Increasing Mechanical Properties of Concrete by Using Steel Fibers

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***Abstract*— Concrete is the one of the world's most widely used construction material. When the concrete is weak in tension and brittle in nature which results in sudden tensile failure without warning .These failures can be reduced by using the steel fibers in concrete. These fibers are thin, short and distributed randomly throughout the concrete member of different aspect ratios (L/d ratio).In this experiment an attempt is made in order to increase the strength and properties by adding steel fibers of different proportions 0%, 0.5%, 1.5%, 2.5% and 3.5%.In order to identify the mechanical properties of concrete various tests have been conducted like compressive strength, split tensile strength & flexural strength for M30 grade of concrete.**

***Keywords*—brittle, steel fibers, split tensile strength & flexural strength**

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1. INTRODUCTION

Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from a long years back. These three materials only play a crucial role in designing of a particular grade of concrete. But now a day there is a scarcity in aggregates. So, some new materials which are very near to our surroundings and some type of materials have to be introduce for adding to the fine aggregates, coarse aggregates and as well as cement to get the more strength in tensile as that these basic materials can give. Portland cement concrete is made with coarse aggregate, fine aggregate, Portland cement, water and in some cases selected admixtures (mineral & chemical). In the last decade, construction industry has been conducting research on enhancing the properties of concrete; each additive product has its own specific effect on properties of fresh and hard concrete. So, we have to search for different fibers to increase the strength of concrete mix with changing the mix design procedure and considerations. We are adding the crimped steel fiber to the concrete in percentage wise. There are some research were done on crimped steel fibers which are very near to use them in concrete mix along with basic natural aggregates. In those researches we observed that these materials can be used in some extent percentages.

For analyzing this drawback, first we add the 0.5% of crimped steel fiber to the concrete later that we add 1.5% of crimped steel fiber and then 2.5% and 3.5% of crimped steel fiber respectively to know the optimum percentage which is to be added to the concrete. When mixing the concrete, observed that there is a proper bonding of crimped steel fiber materials with cement and other aggregates in concrete mix. And when compressive strength test, split tensile strength test& flexural strength test conducted after 28 days curing period on these cube, cylinder & prism samples, observed that there is increment in compressive strength, split tensile strength& flexural strength when compared to the conventional mix. The compressive strength test results of the cube, split tensile strength cylinder & flexural strength of prism samples having crimped steel fiber material and the conventional mix are as follows.

2. MATERIAL AND THEIR PROPERTIES

2.1. Cement:

Cement is a fine material powder manufactured with very precise processes mixed with main raw materials such as lime stone, clay, aluminum oxide & water. This powder transforms into a paste that binds and hardens when submerged in water. Cement is made by grinding together a mixture of lime Stone and clay which is heated at a temperature of 1450 ºc.

2.2. Coarse aggregate:

Material which retained on 4.75 mm size classified as a coarse aggregate. For most works, 20 mm aggregate is suitable. The locally available aggregate having nominal size of 20mm was used.

2.3. Fine aggregates:

Fine aggregate is a material such as sand, crushed stones or crushed gravel passing through 4.75 mm size. Locally available sand is used as fine aggregate in the concrete mix.

2.4. Addition of material (Crimped steel fibers):

2.4.1. Crimped steel:

Fibers are low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase crack resistance of concrete. A crimped steel fiber complies with ASTM C1116, standard specification for fiber reinforced concrete and concrete and ASTM

A820, type 1, standard specifications for steel fibers for fiber reinforced concrete. These steel macro-fibers will also improve impact, shatter, and fatigue and abrasion resistance while increasing toughness of concrete.
Dosage rate will vary depending upon the reinforcement requirements and can range from 25 to 100 lbs/yd3 (15 to 60 kg/m3). Steel Fibers are obtained from a local industry. The most important parameter describing a fiber is its Aspect ratio. "Aspect ratio" is the length of fiber divided by an equivalent diameter of the fiber, where the equivalent diameter is the diameter of the circle with an area equal to the cross sectional area of fiber. The properties of fiber reinforced concrete are very much affected by the type of fiber. Different types of fibers which have been tried to reinforce concrete are steel, carbon, asbestos, vegetable matter, polypropylene and glass. In the present investigation crimped round steel fibers of around 25mm length with the aspect ratio of 50 are used. The properties of the CSF used in the present experimentation are given by the supplier and are presented here.

S.NO	PROPERTY	VALUES
1	Equivalent Diameter,	0.15 to 1.00 mm
2	Specific Gravity, kg/m3	7840
3	Tensile Strength, MPa	345 to 3000
4	Young’s Modulus, GPa	200
5	Ultimate Elongation, %	4 to 10
6	Thermal Conductivity,1%	2.74
7	Aspect Ratio	50 to 100

Table 2.4.1 Summarizes Physical Properties of Crimped Steel:

2.4.2. Chemical composition:

Crimped steel fibres are manufactured fibers composed of stainless steel. Composition may include:

i. Carbon (C),
ii. Silicon (Si),
iii. Manganese (Mn),
iv. Phosphorus (P),
v. Sculpture (S) and
vi. Other elements**.**

3. RESULTS AND DISCUSSION:

WORKABILITY TEST:

S.NO	MIX TYPE	SLUMP (MM)
1	A0 (0%)	100
2	A1 (0.5%)	90
3	A2 (1.5%)	70
4	A3 (2.5%)	55
5	A4 (3.5%)	43

Table 3.1: Slump values of different Concrete Mixes:

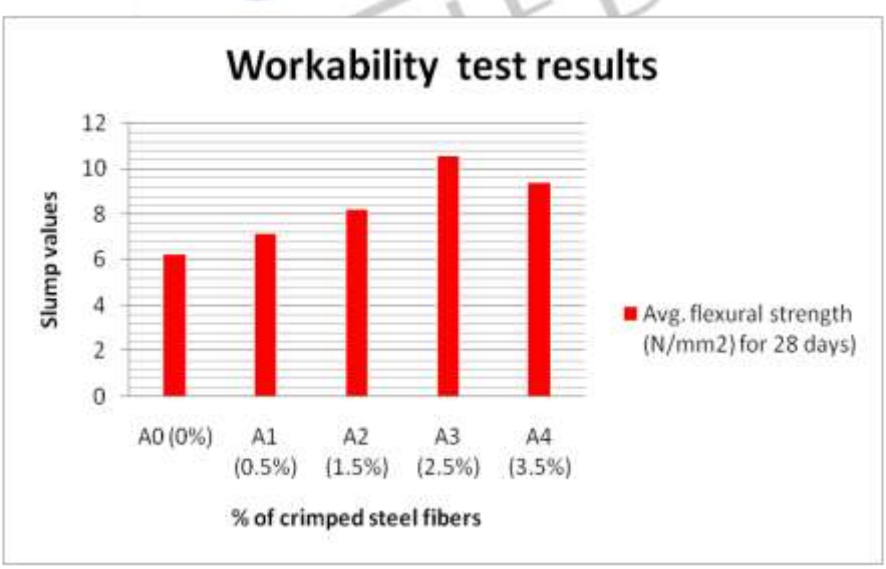


CHART 3.1 SLUMP VALUES FOR DIFFERENT MIXES

Compressive Strength Test (IS 516:1959)

Mix Type	Trail	Peak Load (KN)			Compressive Strength (N/mm2)			Avg Compressive Strength (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days	7 days	14 days	28 days
A0	1	570	641	855	25.33	28.48	38	25.56	29.11	38.34
	2	573.7	655.9	862	25.49	29.15	38.31			
	3	582	668	877.8	25.86	29.86	39.01			
A1	1	595	786	919	26.44	34.93	40.84	26.67	35.55	41.3
	2	600	795	926	26.66	35.33	41.16			
	3	607	818.6	942.8	26.97	36.38	41.90			
A2	1	615	850	982	27.34	37.78	43.64	28.01	38.65	44.5
	2	633.8	875	1006	28.16	38.88	44.71			
	3	642	884	1015.8	28.53	39.28	45.14			
A3	1	832	1040	1240	36.97	46.22	55.12	37.78	46.76	55.67
	2	853	1051	1254	37.91	46.72	55.73			
	3	865	1065	1264	38.44	47.34	56.17			
A4	1	790	943	1163	35.12	41.91	51.68	35.56	42.47	52.12
	2	801	955	1173	35.6	42.44	52.14			
	3	810	969	1182	36	43.06	52.53			

Table3.2: Compressive Strength Values of Different concrete mixes

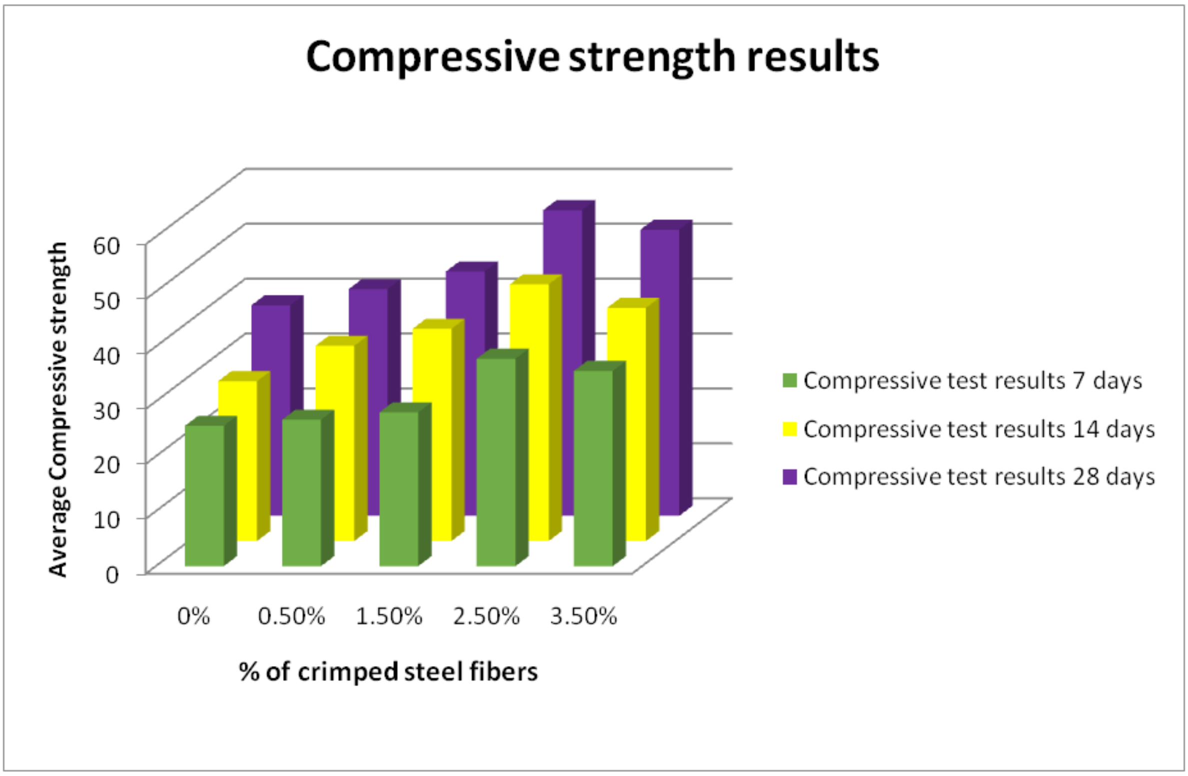


CHART 3.2 COMPRESSIVE STRENGTH VARIATIONS FOR DIFFERENT CONCRETE MIXES

SPLIT TENSILE STRENGTH TEST: (IS 5816-1999):

Mix Type	TRAIL	Peak Load (KN)			Split Tensile Strength (N/mm^2)			Avg Split tensile Strength (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days	7 days	14 days	28 days
A0	1	140	170	214	1.98	2.40	3.02	2.12	2.16	3.22
	2	149	185	229	2.10	2.61	3.23			
	3	160	199	240	2.26	2.81	3.39			
A1	1	172	210	250	2.43	2.97	3.53	2.54	3.12	3.85
	2	178	219	278	2.51	3.09	3.93			
	3	189	233	289	2.67	3.29	4.08			
A2	1	195	241	294	2.75	3.40	4.15	2.92	3.58	4.35
	2	208	255	308	2.94	3.60	4.35			

	3	216	263	320	3.05	3.72	4.52			
A3	1	244	328	385	3.45	4.64	5.44	3.65	4.81	5.62
	2	260	339	397	3.67	4.79	5.61			
	3	270	353	410	3.81	4.99	5.80			
A4	1	225	282	340	3.18	3.98	4.81	3.29	4.24	5.06
	2	230	300	358	3.25	4.24	5.06			
	3	243	318	375	3.43	4.49	5.30			

TABLE3.3 SPLIT TENSILE STRENGTH VALUES OF DIFFERENT CONCRETE MIXES

CHART 3.3 Compressive Strength Variations for Different Concrete Mixes

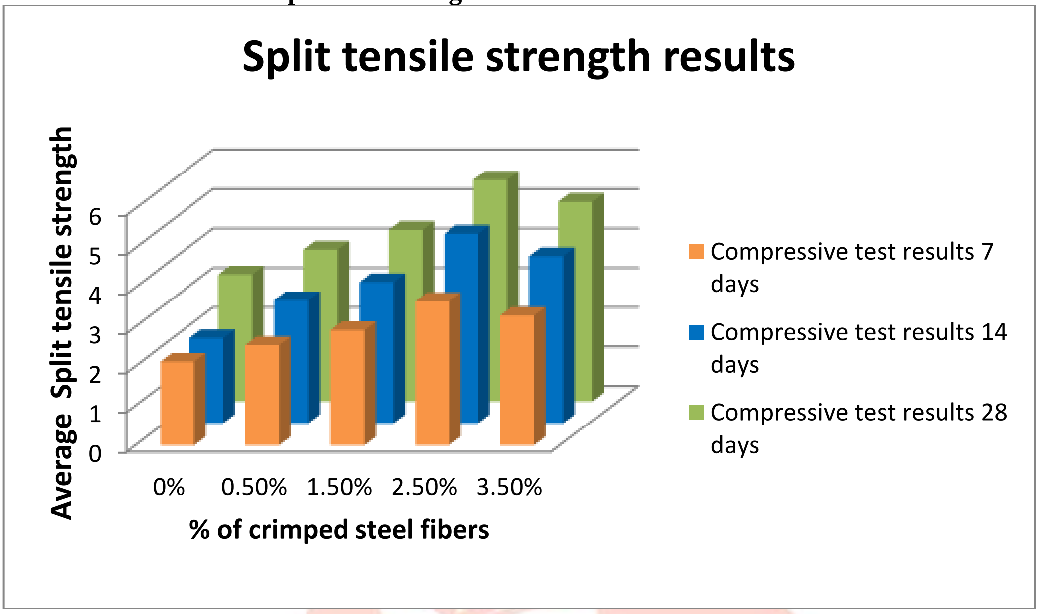
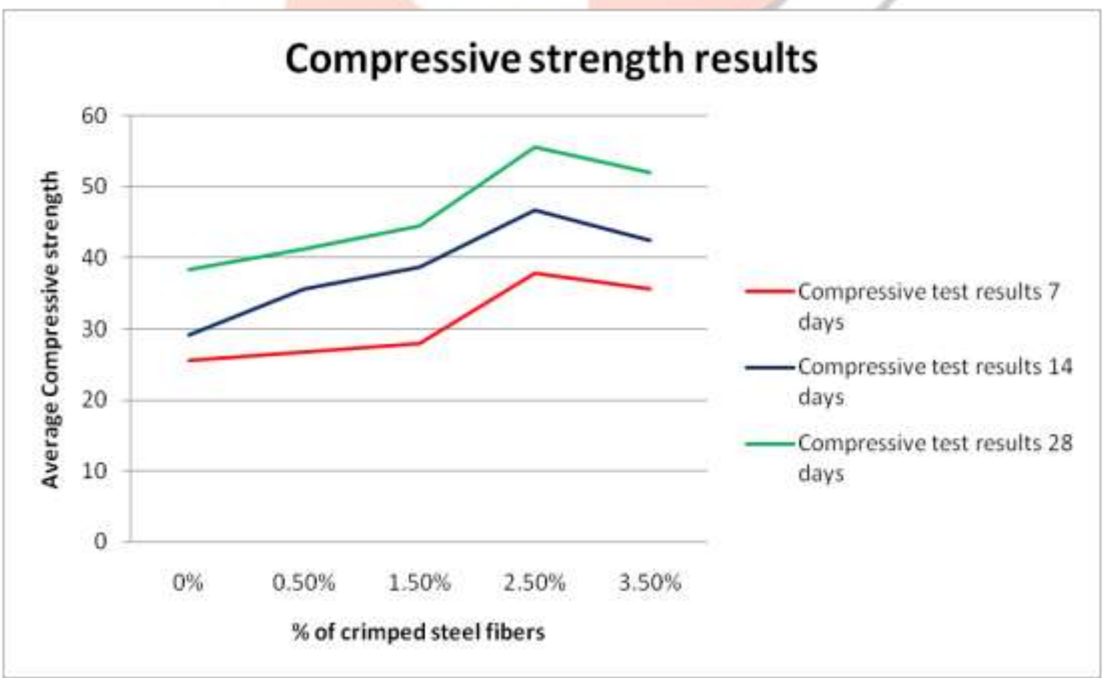


CHART 3.4 Split Tensile Strength Variations for Different Concrete Mixes



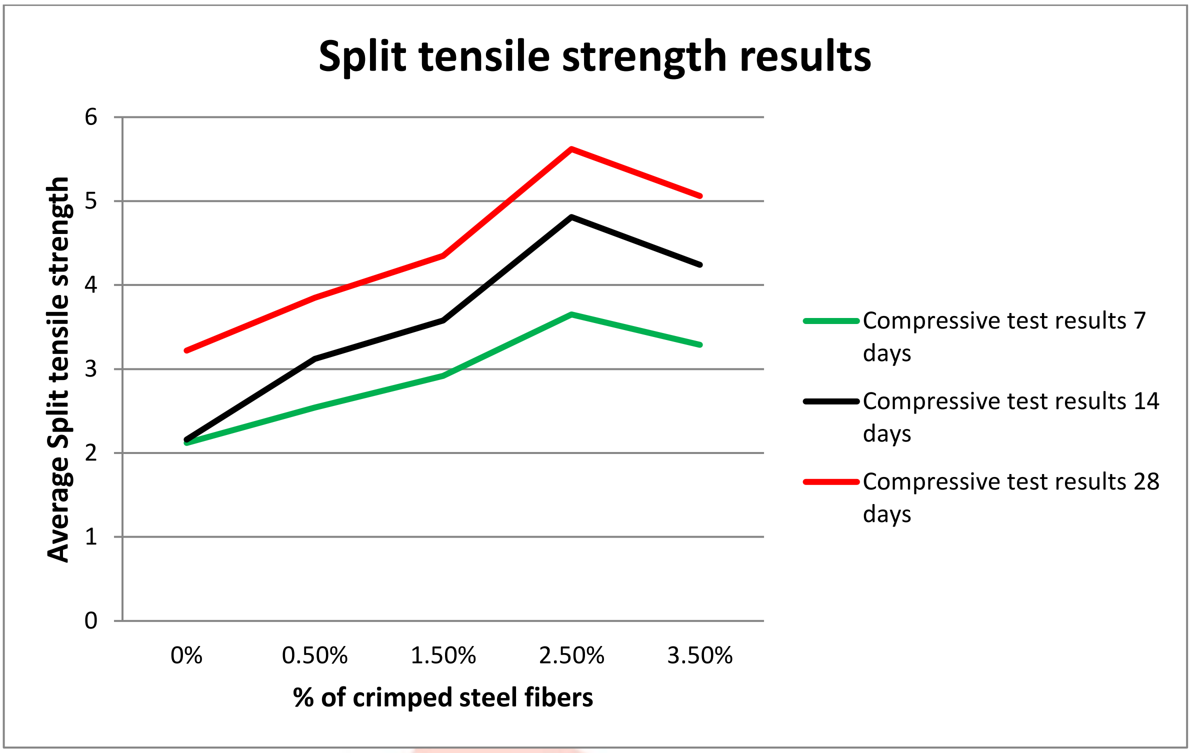


CHART 3.5 Split Tensile Strength Variations For Different Concrete Mixes

FLEXURAL STRENGTH TEST: (IS 516-1959):

Mix Type	Trail	Peak Load (KN)	Flexural Strength (N/mm^2) for 28 days	Avg Flexural Strength(N/mm^2)
A0 (0%)	1	2075	6.22	6.26
	2	2085	6.26	
	3	2100	6.30	
A1 (0.5%)	1	2355	7.06	7.12
	2	2375	7.12	
	3	2390	7.17	
A2 (1.5%)	1	2720	8.16	8.21
	2	2735	8.20	
	3	2755	8.26	
A3 (2.5%)	1	3505	10.51	10.56
	2	3520	10.56	
	3	3535	10.60	
A4 (3.5%)	1	3115	9.34	9.38
	2	3126	9.37	
	3	3139	9.41	

Table 3.4 Flexure strength values of different concrete mixes

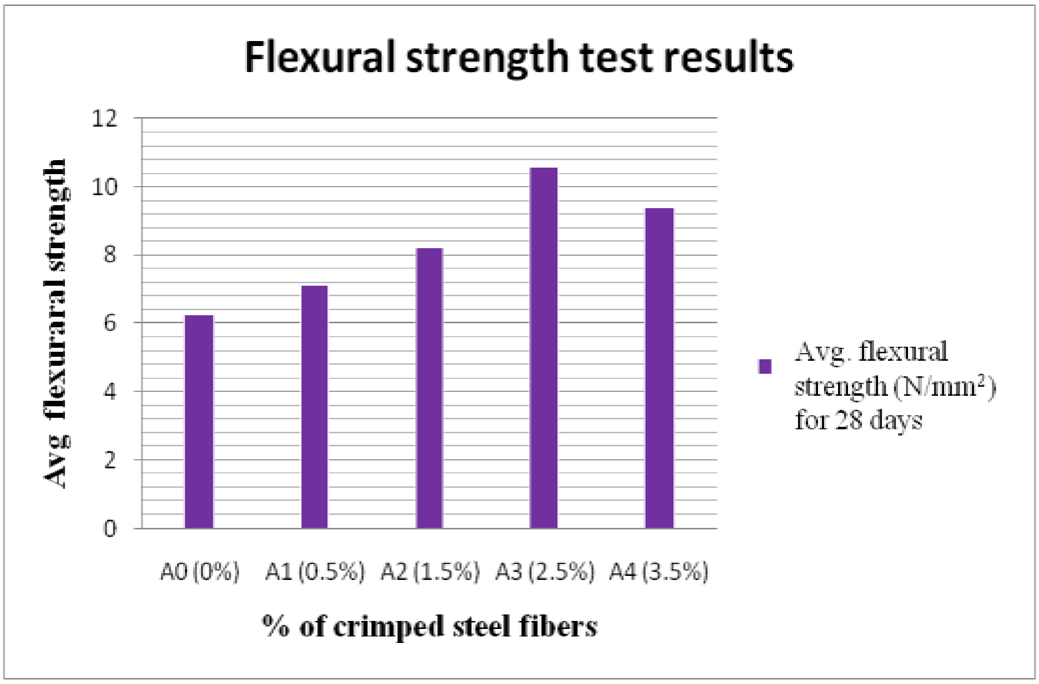


CHART 3.6 Flexural Strength Variations for Different Concrete Mixes

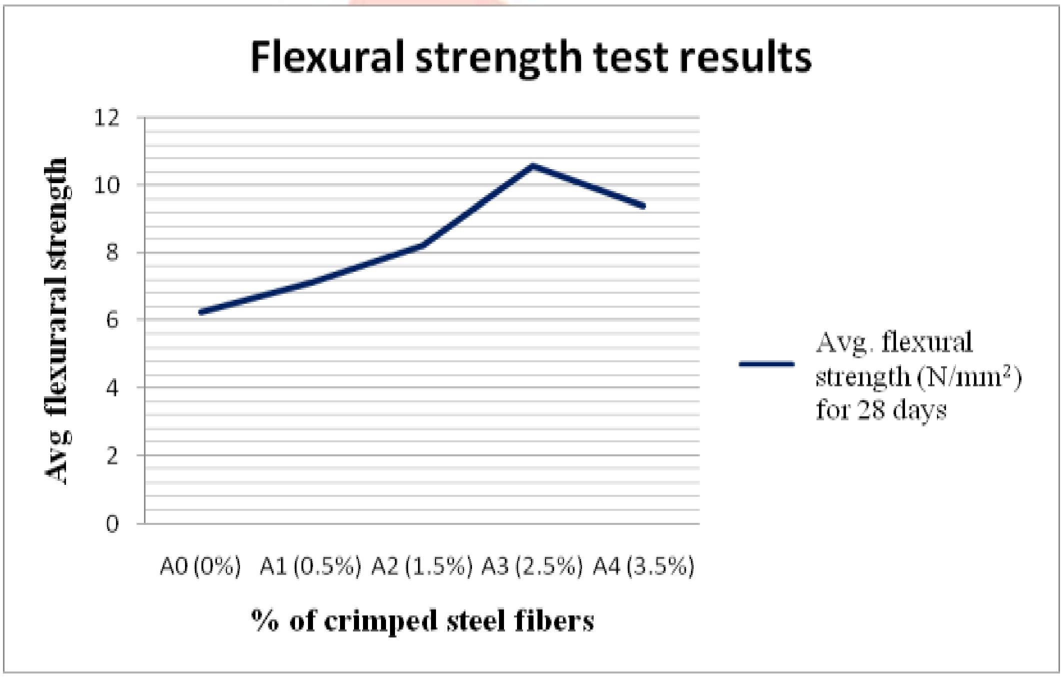


CHART 3.7 Flexural Strength Variations for Different Concrete Mixes

S.no	Concrete mix	Average Compressive Strength (MPa)	Average split tensile strength (MPa)	Average flexural strength (MPa)
1	Conventional mix	38.34	3.22	6.26
2	Mix with 0.5% of steel Fiber	41.3	3.85	7.12

TABLE 3.5 Compressive, Split Tensile & Flexural Strength Results When Crimped Steel Fiber Material Used

4. LITERATURE REVIEW

4.1. Deepthi, Dumpa, Venatateswarulu (2016):

In this paper delay with the study of the effect of addition of wood waste ash (WWA) and crimped steel fiber (CSF) in concrete. The crimped steel fibers are various % will be used 0.1%, 0.5% 1.0% 1.5% on the addition of wood waste in concrete. The test would be conducted for compressive strength split tensile strength and flexural strength-for various proportions adding of crimped steel fibers and wood waste.

In this experiment investigation was made to understand the behavior of concrete with addition of varying quantities of wood waste and crimped steel fibers. The compressive, split tensile strength & flexural strength will be increases to level 20% of wood waste and 0.75% of the crimped steel fibers and beyond these limits which its starts decreasing strengths.

4.2. Vijay M. M Shake, Rahul D. Pandit (2016)

This experimental study was carried out to assessment of mechanical properties of High Strength Fiber Reinforced concrete (HSFRC) for M90 grade High Strength Concrete (HSC) is made with appropriate cementations materials i.e. cement, fly ash, and silica by dot mix design method the crimped steel fiber volume fraction is used 0 to 4% of 0.5% internal.

To investigate the strength properties of high strength fiber reinforced concrete composite with various volume fraction. Such as compressive strength, split tensile strength and bond strength. To compare the properties of these special controlled concrete with that of normal concrete. The experimental study and results are obtained.

The maximum percentage increase in compressive strength at 3.5% of fiber volume fractions and split tensile strength is achieved at 3% of fibers volume fraction.

4.3. Aswani Sabu, Thomas Paul (2016)

Accordingly, it has been found that steel fibers give the maximum strength in comparison to glass and poly propylene fibers. In this experimental study two type of steel fibers namely hooked and crimped fibers are used. The volume of fractions is taken as 0.75%, 1.0%, & 1.25% and M30 grade is adopted. Cement has replaced with 25% of class F fly-ash. The primary focus is to compare the mechanical properties of concrete using both fibers. Various tests have been conducted for compressive test & flexural strength based on after 28th days and 56th days curing period studied. The compressive strength of hooked fiber increased by 5% with the addition of steel fibers 1.25% was found to be optimum and crimped fibers shaved little effect on compressive strength and 1% was found to be optimum.

The split tensile strength for hooked fiber improved by about 10% and optimum was at 1.25% and crimped fibers also shaved an increase of about 9% till 1% and a gradual decrease after that. Flexural strength of hooked fibers at maximum is 1.25% and crimped fibers are at 1%.

5. CONCLUSION

After completion of total experimental methodology, from the above investigations and from the test results some variations observed in workability and compressive, split tensile & flexural strengths of different concrete mixes having different percentages of adding crimped steel fibers. It is observed that compressive, split tensile & flexural strengths are on higher side for 2.5% fibers compared to that produced from 0%, 0.5%, 1.5% & 3.5%.It is observed that compressive strength increases from 8% to 46% with addition of crimped steel fibers.

It is observed that split tensile strength increases from 19% to 75% with addition of crimped steel fibers.

It is observed that flexural strength increases from 13% to 69% with addition of crimped steel fibers.

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