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Mechanical Properties of Self Compacting Concrete using Crimped Steel Fiber

P. S. Prahaanth,
P.G.Student,
Construction Engineering and Management ,
SRM University,
Chennai,India.

Mr. J. Rajprasad,
Assistant Professor,
Civil Engineering,
SRM University
Chennai,India.

Shuaibu Saminu,
P. G. Student,
Construction Engineering and Management,
SRM University,
Chennai,India.

***Abstract*—The purpose of this research is to investigate the use of crimpled steel fiber with various proportion in structural concrete to enhance the mechanical properties of self compacting concrete. The main objective of the study is to determine and do the comparative study of the properties of concrete containing no fibers and concrete with fibers, as well as the comparison on the effect of different proportion of fiber to the self compacting concrete .This crimped fibers which change the properties of hardened concrete significantly .Self compacting concrete is an innovative concrete that is able to flow under its own weight without any vibration. This investigation was carried out using several test ,which included workability test of SCC, compressive test ,split tensile test and flexural test.**

Keywords— ***Self-compacting concrete , Fiber reinforcement, Fly ash, Workability, Strength, Aspect Ratio, etc…***

I. INTRODUCTION

It is estimated that the present consumption of concrete in the world is of the order of 10 billion tonnes (12 billion tons) every year. Humans consume no material except water in such tremendous quantities. Concrete is one of the most commonly used man made construction materials (Paulo Montiero, The University of California Berkeley).It has become very popular not only among civil engineers but also among common people also the secret of its popularity lies in the simple fact that except cement, all other ingrends of concrete are commonly available local materials like aggregate and water. Therefore it is no surprise that the concrete is being used as a construction materials from small pavements to runways and express ways , from small hutments to multistory building and small culverts to long muti span bridges .

The growth of concrete has resulted into many developments and innovations in their field .Before we were thinking of M20 grade concrete only now a days we are producing M60 and above. And now we are producing concrete with new characteristics, therefore high performance concrete ,ready mix concrete & self compacting. Continuing the series of improvement in the quality of concrete recently we have developed new category of concrete called self compacting concrete. This concrete is mainly used where the reinforcement of the members are in dense. And where the vibrator cannot be used .

According to ACI 237R-07, self compacting concrete (SCC) is highly flowable, non segregating concrete that can spread into place, fill the formwork and encapsulate the reinforcement without any mechanical consolidation [1]. The term ‘Self-Compacting-Concrete’ (SCC) was introduced by Professor Ozowa in Japan.Self-compacting concrete (SCC) has little resistance to flow so that it can be placed and compacted under its own weight with little or no vibration effort. SCC has viscosity such that segregation and bleeding do not occur. SCC was developed in Japan in the late 1980s as a solution to achieve durable concrete structures independent of the quality of construction work. With limited aggregate content,low water-powder ratio and use superplasticizer and viscosity modifying agent.

Self compacting concrete (SCC) is a highly flowable, yet stable concrete that can spread readily into place, fill theformwork, and encapsulate the reinforcement, if present,without any mechanical consolidation and without undergoing separation of material constituents. SCC has many advantages over conventional concrete: (1) eliminating the need forvibration; (2) decreasing the construction time and labor cost;(3) reducing the noise pollution; (4) improving the interfacial transitional zone between cement paste and aggregate orreinforcement; (5) decreasing the permeability and improving durability of concrete, and (6) facilitating constructability and ensuring good structural performance [2].

The main objective of this study is to assess the effects of fly ash replacement on the fresh and hardned properties of SCCs incorporating crimped steel fibers.The proportion crimped steel fiber is 0.5%,1%,1.5% & 2%. The water-cement ratio is 0.4. The total mass of the cement is 500kg/m^3,in which 30% of cement is replaced by fly ash and grade of the concrete is M30.Commercially available chemical admixtures used in this study includes a viscosity modifying admixture (VMA) and a polycarboxylic based superplasticizer(SP).

II. METHODOLOGY

The present research work is experimented and requires preliminary investigations in a methodological manner.

A. Cement

The cement used in this experimental work is "Ultratech 53 grade Ordinary Portland cement".All the properties of cement are tested by reffering IS 12269-1987 specification for 53 grade Ordinary Portland cement.The specific gravity of cement is 3.15.The initial setting time is 42 minutes and final setting time is 410 minutes respectively.standard consistency of cement was 28%.The fineness of cement is 96.6%.

B. Fly Ash

Fly ash is available in dry powder form and the light gray, fly ash is available in 30kg bags. There are no standard performance tests.The fly ash produced by the company satisfies all the requirements of the IS 3812:1981,BS 3892:Part I :1997.

C. Aggregate

For SCC all normal concreting sands are suitable.Well both crushed and rounded sands can be used. Siliceous or calcareous sands can be used. The amount of fines less than 0.125 mm which is taken ass powder and is very important for the rheology of the SCC. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation.[3]

Locally available sand which passed through 4.75mm IS sieve is used. The specific gravity of fine aggregate is 2.66 and fineness modulus of 2.7 are used as fine aggregate and water absorption is 1.5% .

The coarse aggregate is obtained from crushed granite aggregate available from local sources has been used. The coarse aggregate with a maximum size of 10mm having the specific gravity value is 2.7 and the fineness modulus 2.1 and the water absorption is 0.2%.

D. Fibers

The crimped fiber is mainly used in the study are in four proportions 0.5%,1%,1.5%& 2%.The aspect ratio is 50 of the crimped fiber.The crimped fiber is the one type of steel fiber.The shape and structure of crimped steel fiber which helps to have a good bond with the concrete.

E. Viscosity Modifying Agent And Superplasticizer

Most VMA's(Viscosity Modifying Agent) are based on high molecular weight polymers with a high affinity to water. By interaction of the functional groups of the molecules with the water and the surfaces of the fines, VMA's build up a three dimensional structure in the liquid phase of the mix to increase the viscosity and/or yield point of the paste. The strength of the three dimensional structure affects the extent to which the yield point is increased.

Some VMA's are based on inorganic materials such as colloidal silica which is amorphous with small insoluble, non-diffusible particles, larger than molecules but small enough to remain suspended in water without settling. By ionic interaction of the silica and calcium from the cement a three dimensional gel is formed which increases the viscosity and/or yield point of the paste.

This three dimensional structure/gel contributes to the control of the rheology of the mix, improving the uniform distribution and suspension of the aggregate particles and so reducing any tendency to bleeding, segregation and settlement.

Most VMA's are supplied as a powder blend or are dispersed in a liquid to make dosing easier and improve dosing accuracy. The dosage depends on the application but typically ranges from 0.1 to 1.5% by weight of cement but can be varied for specific applications.

Most VMA's have little effect on other concrete properties in either the fresh or hardened state but some if used at high dosage, can affect setting time and or the content and stability of entrained air. Users of VMA's should refer to the admixture manufacturer's data sheet for specific information on recommended dosage and the effect on other properties of the concrete.

VMA's are a family of admixtures designed for specific applications. They are used to:

- reduce segregation in highly flowable/self compacting concrete
- reduce washout in underwater concrete
- reduce friction and pressure in pumped concrete
- compensating for poor aggregate grading, especially a lack of fines in the sand
- reducing powder content in self compacting concrete
- reduce bleeding in concrete[4].

And a superplasticizer (SP) based on a modified polycarboxylate was employed to obtain a satisfactory workability of fresh concrete for the different mixes[5].

TABLE 1 PROPERTIES OF CHEMICAL ADMIXTURES

Chemical Admixture	Dosage	Main Component
SP	1%	Polycarboxylic ether
VMA	0.4%	Microscopic silica

TABLE 2 MIXTURES PROPORTION

Cement	Fly Ash	Fine Aggregate	Coarse Aggregate
1	0.667	3.33	2.46

III. RESULT AND DISCUSSION

A. Fresh concrete test results of Self Compacting Concrete:

TABLE 3 SLUMP CONE TEST

S.NO	Percentage of fiber(%)	Aspect Ratio	Slump Flow by Abrams cone(mm)	
			Horizontal Slump(mm)	T50-Time(sec)
1	0	50	765	2.94
2	0.5	50	750	3.59
3	1	50	740	3.73
4	1.5	50	735	3.90
5	2	50	725	4.20

TABLE 4 V-FUNNEL TEST

S.NO	Percentage of fiber(%)	Aspect Ratio	V-Funnel test	
			Flow time(sec)	Flow time at T5 minutes (sec)
1	0	50	7.43	9.20
2	0.5	50	7.62	9.36
3	1	50	7.80	9.65
4	1.5	50	7.94	9.71
5	2	50	8.03	9.96

TABLE 5 L-BOX TEST

S.NO	Percentage of fiber(%)	Aspect Ratio	L-BOX TEST
			H2/H1 Ratio
1	0	50	0.954
2	0.5	50	0.936
3	1	50	0.918
4	1.5	50	0.895
5	2	50	0.891

TABLE 6 U-BOX TEST

S.NO	Percentage of fiber(%)	Aspect Ratio	U-Box Test		
			H1 (mm)	H2 (mm)	H2-H1 (mm)
1	0	50	309	299	10
2	0.5	50	315	304	11
3	1	50	321	308	13
4	1.5	50	323	309	14
5	2	50	327	312	15

These are the results obtained for the above mentioned test for the flow of Self Compacting Concrete and along with crimped fiber.

B.Hardened concrete test results for self compacted concrete.

TABLE 7 COMPRESSION TEST OF CUBES OF SCC AT THE END OF 7 DAYS

S.No	Percentage of Fiber(%)	Days	Compressive Strength (N/mm^2)
1	0	7	17.93
2	0.5	7	24.40
3	1	7	26.80
4	1.5	7	27.46
5	2	7	28.16

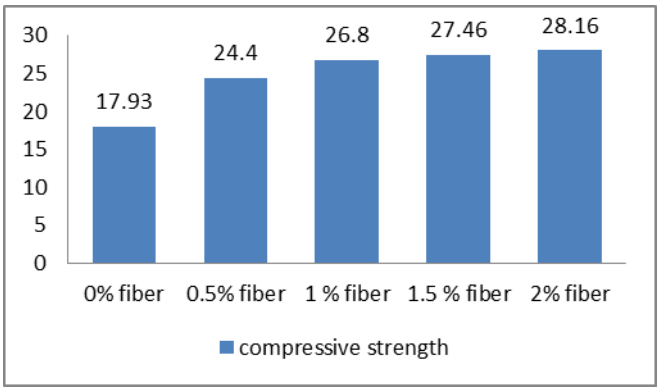

FIGURE. 1 : Figure.of Compressive Strength at the End of 7 Days

From the figure, the graphical representation which shows that the maximum percentage of fiber that is 2% has the increased strength when compared with other proportions.

TABLE 8 COMPRESSION TEST OF CUBES OF SCC AT THE END OF 28 DAYS

S.No	Percentage of Fiber(%)	Days	Compressive Strength (N/mm^2)
1	0	28	32.8
2	0.5	28	35.63
3	1	28	37.56
4	1.5	28	41.23
5	2	28	43.33

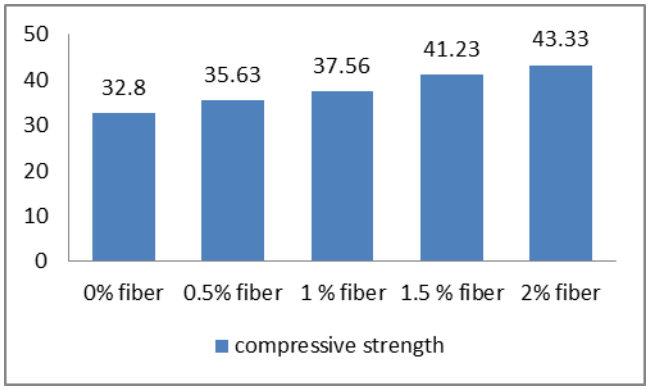

Figure .2: Figure Of Compressive Strength At The End Of 28 Days

From the figure 2, the graphical representation which shows that the maximum percentage of fiber that is 2% has the increased strength and the increased percentage is 32.10% with comparison of zero percent fiber added SCC.

Table 9 Split-Tensile Strength Test of Cylinder of Scc at the End of 7 Days.

S.No	Percentage of Fiber(%)	Days	Split-Tensile Strength (N/mm^2)
1	0	7	1.86
2	0.5	7	1.98
3	1	7	2.01
4	1.5	7	2.06
5	2	7	2.12

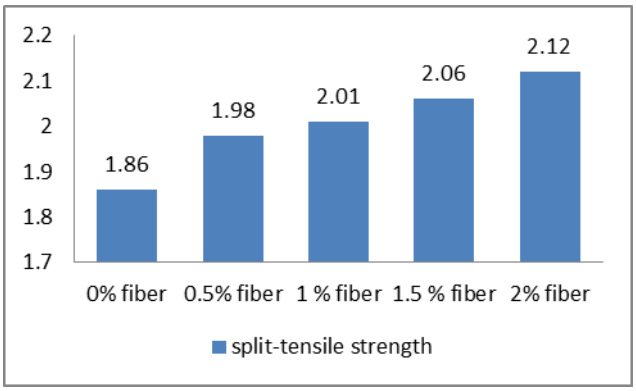

FIGURE. 3: Figure of Split –Strength At The End 7 Days

From the figure 3,the graphical representation which shows that the maximum percentage of fiber is 2% which has the increased strength.

Table 10 Split-Tensile Strength Test of Cylinder Of Scc At The End Of 28 Days.

S.No	Percentage of Fiber(%)	Days	Split-Tensile Strength (N/mm^2)
1	0	28	3.88
2	0.5	28	4.61
3	1	28	4.93
4	1.5	28	5.10
5	2	28	5.20

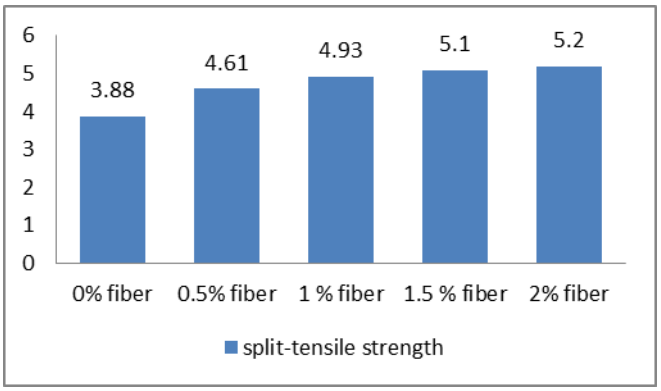

Figure. 4: Figure of Split-Tensile Strength At The End Of 28 Days

From the figure 4,the graphical representation which clearly shows that the maximum percentage of fiber is 2% which has the increased strength and the increased percentage is 34.02% with comparison of zero percent fiber added SCC.

TABLE 11 FLEXURAL STRENGTH TEST ON BEAMS OF SCC AT THE END OF 7 DAYS

S.No	Percentage of Fiber(%)	Days	flexural Strength (N/mm^2)
1	0	7	2
2	0.5	7	2.5
3	1	7	2.67
4	1.5	7	3
5	2	7	3.33

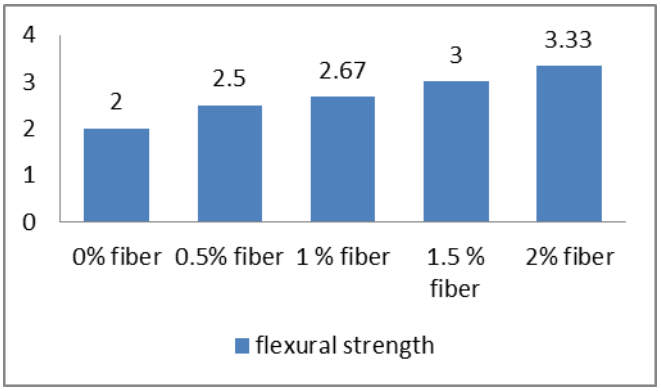

Figure.5: Figure Of Flexural Strength At The End Of 7 Days

From the figure 5,the graphical representation which shows that the maximum percentage of fiber that is 2% has the increased strength.

Table 12 Flexural Strength Test on Beams of Scc at the End Of 28 Days

S.No	Percentage of Fiber(%)	Days	Flexural Strength (N/mm^2)
1	0	28	3.83
2	0.5	28	4.16
3	1	28	4.83
4	1.5	28	5.20
5	2	28	5.83

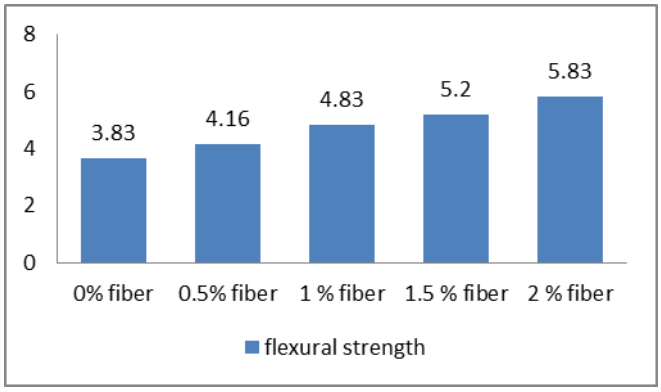

Figure 6 : Figure Of Flexural Strength At The End Of 28 Days

From the figure 6,the graphical representation which shows that the maximum percentage of fiber that is 2% has the increased strength and the increased percentage is 52.21% with the comparison to zero percent fiber added SCC.

IV . CONCLUSION

This investigation shows that it is possible to achieve the self compaction of crimped fibers with various proportions such as 0.5%,1%,1.5% & 2%. And the results obtained from all of the mixture satisfies the lower and upper limits suggested by EFNARC (European Federation of National Trade Associations) and all mixtures have good flow ability and they possess self-compaction characteristics. From the figure 2, the graphical representation which shows that the maximum percentage of fiber that is 2% which has the increased strength and the increased percentage is 32.10% with comparison of zero percent fiber added SCC. From the figure 4,the graphical representation which clearly shows that the maximum percentage of fiber is 2% which has the increased strength and the increased percentage is 34.02% with comparison of zero percent fiber added SCC. And From the figure 6,the graphical representation which shows that the maximum percentage of fiber that is 2% has the increased strength and the increased percentage is 52.21% with the comparison to zero percent fiber added SCC. The flexural strength shows the better result when compare with compressive and split-tensile strength. Normally, how we get increased strength in concrete when the bond is good between the particles and voids are closed .This is how here we have seen crimped fiber having good bonding in the concrete due to its shape and structure. And this helps to decrease the voids and makes crack resistance where,fly ash is used to increase the durability. The crimped steel fiber which tends to corrode but it is limited.

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