Properties of Fibre Reinforced Concrete- A Comparative Studies of Steel Fibre & Poly-Fibre

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Abstract:- **Fibres are a kind of material, which works generally as crack shocker and strength provider. Our research paper is concerned with experimental study of fibres which are used in mixture of conventional concrete i.e. steel fibres as well as synthetic (polypropylene) fibres. The steel fibre and polypropylene fibre were mixed with the same concrete design mix i.e. M40 grade, have used to cast the cubes for compressive test, beams for a flexural test and cylinders for split tensile test. The data results during experiment, displays that the steel fibre reinforced concrete is strong in flexure at initial stage, while steel fibre reinforced concrete as well as polypropylene fibre reinforced concrete shows similar results in compressive strength and flexural strength after 28 days. Steel is more useful for providing post-cracking.**

Keywords: - Steel fibre reinforced concrete fibre, polypropylene fibre reinforced concrete, compressive strength, flexural strength.

I. INTRODUCTION

Synthetic fibres and Steel fibres are most used fibres in the world [1]. The bunch of small fibres distributes randomly and makes mix with concrete and these mixes change the property of nominal concrete. The shape and size of fibres may be triangular, zigzag or flat. Aspect Ratio is a limiting factor which describes a value. This value is the ratio of length to diameter of that fibre [2]. This research paper will provide different comparative results. It included the comparative results of both steel and polypropylene fibres for compressive, flexural and split tensile strengths after 28 days.

The most needed and consumed construction material is concrete [3]. If axial load applied on concrete, it shows the property of compression and weak if we stretch in elongation. So, during casting; steel bars are used to make more resistible [4]. The mechanical properties like crack resistance, toughness, reinforcement of steel depends on composite materials of FRC [5]. If the coefficient of elasticity of fibre is more than the concrete mix's elasticity, then it helps to bear the load by increase in the tensile strength of the material. The addition of steel or polypropylene fibres in concrete mix improves the strengths associated with resulting product [6]. Normally, a steel fibre improves the cracking during load applied on structures due to combined effect of concrete mix with steel [7].

II. LITERATURE REVIEW

Polypropylene (synthetic) fibres were first suggested as an admixture to concrete in 1965 for the construction of blast resistant buildings for the US Corps of Engineers [8]. During ancient period, different types of material used for making housing walls like straw, animal hairs etc because these were behaving just like brittle materials. Many other materials like jute, bamboo, coconut, rice husk and sawdust have also been used for reinforcing the concrete. Similarly, the steel fibre reinforcement not only improves the toughness of the material, the impact and the fatigue resistance of concrete, but it also increases the material resistance to cracking and, hence water and chloride ingress with significant improvement in durability of concrete structures. In the present scenario, many countries like USA, UK and developed countries are working these phenomenal materials. They made different Codes for making this type of special concrete.

III. MATERIAL PROPERTIES

Raw materials used include: Water, fine aggregates, coarse aggregates, cement, steel (mild) and synthetic fibre (polypropylene).

- ***Cement:*** There are three grades of Ordinary Portland cement (OPC) i.e. 33, 43 and 53 grade. These grades depend upon the strength of cement at 28 days. Tests required as per Indian Standards IS 4031-1988. Ultratech Company's OPC of 53 grade cement is used for experiment with each bag of cement is 50kg weight.

Table 1

Characteristics of cement

No.	**Characteristics**	**Investigated Value**	**Standard Value**
1.	Fineness	1.71	Not exceed 10
2.	Specific gravity	3.15	-
3.	Consistency (%)	29.99	-
4.	Initial setting time in minutes	88	Less than 30
5.	Final setting time in minutes	176	More than 600
Compressive Strength (N/mm^2)			
1.	3-days	30.68	Less than 27
2.	7-days	50.74	Less than 37
3.	28-days	58.89	Less than 53

- ***Fine aggregates**:*
  Specifications:
  1. Should pass IS sieve 4.75mm.
  2. Fineness modulus 2.50-3.50.
  3. Silt contents less than 4%.
  4. Should follow IS 383-1970.
  In our region, fine aggregates can be found from bed of Mahanadi river (situated in Raipur,Chattishgarh-India).
- ***Coarse aggregate:***
  Specifications:
  1. Should pass IS sieve 4.75mm.
  2. Fineness modulus 6.50-8.0.
  3. Flakiness avoidable.
  4. Should follow IS 2838-1964.
- ***Water:*** water should be free from acids, oils, alkalis, vegetables or other organic impurities. Soft water also produces weaker concrete. Water has two functions in concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.
- ***Synthetic Fibre (Polypropylene):*** **(Table 2)**

Table 2

characteristics of Polypropylene Fibres

Characteristics	**Description**
Fibre length	60mm and 120mm
Type/Shape	Large
S. Gravity	0.91
Aspect Ratio	60, 120
Acid and salt resistance	High
Melting Point	1640 ^{0}C
Ignition Point	>5500 ^{0}C

- ***Steel Fibre:*** **(Table 3)**

Table 3

characteristics of Steel Fibres

Characteristics	**Description**
Fibre length	25-35mm
Acid and salt resistance	Low
Diameter	0.05mm
Aspect ratio	50, 60

- *Admixture:* A material which works as accelerator or retarder during the mixing with mortar or concrete mix. These concrete mixes contain cement, sand and aggregates. CICO admixture is used for this purpose in our experiment.
- *Super Plasticizers:* These are higher version of admixtures. The reactivity and time duration of super plasticizers are fast as compared to other materials. We can use super plasticizers up to 15% for reducing the water content up to 30% by no change in workability.

IV. EXPERIMENTAL METHODOLOGY

1. *Compressive Strength Test:* For compressive strength test, cube samples of dimensions 150 x

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150x 150mm, casted for Design mix concrete of grade M40. During this mix preparation the super plasticiser added by 0.6% to 0.8% with weight of cement. The moulds were filled with 1%, 2% and 3% by fibres (i.e. steel fibre and polypropylene fibre). This test is performed with reference to IS516-1959. The load was applied at a rate of approx. 140 Kg/mm^2/min. Until the resistance of the specimen to the increasing load, by using Compression Testing Machine. The failure load was noted.

Compressive strength = $\frac{\text{Failure Load}}{\text{Cross−sectional Area}}$

2. *Flexural Strength Test:* For flexural strength test, beam samples of dimension 100 x 100 x 500mm were cast by mixing of 1%, 2% and 3% of steel fibres and polypropylene fibres. These samples were placed in water for 28 days after de-moulding. The samples were placed in the machine parallel to the machine requirement and load applied at the upper surface of beams. The axis of the samples was aligned with to the axis of the loading machine. The load was applied without shock and increasing continuously at a rate of 180Kg/min. Until the specimen failed.

Flexural strength = $\frac{PL}{B \times D \times D}$

Where P= Failure Load,
L= centre to centre distance between the support = 400mm,
B= width of specimen,
D= depth of specimen.

3. *Split Tensile Strength Test:* For split tensile strength test, the samples of 300mm and diameter 150mm with cylindrical shape were casted. These samples were dipped in water for 24 hours and cured in water for 28 days. These were tested under Compression Testing Machine. In each category three cylinders were tested and their average value is reported.

Split Tensile Strength = $\frac{2P}{\pi DL}$

Where P= Failure Load
D= Diameter of cylinder
L= Length of cylinder

V. RESULTS

Table 4

Compressive Strength After 28 Days for conventional concrete Grade M40

Sample	C.S.(MPa)	Avg. C. S. (MPa)
Sample M.1	45.1	
Sample M.2	43.4	
Sample M.3	48.8	**45.54**
Sample M.4	44.4	
Sample M.5	46	

Table 5

Compressive Strength After addition of steel fibres with 1%, 2% and 3% in M40 Grade

Aspect Ratio		1%	Avg.(MPa)	2%	Avg.(MPa)	3%	Avg.(MPa)
50	Sample CS1.1	51.2	52.74	53.1	54.34	55.6	55.66
	Sample CS1.2	53.2		54.8		55.0	
	Sample CS1.3	54.1		54.0		54.0	
	Sample CS1.4	54.4		55.0		57.5	
	Sample CS1.5	50.8		54.8		56.2	
60	Sample CS2.1	53.3	53.4	54.8	56.94	56.0	58.12
	Sample CS2.2	52.1		54.5		55.8	
	Sample CS2.3	54.4		58.0		58.0	
	Sample CS2.4	55.1		58.0		60.2	
	Sample CS2.5	52.1		59.4		60.6	

Table 6

Compressive Strength After addition of polypropylene fibres with 1%, 2% and 3% in M40 Grade

Aspect Ratio		1%	Avg.(MPa)	2%	Avg.(MPa)	3%	Avg.(MPa)
50	Sample CP1.1	48.1	46.8	40.0	48.04	44.0	49.78
	Sample CP1.2	45.5		44.2		45.2	
	Sample CP1.3	48.9		50.1		53.6	
	Sample CP1.4	43.5		55.8		52.2	
	Sample CP1.5	48.0		50.1		53.9	
60	Sample CP2.1	48.8	47.02	49.4	49.2	42.1	50.2
	Sample CP2.2	44.4		50.8		45.4	
	Sample CP2.3	49.5		43.5		55.01	
	Sample CP2.4	44		57.8		55.4	
	Sample CP2.5	48.4		44.5		53.	

Table 7		
Flexural Strength After 28 Days for conventional concrete Grade M40		
Sample	**F.S.(MPa)**	**Avg. F. S.(MPa)**
Sample MF.1	3.5	**3.66**
Sample MF.2	5.2	
Sample MF.3	4.2	
Sample MF.4	2.1	
Sample MF.5	3.3	

Table 8							
Flexural Strength After addition of steel fibres with 1%, 2% and 3% in M40 Grade							
Aspect Ratio		**1%**	**Avg.(MPa)**	**2%**	**Avg.(MPa)**	**3%**	**Avg.(MPa)**
50	Sample FS1.1	5.01	3.88	2.1	4.04	2.3	4.3
	Sample FS1.2	3.4		3.4		2.3	
	Sample FS1.3	3.7		5.1		6.7	
	Sample FS1.4	3.4		5.1		5.1	
	Sample FS1.5	3.9		4.5		5.1	
60	Sample FS2.1	3.2	4.08	3.4	4.13	4.25	5.34
	Sample FS2.2	5.4		3.95		4.58	
	Sample FS2.3	3.4		3.4		5.6	
	Sample FS2.4	3.01		3.5		8.9	
	Sample FS2.5	5.4		6.4		3.4	

Table 9							
Flexural Strength After addition of polypropylene fibres with 1%, 2% and 3% in M40 Grade							
Aspect Ratio		**1%**	**Avg.(MPa)**	**2%**	**Avg.(MPa)**	**3%**	**Avg.(MPa)**
50	Sample FP1.1	5.1	3.72	4.1	3.82	4.5	3.91
	Sample FP1.2	2.1		3.3		4.05	
	Sample FP1.3	1.1		3.9		2.7	
	Sample FP1.4	4.1		3.7		4.03	
	Sample FP1.5	6.2		4.1		4.3	
60	Sample FP2.1	4.0	3.74	4.5	3.82	2.7	3.94
	Sample FP2.2	4.2		3.02		3.7	
	Sample FP2.3	3.4		3.4		3.7	
	Sample FP2.4	4.01		3.4		4.8	
	Sample FP2.5	3.1		4.8		4.8	

Table 10		
Split Tensile Strength After 28 Days for conventional concrete Grade M40		
Sample	**S.T.S.(MPa)**	**Avg.S.T.S. (Mpa)**
Sample MT.1	2.9	**3.56**
Sample MT.2	3.1	
Sample MT.3	3.4	
Sample MT.4	4.2	
Sample MT.5	4.2	

Table 11							
Split Tensile Strength After addition of steel fibres with 1%, 2% and 3% in M40 Grade							
Aspect Ratio		**1%**	**Avg.(MPa)**	**2%**	**Avg.(MPa)**	**3%**	**Avg.(MPa)**
50	Sample TS1.1	3.2	3.72	4.1	4.36	5.2	5.16
	Sample TS1.2	4.12		4.1		4.2	
	Sample TS1.3	4.1		4.3		5.4	
	Sample TS1.4	3.4		4.2		5.4	
	Sample TS1.5	3.8		5.1		5.6	
60	Sample TS2.1	3.4	3.86	6.0	4.76	4.5	5.28
	Sample TS2.2	4.1		3.5		5.6	
	Sample TS2.3	3.4		3.5		5.8	
	Sample TS2.4	4.2		5.2		5.9	
	Sample TS2.5	4.2		5.6		4.6	

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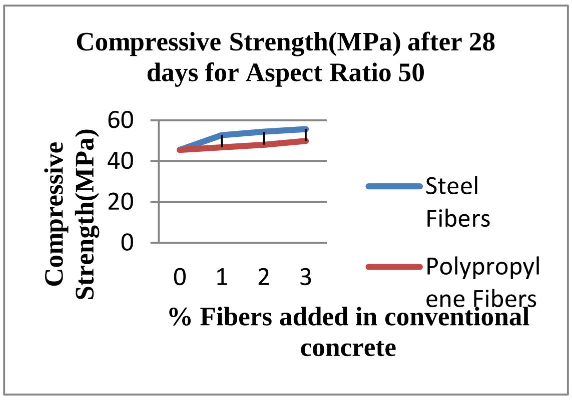
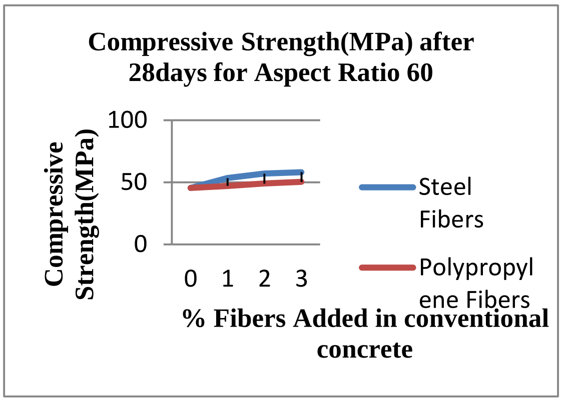
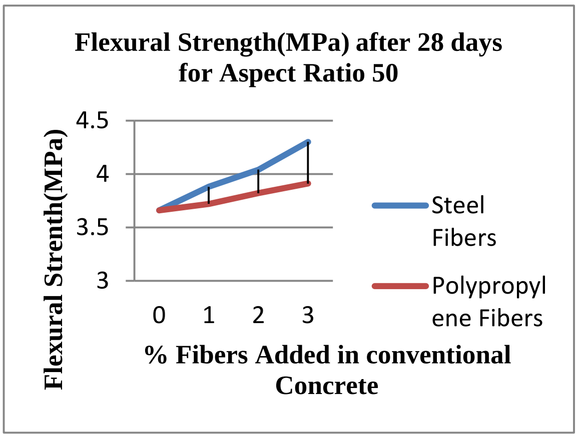
Table 12

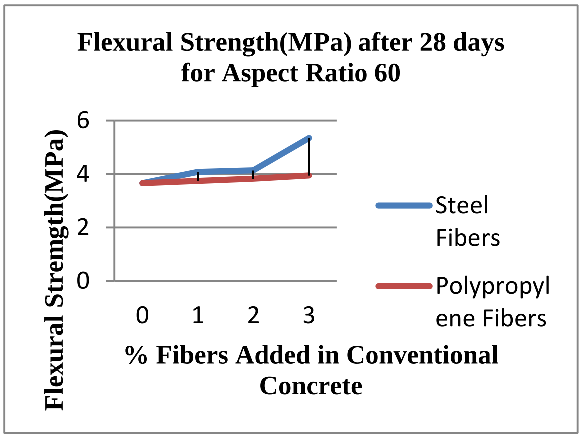
Split Tensile Strength After addition of polypropylene fibres with 1%, 2% and 3% in M40 Grade

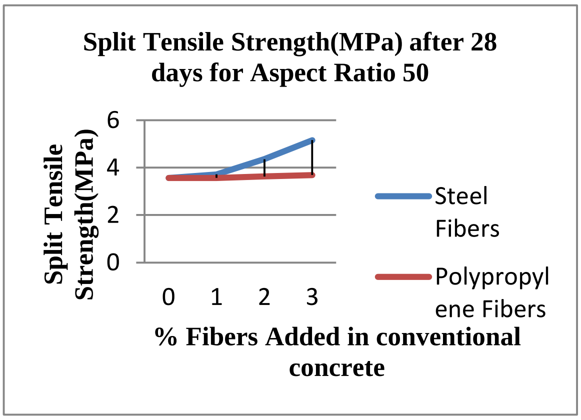
Aspect Ratio		1%	Avg.(MPa)	2%	Avg.(MPa)	3%	Avg.(MPa)
50	Sample TP1.1	2.12	3.568	3.56	3.63	2.11	3.688
	Sample TP1.2	3.22		3.6		3.2	
	Sample TP1.3	3.5		4.1		4.2	
	Sample TP1.4	4.2		3.8		4.1	
	Sample TP1.5	4.8		3.1		4.8	
60	Sample TP2.1	2.1	3.58	3.4	3.7	4.2	6.18
	Sample TP2.2	2.4		3.2		4.1	
	Sample TP2.3	3.4		3.2		3.4	
	Sample TP2.4	4.2		3.8		3.1	
	Sample TP2.5	5.8		4.9		4.1	

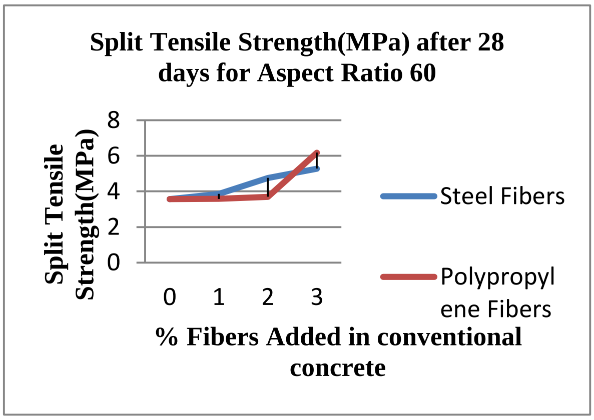












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VI. RESULTS

The following results came after analysis:

1. The compressive strength, flexural strength and split tensile strength of 3% fibres are more as compared to conventional concrete and 1% and 2% fibres.
2. Strengths i.e. compressive, flexural and split tensile have greater values for Aspect ratio 60 as compared to 50 for steel fibre mix.
3. Compressive strength by using steel fibres increases 15% to 28% where as by using polypropylene fibres increases 2% to 10%.
4. Flexural strength increases by 6% to 46% after mixing of steel fibres where as almost 1% to 8% on addition of polypropylene fibres.
5. Split tensile strength increases by 4% to 48% after mixing of steel fibres where as 0.2% to 6%on addition of polypropylene fibres.

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