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MECHANICAL PROPERTIES OF STEEL FIBRE REINFORCED CONCRETE IN HIGH STRENGTH CONCRETE

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Abstract: *The paper present the basic information on mechanical properties of steel fibre reinforced in high strength concrete. critical investigation on for M40 grade concrete having proportions 1:2.42:3.43 with water cement ratio 0.40.To study the compressive strength, split tensile strength, flexural strength and durability of steel fibre reinforced concrete(SFRC) containing the fibre of (0%, 1%, 2%, 3%) volume fraction hook-end steel fibre of aspect ratio 50 were used. A Data resulted analyzed and compare with a control specimen(0% fibre).Result data Clearly shows the percentages increase in 28 days of compressive strength, split tensile strength, flexural strength, durability, and impact strength for M40 grade of concrete.*

Keywords- *steel fibre, compressive strength, split tensile strength, flexural strength, durability, impact strength.*

I. INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry.

The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementations material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. However concrete has some deficiencies as listed below:

1) Low tensile strength
2) Low post cracking capacity
3) Brittleness and low ductility
4) Limited fatigue life
5) Incapable of accommodating large deformations
6) Low impact strength

A major advantage of using fiber reinforced concrete besides reducing permeability and increasing fatigue strength is that Fiber addition improves the toughness or residual load carrying ability after the first crack. Additionally, a number of studies have shown that the impact resistance of concrete can also improve dramatically with the addition of fibers.

The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mixture. Different types of fibers, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibres help to transfer loads at the internal micro cracks. Such a concrete is called fibre-reinforced concrete (FRC).

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. EXPERIMENTAL PROGRAMME

1.1 Material Used

The material used for this experimental work are cement, sand, aggregate, water, steel fibre, and super-plasticizer.
Cement: Ordinary Portland cement 53grade was used in the experimental work confirming IS12269-1987.

Sand: Locally available sand zone III with specific gravity 2.60, water absorption 2% and fineness modulus 4.0, conforming to I.S. – 3831970.

Coarse aggregate: Crushed granite stones of 20mm and 10 mm size having specific gravity of 2.86 &2.91 respectively, fineness modulus of 4.09 & 5.18 respectively, conforming to IS 383-1970
Water: Potable water was used for the experimentation.

Super plasticizer: To impart additional workability a super plasticizer (brocrete SCC) 0.6 % to 0.8% by weight of cement was used. It is based on sulphonated naphthalene polymers with following properties as per I.S. – 9103-1999.

1.2 Experimental Methodology

Compressive strength test: (IS 516-1959)

Cube compressive strength at age 7 days and 28 days. Cube specimens sizes of 150mm X 150mm X 150mm were casting for compressive strength as per Indian standard specification BIS: 516-1959.

After casting, all test specimens were finished with steel trowel. Immediately after finishing. The specimens were covered with sheets to minimize the moisture loss from them. Specimens were demoulded after 24 hours and then cured in water at approximately room temperature till testing. Compressive strength tests for cubes were carried out at 7 and 28 days. All the specimens were tested in automated CTM shown in figure. The compression strength was calculated according to the formula:

$$\sigma = \frac{P}{A}$$

Where, σ = Compressive strength (N/mm^2)
P = Maximum load (N)
A = Cross Sectional area of cube (mm^2)

Fig 1 compression testing equipment

Split Tensile Strength test: (IS 5816-1999)

The splitting tensile strength is well known indirect test used for determining the tensile strength of concrete. Tensile strength is one of the most important fundamental properties of concrete. An accurate prediction of tensile strength of concrete will help in mitigating cracking problems, improve shear strength prediction. The splitting tensile strength was determined at the age of 7days and 28 days on cube 150 mm X 150 mm as per Indian standard specification IS: 5816-1999.

The test consists of applying compressive line loads along the opposite generators of concrete cylinder placed with its horizontal between the plates. Due to applied line loading a fairly uniform tensile stress is introduced over nearly two third of the loaded diameter as obtained from an elastic analysis.

$$\sigma = \frac{2P}{\Pi LD}$$

Where, σ = split tensile strength strength (N/mm^2)
P = Maximum load (N)
D = diameter (mm)
L= length (mm)

Fig 2 split tensile strength specimens

Flexural strength test:

For flexural strength test beam specimens of dimension 150x150x700 mm were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These flexural strength specimens were tested under two point loading as per I.S. 516-1959, over an effective span of 500 mm on Flexural testing machine. Load and corresponding deflections were noted up to failure. In each category three beams were tested and their average value is reported. The flexural strength was calculated as follows.

Flexural strength (MPa) = (P x L) / (b x d2),

Where, P = Failure load,

L = Centre to centre distance between the support = 500 mm,

b = width of specimen=150 mm,

d = depth of specimen= 150 mm.

Fig 3 flexure strength testing specimens

DURABILITY TEST

Acid attack test:

The concrete cube specimens of various concrete mixers (0%, 1%, 2%, 3%) of sizes 150mm x 150mm were cast and after 28 days of curing of water, the specimens of removed from curing tank. And allowed to dry for one day. The weights of cube specimens were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water 28 days after 28 days of curing.
H_2 SO_4Acid with pH about 2 at 5% wt of water added to water in which concrete cubes taken out of acid water. Then specimens were tested for compressive strength.

Fig 4 durability (Acid attack testing) specimens

Impact test (cube):

The impact resistance of the specimens was determined in accordance with the Procedure recommended by ACI committee 544. For this purpose, from each mixture, three cubes (100 mm) were tested under the impact loads. The 13.5 kg hammer was used for applying the impact load which was dropped continuously from a height of 413 mm onto a specimen that was located at the base plate of the impact testing machine is shown in Figure.

In each test, the number of blows required to produce to cause complete failure of the specimen was recorded as the impact failure strength. The impact energy delivered by the hammer per blow was calculated as follows:

Impact energy = $(\frac{m.v^2}{2}).n = mgH.n$

$$H = \frac{gt^2}{2}$$

$$V = g.t$$

$$W = m.g$$

Where V is the velocity of the hammer at impact, g is acceleration due to gravity, and t is the time required for the hammer to fall from a height of 457 mm. H is the height of the fall, m is mass of the hammer, n is the number of blows and W is the weight of the hammer.

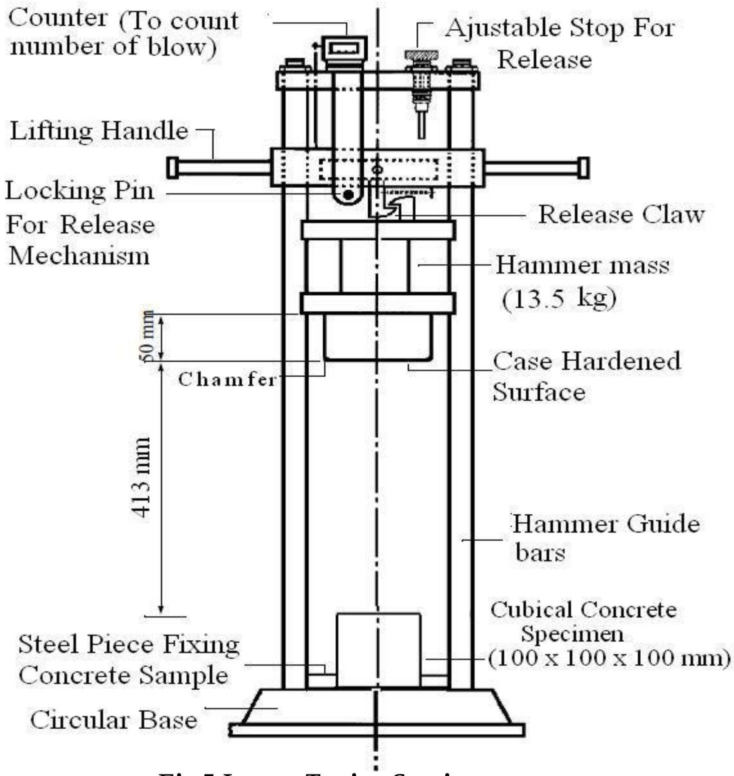

Fig 5 Impact Testing Specimens

1.3 Experimental Result

Following graphs give compressive strength, flexural strength and Split Tensile strength result for M-40 grade of concrete with 0%, 1%, 2% and 3% steel fibres for aspect ratio 50.

Table 1– Compressive Strength of SFRC with 0% fibres M40 grade

Compressive strength (N/mm^2)	**Average compressive strength (N/mm^2)**
47.90	47.70
48.27	
46.93	

Table 2 – Compressive Strength of SFRC with 1%, 2% AND 3% fibres M40 grade

Aspect Ratio	For SFRC with 1% of steel fibre		For SFRC with 2% of steel fibre		For SFRC with 3% of steel fibre	
50	**Compressive strength (N/mm^2)**					
		Average		Average		Average
	51.90	51.36	52.72	53.40	56.65	56.35
	51.26		53.40		55.50	
	50.92		54.10		56.90	

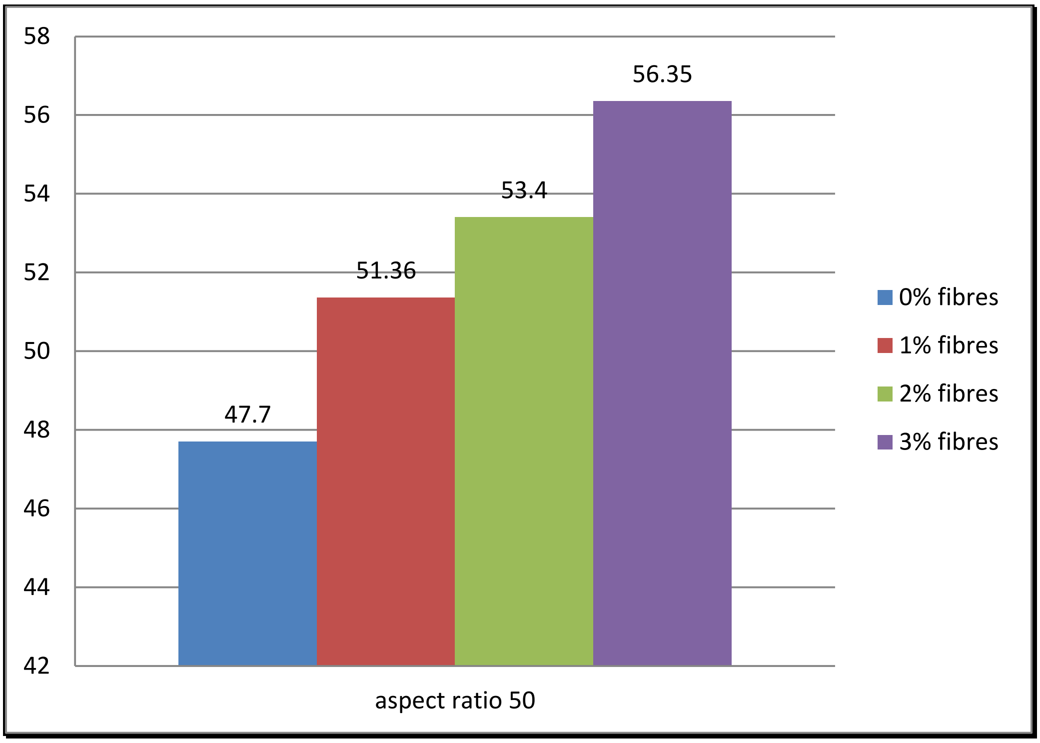

Fig 6 Aspect Ratio 50 VS Compressive Strength

Table 3– split tensile Strength of SFRC with 0% fibres M40 grade

split tensile Strength (N/mm^2)	**Average split tensile Strength (N/mm^2)**
3.16	2.991
2.915	
2.90	

Table 4 – split tensile Strength of SFRC with 1%, 2% AND 3% fibres M40 grade

Aspect Ratio	For SFRC with 1% of steel fibre		For SFRC with 2% of steel fibre		For SFRC with 3% of steel fibre	
50	**split tensile strength (N/mm^2)**					
		Average		Average		Average
	3.16	3.283	3..80	3.913	4.40	4.38
	3.29		3.82		4.39	
	3.40		4.12		4.35	

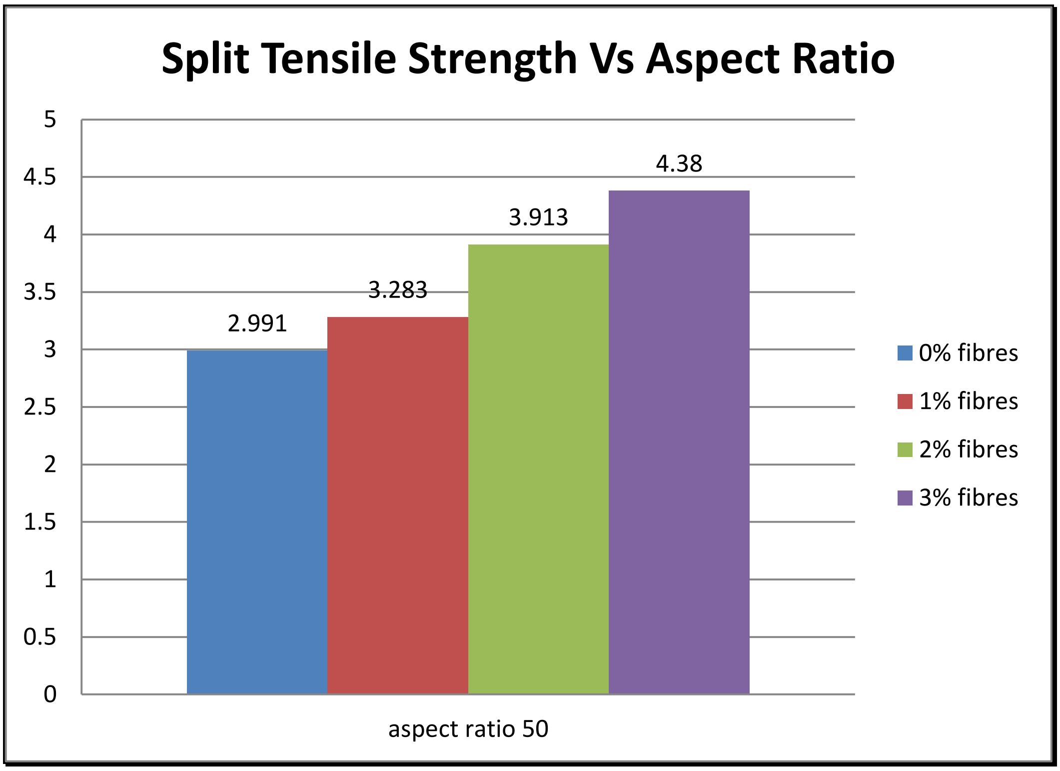

Fig 7 Aspect Ratio 50 VS Split Tensile Strength

Table 5– Flexure Strength of SFRC with 0% fibres M40 grade

Flexure Strength (N/mm^2)	**Average Flexure Strength (N/mm^2)**
7.6	
7.3	7.47
7.5	

Table 6 –Flexure Strength of SFRC with 1%, 2% AND 3% fibres M40 grade

Aspect Ratio	For SFRC with 1% of steel fibre		For SFRC with 2% of steel fibre		For SFRC with 3% of steel fibre	
	Flexure strength (N/mm^2)					
		Average		Average		Average
50	8.7		8.9		10.40	
	8.9	8.6	9.2	9.3	10.10	10.43
	8.2		9.8		10.9	

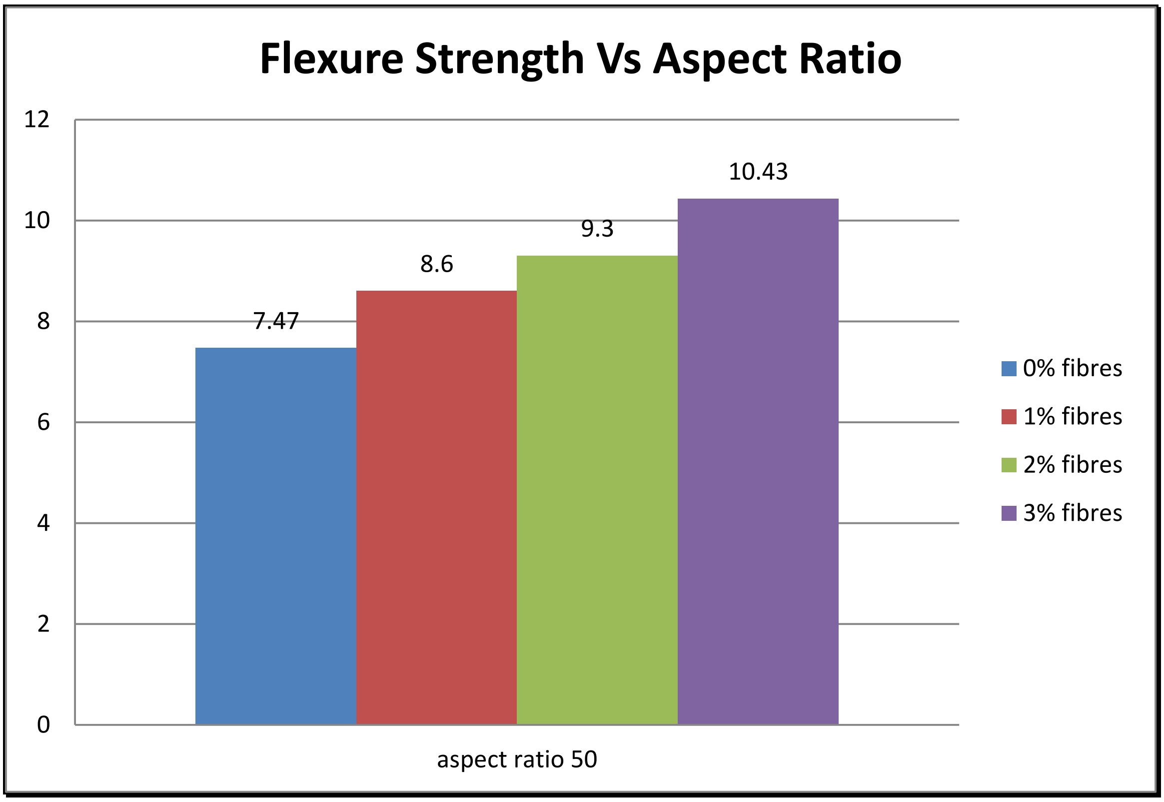

Fig 8 Aspect Ratio 50 VS Flexure Strength

Table 7 –Compressive Strength (Acid Attack test) of SFRC with 0%, 1%, 2% AND 3% fibres M40 grade

Sr.No	Description	Wt. after 28 days of water curing	Wt. after 28 days of acid attack	% loss of wt.	Compressive Strength after 28 days after Curing (N/mm^2)	Compressive Strength after 28days after acid attack (N/mm^2)	% loss of compressive strength
1	0% steel fibre concrete	8.57	6.52	23.92	47.70	34.30	28.10
2	1% steel fibre concrete	8.62	6.90	19.95	51.36	42.20	17.83
3	2% steel fibre concrete	8.66	7.21	16.74	53.40	45.85	14.14
4	3% steel fibre concrete	8.71	7.40	15.04	56.35	49.67	11.85

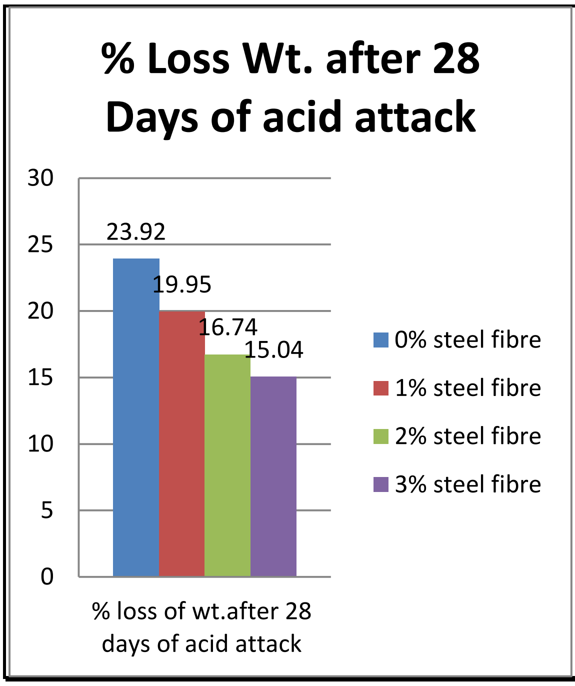

Fig 9 Percentages Loss of weight after 28 Days of Acid Attack

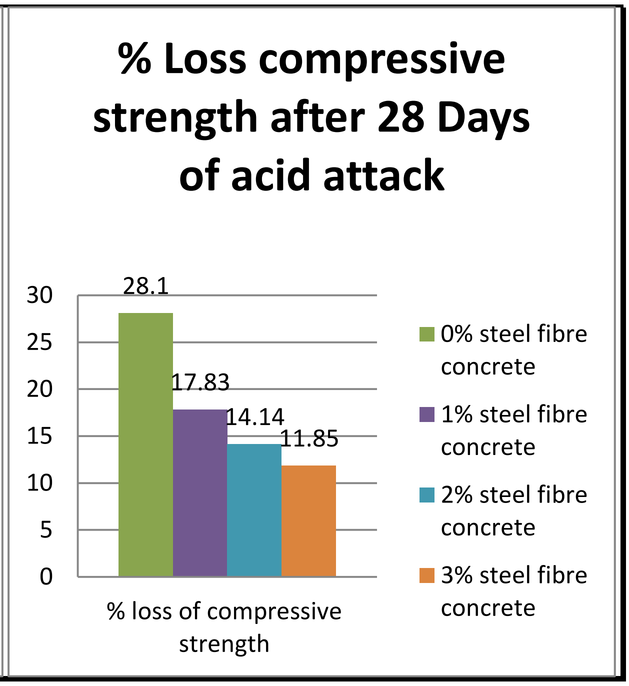

Fig 10 Percentages Loss of compressive strength after 28 Days of Acid Attack

Table 8 –Impact Strength of SFRC with 0%, 1%, 2% AND 3% fibres M40 grade

Sr. No	*Mix Name*	*Fiber volume in fraction (%)*	*Impact Resistance (No of Blows)*		*Impact Energy (N.m)*
			First Crack	*Ultimate Failure*	*(Static)*
1	M40-1	0%	4	5	192.03
2	M40-4	1%	5	7	268.84
3	M40-8	2%	6	9	345.65
4	M40-10	3%	6	10	384.06

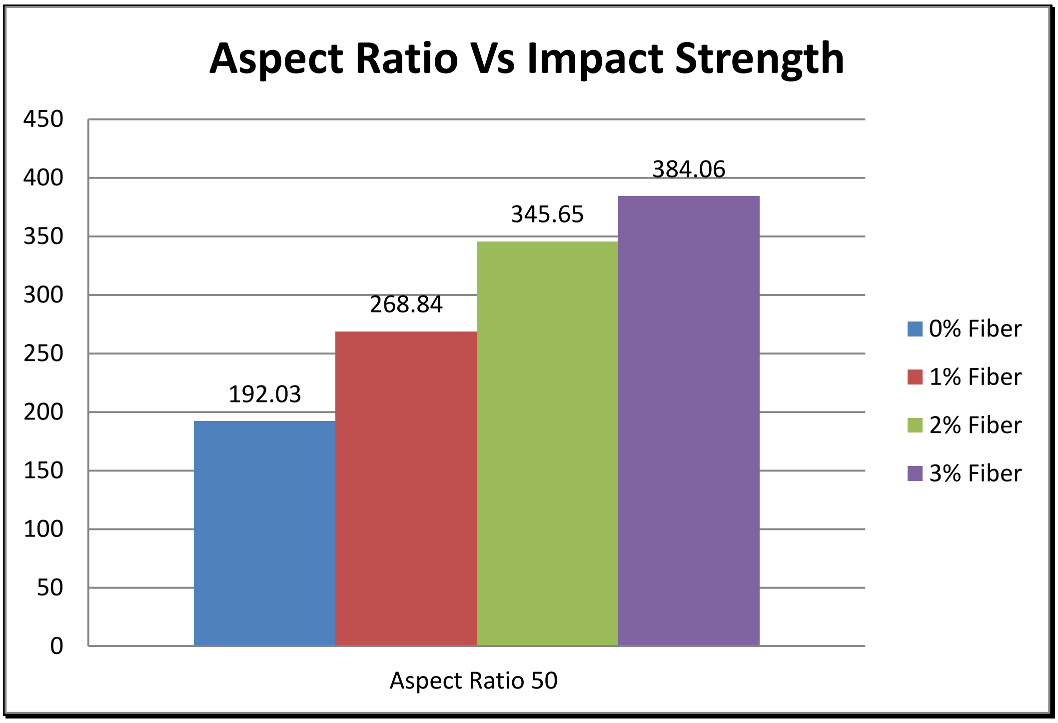

Fig 11 Aspect Ratio 50 VS Impact Strength

III. CONCLUSION

The following conclusions could be drawn from the present investigation.

1. It is observed that compressive strength, split tensile strength and flexural strength, durability test (based on acid attack) are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres.
2. All the strength properties are observed to be on higher side for aspect ratio of 50
3. It is observed that compressive strength increases from 10 to 20% with addition of steel fibres.
4. It is observed that flexural strength increases from 12 to 40% with addition of steel fibres.
5. It is observed that split tensile strength increases from 3 to 35% with addition of steel fibres.
6. The durability studied on specimens with acidic exposure condition. Due to acidic exposer, the deterioration in the control specimens were high than specimens.
7. It was found that increase in volume of steel fibers leads to increase in impact resistance.
8. The impact resistance also increased against the first visible crack and final fracture, which means that the energy absorption capacity in concrete with steel fibers increased.

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