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Mechanical properties of fibre reinforced concrete using different types of steel fibres

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ABSTRACT

The Steel Fiber Reinforced Concrete (SFRC) is composed of cement, fine and coarse aggregates and discontinuous discrete steel fibers. In tension SFRC fails only after the steel fiber breaks or pulled out of the cement matrix. The composite nature of SFRC is responsible for its properties in freshly mixed and hardened state. The mechanical properties of SFRC are depending on type of fiber, aspect ratio, volume fraction of fibers and the size of the aggregates. SFRC transfer stresses across a cracked section which increases toughness of concrete in hardened state. This paper invistigate the behavior of steel fiber reinforced concrete for compressive strength, tensile strength and flexural strength, using different types of steel fibers and different aspect ratio.

Introduction

Cement concrete is the most extensively used construction material in the world due to its workability and mould ability. Production of Cement and Steel has environmental hazards due to emission of CO_2 and dust particles in the atmosphere. Hence prudent use of cement and steel has distinct economic and environmental impacts. Under impact and dynamic loading plain concrete exhibits extensive cracking and undergoes brittle failure. The concrete is weak in tension and hence to overcome this problem cement concrete is reinforced using steel bars and thus called as reinforced cement concrete (R.C.C,). Fiber Reinforced Concrete (FRC) is a composite material made primarily from hydraulic cements, aggregates and discrete reinforcing fibers. Fiber incorporation in concrete, mortar and cement paste enhances many of the engineering properties of these materials such as fracture toughness, flexural strength, resistance to fatigue, impact, thermal shock and spalling. The use of fiber reinforcement is not a particularly recent idea. The first applications were mainly defense related where FRC was used in various shelter structures. Research development has led the FRC to increase its use as a building material. Nowadays, it is commonly applied in shotcrete, pavements, industrial floors, bridge decks and precast elements..

The Steel Fiber Reinforced Concrete (SFRC) is a composite material made of cement, fine and coarse aggregates and discontinuous discrete steel fibers. In tension SFRC fails only after the steel fiber breaks or pulled out of the cement matrix. The composite nature of SFRC is responsible for its properties in freshly mixed and hardened state. The SFRC possess many excellent dynamic performances such as high resistance to explosion and penetration as compared to traditional concrete. When used in structural applications, The mechanical properties of SFRC are influenced by the type of fiber, aspect ratio, and volume fraction of fibers and the size of the aggregates. One of the most important properties of SFRC is its ability to transfer stresses across a cracked section which increases toughness of concrete in hardened state. The investigation reported in this paper is aimed at studying the behavior of steel fiber reinforced concrete for compressive strength, tensile strength and flexural strength, using different types of steel fibers and different aspect ratio.

Methodology:

Different required tests were carried out on ingredient material. the results are as follows:

Cement:

Physical Properties of Cement. (Confirming to IS 12269 – 1987)

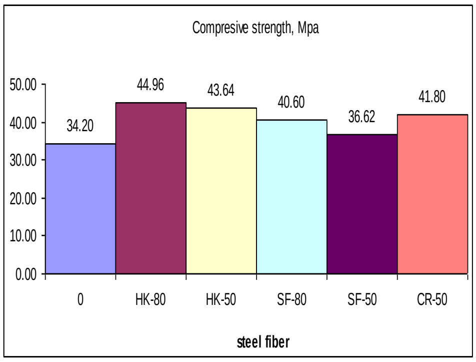

Fig. 1 Comparative Chart of Compressive Strength

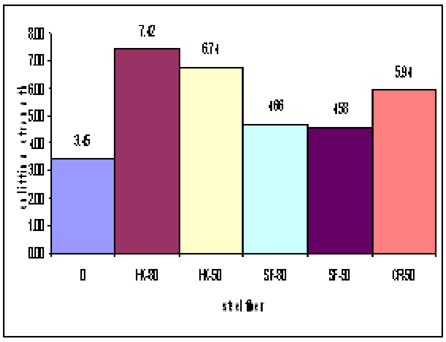

Fig. 2 Comparative chart of Splitting Strength

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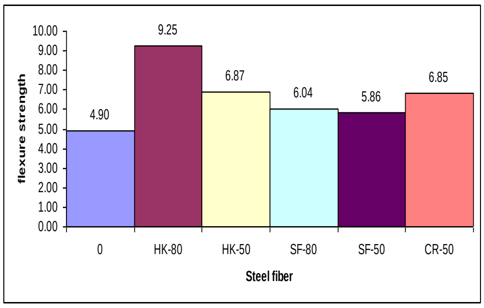

Fig. 3 Comparative Chart of Flexure Strength

Discussion:

In general, the significant improvement in various strengths is observed with the inclusion of hooked end steel fibres in the plain concrete as compared to crimped & straight types of steel fiber.

From comparative statement of same aspect ratio:

Compressive strength: Addition of steel fiber irrespective of type and aspect ration improves the compressive strength of concrete. Strength comparison between same aspect ratio HK-80 & SF-80 is 44.96 Mpa and 40.60 Mpa respectively and HK-50, SF-50 and CR-50 is 43.64 Mpa, 36.62 Mpa and 41.80 Mpa respectively.

Flexural strength: Flexural strength and tensile strength also enhanced due to addition of fibers. The reason for this is the fibers arrests micro crack in concrete. Observations shows, same types aspect ratio HK-80 & SF-80 is 9.25 Mpa and 6.04 Mpa respectively and HK-50, SF-50 and CR-50 is 6.87Mpa, 5.86Mpa and 6.85 Mpa respectively.

Split tensile strength: It is observed that the tensile strength between same types aspect ratio HK-80 & SF-80 is 7.42 Mpa and 4.66 Mpa respectively and HK-50, SF-50 and CR-50 is 6.74 Mpa, 4.58 Mpa and 5.94Mpa respectively.

Conclusion:

1. From above discussion it is conclude that, all mechanical properties viz. compressive strength, flexure strength, splitting strength, are improved by addition of fibers irrespective of fiber type and aspect ratio.
2. All strength likes compressive strength, flexure strength and splitting strength are improved with increasing aspect ratio.
3. Also it is observed that for same aspect ratio the hook ended fibre showing pronounce improvement in all properties of concrete as compare crimped & straight fiber. There is decrease in the strength with decrease in aspect ratio of same fiber type. The straight fibers having less strength as compared with hook end and crimped fibers. This is obvious that the hook end and crimped fiber because of their shape having good bond and anchorage in the matrix resulting in more strength.

Acknowledgement

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Sr. No.	Description of Test	Results
	Brand Name and grade of cement ACC 43 grade	
01	Fineness of cement (residue on IS sieve No. 9)	3 %
02	Specific gravity	3.15
03	Standard consistency of cement	29 %
04	Setting time of cement a) Initial setting time b) Final setting time	 108 minute 288 minute
05	Soundness test of cement (with Le-Chatelier's mould)	1.3mm
06	Compressive strength of cement: a) 7 days b) 28 days	57.8 N/mm^2 79.5 N/mm^2

Sr. No	Property	Results
1.	Particle Shape, Size	Round, 4.75mm down
2.	Fineness Modulus	3.16
3.	Silt content	2%
4.	Specific Gravity	2.64
5.	Bulking of sand	4.16%
6.	Bulk density	1793 Kg/m^3
7.	Surface moisture	Nil

Sr. No	Property	Results
1.	Particle Shape, Size	Angular, 20mm,10mm down
2.	Fineness Modulus of 20mm aggregates	7.4
3.	Fineness Modulus of 10mm aggregates	6.87
4.	Specific Gravity	2.77
5.	Water absorption	1.02%
6.	Bulk density of 20mm aggregates	1603 Kg/mm^3
7.	Bulk density of 10mm aggregates	1585 Kg/mm^3
8	Surface moisture	Nil

Properties of Steel Fibers:

Sr. No.	Property	Type of Fiber				
		Hook Ended		Crimped	Straight	
		HK-80/60	HK - 50/30	CR 50/30	SF-50/80	SF-80/130
1.	Diameter	0.75 mm	0.5 mm	0.6 mm	1.6 mm	1.6 mm
2.	Length of fiber	60 mm	30 mm	30 mm	80 mm	130 mm
4.	Average aspect ratio	80	50	50	50	80
7.	Tensile strength	1050 Mpa	1050 Mpa	1025 Mpa	1050 Mpa	1050 Mpa
8.	Modulus of Elasticity	200 GPa	200 GPa	200 GPa	200 GPa	200 GPa
9.	Specific Gravity	7.8	7.4	7.5	7.15	7.15

Dosages used: 2.5 % at the constant by weight of cement.

Quantity of Materials per Cubic Meter of Concrete

Material	Proportion by Weight	Weight in Kg/m^3
Cement	1	411.0
F.A.	1.08	443.88
C A	2.32	953.52
CAI (10-12 mm) (60%)	1.392	572.12
CAII (20mm) (40%)	0.928	381.40
W/C	0.38	156.80

Schedule of Specimen Preparation:

Sr. No	Types of Steel fiber	Steel Fiber content (%)	Compression Test	Flexure test	Split Test
1	0	00	9	3	3
2	HK-80/60	2.5	9	3	3
3	HK-50/30	2.5	9	3	3
4	RD-80/130	2.5	9	3	3
5	RD-50/80	2.5	9	3	3
6	CR-50/30	2.5	9	3	3

Total Number of Specimens = 126

Results and Discussion:

Sr. No	Type of steel fiber	% of Steel fiber	28 days Strength N/mm^2		
			Fc	Ft	Ff
1	0	0	34.20	3.45	4.90
2	HK-80/60	2.5	44.96	7.42	9.25
3	HK-50/30	2.5	43.64	6.74	6.87
4	SF-80/130	2.5	40.60	4.66	6.04
5	SF-50/80	2.5	36.62	4.58	5.86
6	CR-50/30	2.5	41.80	5.94	6.85

Fc – Compressice Strength
Ft –Indirect Tensile Strength
Ff – Flexural Strength