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Influence of Steel Fiber on Mechanical Strength and Abrasion Resistance of Cement Concrete Pavement

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ABSTRACT

Fibers are generally used as resistance of cracking and strengthening of concrete. Steel fiber is one of the most commonly used fibers. Short, discrete steel fibers provide discontinuous three-dimensional reinforcement that picks up load and transfer stresses at micro-crack level. Plain, unreinforced concrete is a brittle material, with possesses a very low tensile strength, limited ductility and little resistance to cracking. In order to improve the strength of concrete various types of fiber reinforced concrete are being used against plain concrete due to their higher flexural strength, better tensile strength, modulus of rupture and crack resistance. The present study is to evaluate the performance of steel fiber reinforced concrete pavement with regard to compressive strength, split tensile, flexural strength, cantabro abrasion loss by varying the percentage of steel fibers from 0.5%, 1%,1.5%,2%,2.5%,3% by weight of concrete were found out . The type of steel fiber used is of hooked end with aspect ratio 60. The obtained result shows that increase in percentage of steel fiber up to 2% gives the optimum the strength for compressive strength,flexural strength and cantabro abrasion test. And for split tensile strength 1.5% addition of steel fiber gives the maximum strength of cement concrete pavement than the plain concrete.

Keywords: Steel Fiber, Aspect Ratio, Compressive Strength, Split Tensile Strength And Flexural Strength, Cantabro Abrasion Test.

INTRODUCTION

In almost every part of the world, pavements have shown premature distress because concrete has low tensile strength, brittleness, low ductility, low post cracking capacity and limited fatigue life, which requires frequent replacement of the existing surface. Time is lost due to frequent resurfacing and replacement. On the other hand resources are depleting day by day, it has become essential to implement the designs based on materials that cost the least for the complete transportation system life and at the same time have minimum impact to the environment over a sufficiently large analysis period. Though there are a few modern material solutions that may meet these criteria, like the use of steel fiber reinforced concrete (SFRC) for pavement constructions.

SFRC is concrete containing dispersed steel fiber. The fiber helps to transfer the load at the internal micro cracks. Steel fiber reinforced concrete is a new innovation and technique used in concrete. And it is proved that, it is the best suited construction material having ultimate performance properties when compared to conventional concrete. Incorporation of

Steel fibers use in concrete offer increased toughness, abrasion and impact resistance, and allow for increased slab size. [2]

The steel fiber reinforced concrete has found number of new applications due to its superiority over conventional concrete and RCC among the following properties; rich flexural strength, higher tensile strength, modulus of rupture, better ductility, fatigue and more. SFRC is extensively used in various construction works such as airport pavement, bridge decks, machine foundation, blast resistance structure, hip hulls and storage tanks etc.[1]

EXPERIMENTAL PROGRAM

Material Specification

Cement: The cement utilized in this experimental work is ACC 43 grades Ordinary Portland Cement. All properties of cement are tested by referring IS 8112-1989 Specification for 43 Grade Ordinary Portland cement.

Table 1 : physical properties of cement

Sl no	Characteristics	Test results	Recommended value(as per IS code)	IS codes
1	Normal consistency	34%	Not less than 30%	IS:4031-part 4 1998
2	Initial setting time	65 min	Not less than 30 min	IS:4031-part5-1998
3	Final setting time	300 min	Not more than 600 min	IS:4031-part5-1998
4	Specific gravity	3.11	3.0 - 3.15	IS:4031-part11-1998
5	Fineness of cement	3%	Not more than 10%	IS: 4031-part1-1996
6	Soundness test (Le-chartlier Exp.)	3 mm	Not more than 10mm	IS: 4031-part3-1998
7	Compressive strength of cement 3days 7days 28days	 25 Mpa 36 Mpa 46 Mpa	 Not less than 23Mpa Not less than 33 Mpa Not less than 43Mpa	IS: 4031-part-1998

Water: potable water used for this project work.

Fine aggregate: Locally available M sand passing through 4.75mm IS sieve was used, and this sand of zone confirming to IS 383-1970.

Table 2: Physical Properties of Fine Aggregate

SL.NO.	Characteristics	Test results	Standard values	IS codes
1	Specific gravity	2.77	2.5-2.9	IS 383-1970
2	Fineness module	3.079	2-4	IS 383-1970
3	Bulk density Kg/m^3	1555	1520-1680	IS 383-1963

Coarse aggregate: Hard, strong, dense, durable and clean Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20mm and retained on 4.75mm IS sieve confirming to IS 383-1970 was used.

Table 3: Physical Properties of Coarse Aggregate

SL.NO.	Characteristics	Test results	Standard value	IS codes
1	Specific gravity	2.7	2.5-3	IS 383-1963
2	Aggregate impact test	24%	30%	IS:2386 part 4-1963

3	Aggregate crushing test	26 %	30%	IS:2386 part 4-1963
4	Los angeles abrasion test	30.5 %	35%	IS:2386 part 4-1963
5	Shape test a)Elongation index b) Flakiness index	 40% 26%	 45% 30%	IS:2386 part 1-1963

Steel fiber: Steel fibre is obtained from the jeetmull jaichandlall madras pvt.Ltd. In this work hooked end steel fiber of aspect ratio 60 and fibers up to 3% are used by total volume of concrete.

Table 4: Chemical and mechanical properties of steel fiber

Chemical composition	**%**		**Mechanical properties**	
Carbon(C)	.08		Diameter	0.50mm
Mn	.340		Length	30mm
Si	.079		Tensile strength	1212Mpa
P	.013		Tolerance for diameter and length	(+/-) 10%
S	.012			

METHODOLOGY

In this work, target concrete mix of grade M20 was considered .The designed mix proportions are obtained by using IS 10262:2009 method of mix design for normal strength concrete. The mix proportion of concrete is 1:1.67:2.63 with water cement ratio of 0 .45.whereas the steel fiber usage varies from 0% to 3% with an interval of 0.5% taken by the weight of concrete and steel fiber mixed in three layers. Compressive strength, split tensile strength, flexural strength, test were carried out under CTM and UTM to check the mechanical properties(As per IS 516 -1959) and also durability test cantabro loss test were also conducted.

Table 5: Quantities of materials per cubic meter of M20

Sl no.	Materials	Quantity (Kg/m^3)
1	Cement	413.33
2	Fine aggregate	690
3	Coarse aggregate	1189.9
4	Water	186

RESULT AND DISCUSSION

In this section, all the test result conducted during the experimental work and their corresponding graphs were plotted.

Table 6: 7 and 28 day test results

% of steel fiber	Compressive strength(MPa)		Split tensile strength(MPa)		Flexural strength strength(MPa)		Cantabro loss in (%)	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
0%	25.55	28.6	1.93	2.72	6.07	8.1	9.76	8.84
0.5%	26.37	33.48	1.95	3.33	6.33	8.37	8.71	7.59
1%	27.2	34.37	2.14	3.54	7.46	8.41	7.23	5.58
1.5%	27.78	35.63	2.28	3.7	8.22	8.82	6.55	5.26
2%	27.93	36.67	2.00	3.11	8.53	9	5.71	5.10

2.5%	24.9	30	1.41	2.64	7.43	8.21	7.95	5.7
3%	24.3	27.11	1.39	2.62	7.3	8.12	9.64	7.51

Compressive strength test:

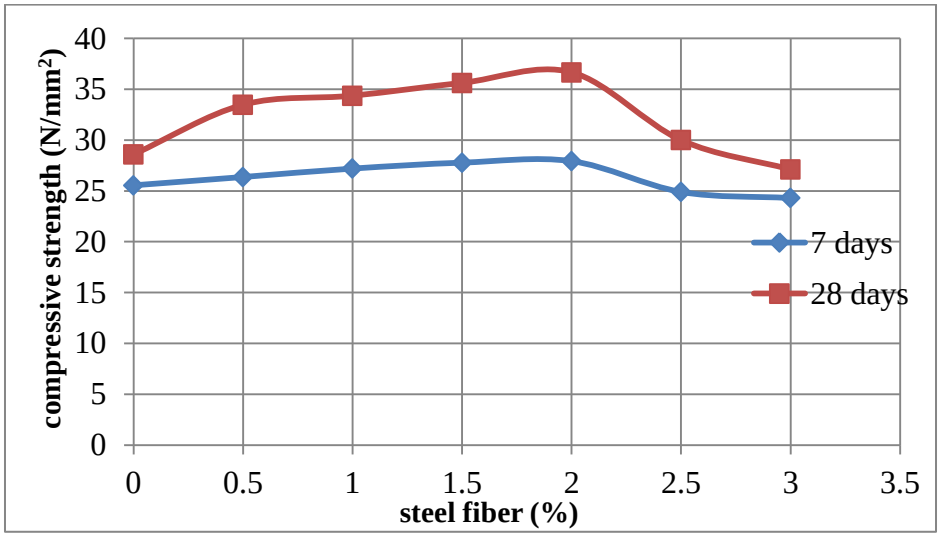

Figure 1: 7 and 28 days compressive strength

From the graph it is fond that compressive strength increases with increase in percentage of steel fibers, i.e. up to 2%, further increasing steel fiber the compressive strength reduce up the 23N/mm^2 range of starts decreasing. The percentage of compressive strength increase by 22% increases for 2percentage of steel fiber.

Split tensile strength:

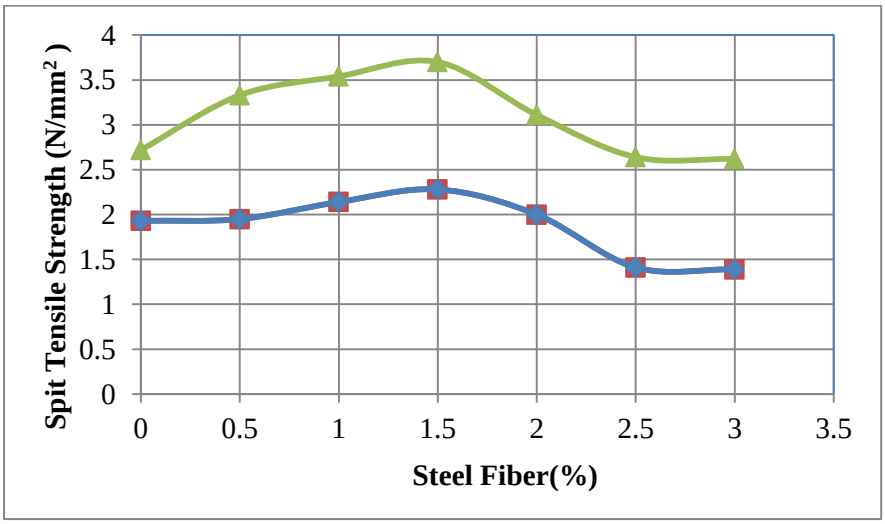

Figure 2:7 and 28 days split tensile strength

From the figure it is found that for the split tensile strength for 7 and 28 days for different percentage of steel fiber, the tensile strength increases up to 1.5% of steel fiber there after it starts decreasing. Split tensile strength is more for 1.5% of steel fiber and it is 26.4% more strength than the control mix.

Flexural strength test:

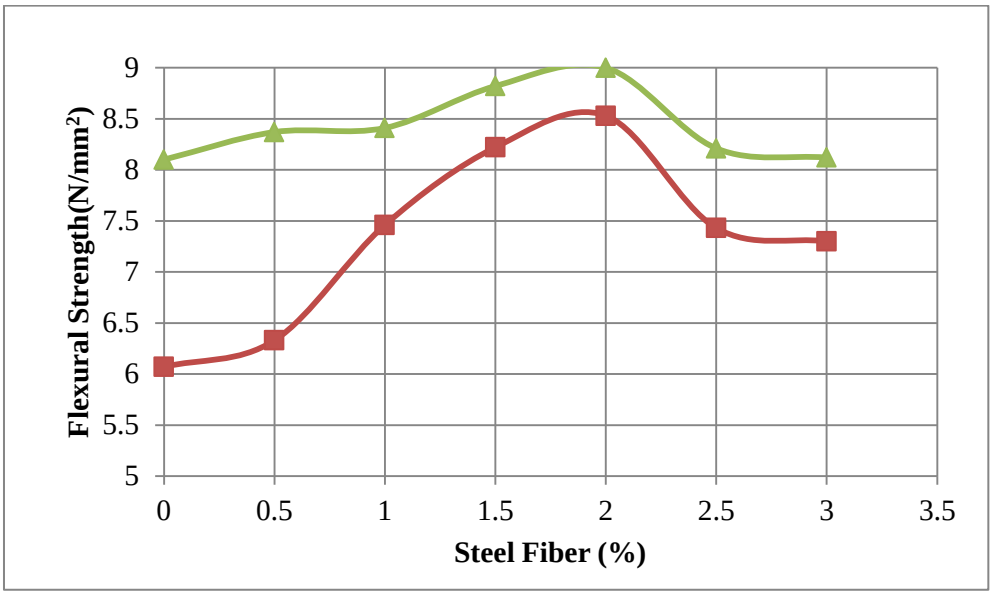

Figure3: percentage increase in 7 and 28 days flexural strength

The above figure shows the flexural strength of prism for both 7 and 28 days, the flexural strenth incresses with increses in the % of steel fiber than the control mix up to 2% of steel fiber. After the concrete loses the bonding with steel fiber shows the less flexural strength

Cantabro abrasion test:

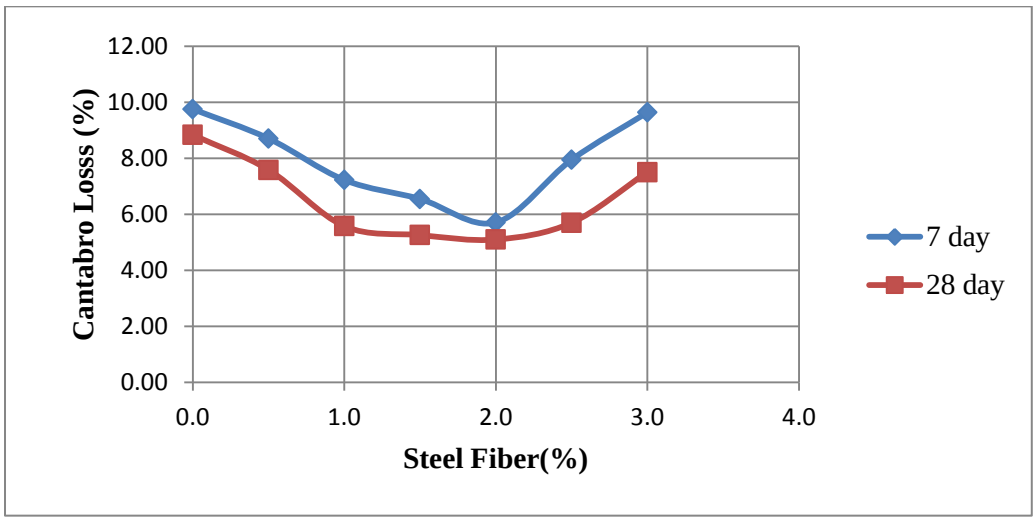

Figure6: Cantabro loss for different % of steel fiber

The figure shows the cantabro loss graph for concrete containing different percentage of steel fibers; from the graph we can observe that the loss is more in the case of concrete without steel fiber. As the percentage of steel fiber increases, the loss of material decreases up to 2% addition of steel fiber after words the concrete loses the bonding with steel fiber losses will be more for 2.5 and 3% of steel fiber.

CONCLUSION

The following conclusion can be drawn from the present study

1. The compressive strength increases with increase in percentage of steel fiber. For the control mix the compressive is 28.6 N/mm^2 and the maximum value obtained for 2% addition of steel fiber that is 36.67N/mm^2. Compressive strength increases 22% than the control mix concrete.
2. Flexural strength increases from 8.1 N/mm^2 to 9 N/mm^2. It shows the optimum results at 2% addition of steel fiber

3. Split tensile strength is more for 1.5% of steel fiber and it is 26.4% more strength than the control mix.
4. Durability of concrete is known from the cantabro loss test, cantabro loss is decreases with increase in percentage up to 2% of steel fibers. Concrete with 2% of steel fiber gives the better durability.
5. From the above conclusion, use of steel fiber in the concrete can still be promising work, we can overcome the brittleness problem of concrete.

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