength and strain capacity of fracture. To conquer this imbalance, steel bars were added to increase tensile strength. The steel bars are continuous and in structure to improve performance. Steel fibers were used to enhance concrete, asperse fibers that at random spread in the concrete mix. Tensile strength increases by up to 59% when adding volume fraction of 2% steel fiber. **[12]** Add both steel and polypropylene fibers together in the concrete mix, the increase in tensile strength reach to 116%. **[8]** The tensile strength increased to 20% when adding 0.5% of the glass fiber. **[13]** Tensile strength of nylon fiber increment by 6.7% compared to the polypropylene fiber. **[17]**

Table -2: The results of tensile split strength and compressive strength of reinforced concrete of steel and ordinary concrete. **[3]**

Fibre mix proportion by weight		Fibre volume fraction (%)	28 days strength (MPa)			
50 mm (%) long fibres[a]	25 mm (%) long fibres[b]		Cube compression	% Increase	Split tensile	% Increase
0	0	0	57.82[c]	0	3.83	0
100	0	1.0	59.80	3	4.82	26
65	35	1.0	62.40	8	4.88	27
50	50	1.0	62.89	9	4.65	21
35	65	1.0	64.69	12	4.63	21
0	100	1.0	69.83	21	4.58	20
100	0	1.0	63.98	11	5.78	51
65	35	1.5	67.39	17	5.55	45
50	50	1.5	65.85	14	5.21	36
35	65	1.5	69.05	19	5.06	32
0	100	1.5	72.13	25	4.83	26
100	0	2.0	62.06	7	5.97	56
65	35	2.0	67.12	16	6.09	59
50	50	2.0	65.42	13	5.40	41
35	65	2.0	68.58	19	5.17	35
0	100	2.0	72.82	26	4.98	30

[a] Fibre aspect ratio = 20.
[b] Fibre aspect ratio = 40.
[c] Average of 10 tests, rest average of five tests.

2.7 Durability

Concrete can withstand chemical attack and corrosion while preserving concrete properties and known as the longevity of the material against various ecological conditions, when bars of steel is used with fiber in chloride environments as a means of improving concrete durability, it reduces the permeability of concrete elements, and steel fibers act as self-protection, thus protecting reinforcement bars from corrosion. **[16]** When using polyester fiber, it gives high resistance to the alkaline environment. **[17]** Natural fibers cause a risk to the concrete structure due to affected the fibers from the alkaline environment. **[15]**

2.8 Freezing

Due to freezing cycles and water leakage within cracks leading to break of concrete samples, the steel fibers act to contain the small cracks and prevent the increased width of the cracks. This was achieved by introducing different amounts of slag on the fiber concrete mix **[18].** Resistant freeze of concrete with polypropylene fibers found a small increase compared to without fiber. **[19]** The use of cement blended concrete by slag, after twenty cycles of (freeze and thaw), tensile strength when bending in steel reinforced concrete reduce by 25%. The deformities in concrete on Portland cement exposed to frosts are significantly less than the deformities in concrete on Portland cement specific at one level of strain. **[18]**

Table -3: Change the porosity of the concrete beneath periodic freezing. **[18]**

No. of Cycles	Porosity Index	Content of Slag, %							
		0		30		50		80	
		C	SRC	C	SRC	C	SRC	B	SRC
0	Index of pore size uniformity	0.62	0.63	0.63	0.63	0.64	0.66	0.47	0.46
	Index of pore average size	1.78	1.76	1.37	1.24	1.20	1.02	1.92	1.87
	Open capillary porosity, %	23.2	22.9	25.2	24.8	26.0	26.2	28.7	28.3
100	Index of pore size uniformity	0.49	0.51	0.55	0.54	0.55	0.55	0.44	0.43
	Index of pore average size	5.98	4.69	4.81	3.38	3.74	2.63	6.29	6.37
	Open capillary porosity, %	30.5	29.5	29.8	28.2	28.8	27.0	32.9	30.6

2.9 Permeability

As a result of increased cracks growth and increased concrete permeability to the deterioration of the sample, the adding of steel fibers reduces the permeability of the concrete, and steel fibers can be used reliably and effectively in the structures of reservoirs and dams. **[20]** Inclusion Polypropylene fiber with concrete, decrease porosity of concrete and water absorption. **[19]**

2.10 Carbonation resistance

Resistance to carbonization increases with the increase in the volume of PP fibers, fibers prevent capillary channels in concrete and reduce the channels of CO2 propagation. **[19]**

2.11 Impact

With increased volume fiber in concrete, impact resistance increases, when silica fume is added with fiber, Increases concrete resistance to impact. **[2]** Adding 0.2% of PP fibers. amelioration in impact resistance for concrete with PP fibers and rising resistance to 71% by adding fiber reinforced by 0.2%. **[20]** 0.5. % and 1.0 % Steel fiber caused the number of blows in the initial crack to excess by 2.7 and 6.3 and at failed to 3.3 and 7.15 respectively. **[2]** Fibers boost the impact strength of concrete against the first crack initiation and final break, which means the ability to absorb energy in reinforced concrete fibers, sometimes a break in regular concrete occurs suddenly because of its fragile conduct, the number of blow wanted until the first crack and the final break is almost equal. **[8]**

2.12 Absorption of energy

Absorption of energy Concrete resistance to fracture when exposed to stresses, known as the amount of energy in the volume of material that can be absorbed before the break. Energy absorption of self-compacting concrete with steel fiber increased 63% when compared to concrete without fiber. **[23]** The energy absorption of concrete in the presence of hooked steel fiber addicted more than the concrete containing Straight fibers. **[1]**

2.13 Fatigue

Fatigue is the utmost stress that can influence the concrete without causing it to collapse. The flexure fatigue resistance increases of the concrete, with a rise in the volume of the steel fibers in the concrete. **[9]** The fatigue resistance of the concrete is greatly increased with the containment of steel fibers, and Improve their characteristics and behaviors **[1]** Given that the level of this force, ultra-high-performance fiber reinforced Joint concrete combined in the field hardness hardening, In the applied of fatigue stress on high performance concrete strengthened with steel fiber resulted in great resistance to stress fatigue due to the distribution of stresses on the components of concrete. The contribution of high performance fiber reinforced Combined concrete and steel rebar for the fatigue resistance of ultra-high-performance fiber reinforced Concrete with steel rebars depend on the maximum Fatigue level and fatigue test phase allocation of tension and transfer amidst UHPFRC and steel Rebar enhances the fatigue capacity of Components of materials. **[26]** The steel fiber reinforcement concrete with 1.0, 1.5 and 2.0% fiber content Each containing fibers of aspect ratio 50% 50 mm + 50% 25 mm long fibers have been analyzed Trying to define the relation between them S stress level, N life fatigue and the possibility of failure Pf or probability of Survival L.A Family of S-N-Pf Curves were formed. **[25, 28]**

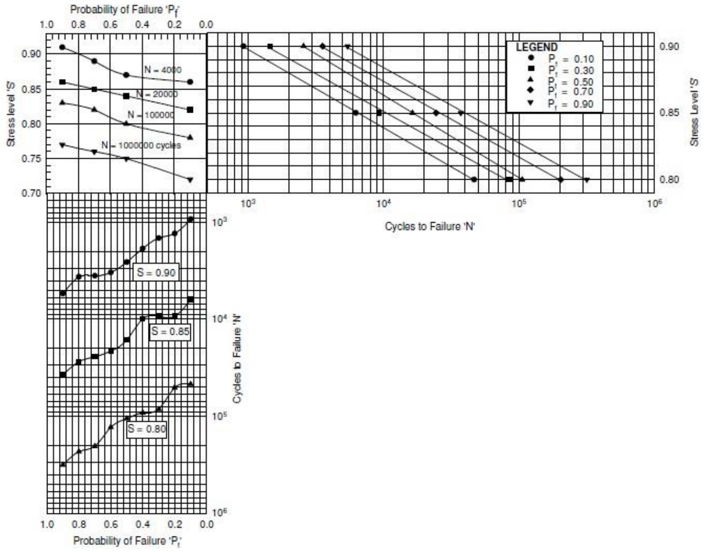

Chart -5: A-N-Pf diagram for SFRC beneath flexural loading, Vf = 1.0%. **[25]**

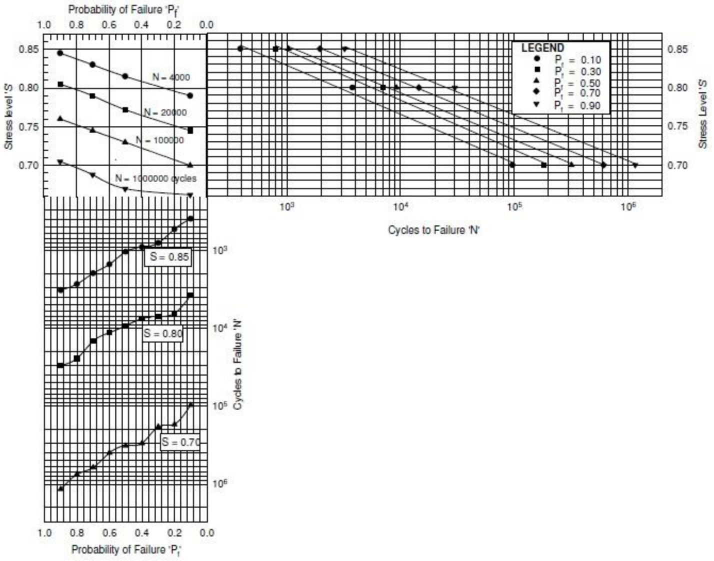

Chart -6: S-N-Pf diagram for SFRC beneath flexural loading, Vf = 1.5%. **[25]**

2.14 Fire resistance

Is the capability of concrete to conduct its assignment and resist loads during fires or high temperatures, this is very important for buildings at hazard, of explosions or fires the demeanor of strengthened concrete with steel fiber at 200,400,800 temperatures and compared to the non-reinforced fiber found that reinforced concrete steel fiber at 600-800 temperature was the remaining concrete strength of 30% of the original strength. **[13]** When studying concrete strengthened with PP fiber, it was found that this fiber enhances the level of performance of fire resistance because the burning of fiber inside the concrete provides channels to discharge steam of water and gases. **[24]**

3. CONCLUSIONS

With increase in fiber volume fraction, the fluidity of fresh concrete decreases and coherence of fresh concrete components increases. The Workability diminution uniformly with increased content of fiber. To increase the operability of fresh concrete, Fiber that prevent movement, can be reduced by dereliction the aspect ratio of fiber. An increase of 14.2% in compressive strength when using SFRC compared to plain concrete results. Diminution in compressive resistance 1 to 10% when adding PP fibers compared to plain specimen. The combination of short nylon fibers reduces the compressive resistance reach to 37%. Use of 1.5% volume fractures of steel fibers excess the concrete impedance to tensile loads up to 70%. A 32% raise in flexural strength, when inserting 1.0% of PP fibers. Add 1% volume fraction fiber of glass an increase occurs up to 75% in the strength of flexural. The shrinkage effect was clearer with a decrease in w /c ratio in concrete blend with steel fiber. The volume excess of 0.12% polypropylene fiber led to a 24% lessening in drying shrinkage. Tensile strength raises by up to 59% when adding volume fraction of 2% steel fiber. Add both steel and PP fibers together in the concrete mixture Leads to the increase in tensile strength is up to 116%. About 20% rise tensile strength after adding 0.5% of glass fiber. The tensile strength of nylon fibers raised by 6.7% over those of polypropylene fibers. When rebar is used with fiber in chloride medium, as a means of improving concrete durability, it decreases the permeability of concrete elements, and steel fibers act as self-protection, thus protecting reinforcement bars from corrosion. Add Polyester fibers furnish the best resistance against the alkaline environment. Natural fibers weaken the concrete structure because fiber is affected by the alkaline milieu of Portland cement. Due to freezing cycles and leakage of water within cracks leading to break of concrete specimens, steel fibers prevent increased cracks and act to contain small cracks. The resistant of freeze for concrete with poly propylene fibers found a small increase compared to non-fiber concrete. When the steel or Polypropylene fibers are added, the permeability of the concrete decreases. Adding 0.5%, 1% of the steel fibers rise a number of blows in the first crack to increase from 2.7 and 6.3 to 3.3 and 7.15 when the failure rose respectively. improvement in impact resistance for concrete with polypropylene fibers and rising resistance to 71% by adding fiber reinforced by 0.2%. The energy absorption capacity of self-compressed concrete increased with 63% steel fiber parallel to non-fiber concrete. The energy absorption of concrete with hooked fiber more than concrete with fiber straight. Reinforced concrete with steel fiber the remaining strength 30% of its original strength after exposure to high temperatures up to 800 ° C.

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