PERFORMANCE OF CARBON STEEL-POLYPROPYLENE FIBER REINFORCED SELF COMPACTING CONCRETE

K J SAGAR, Dr. K. B. PARIKH

ABSTRACT: The effect of carbon steel fibers and polypropylene fibers in self compacting concrete was studied in this paper. The self compacting concrete is a concrete that can be placed and compacted by its own weight. Self compacting concrete provides several economic and technical benefits and the use of fibers in self compacting concrete extents its possibility. Various researchers were performed the slump flow test, compressive strength test and flexural strength test to study the effect of fibers on fresh and harden properties of self compacting concrete. Polypropylene – carbon steel fiber reinforces self compacting concrete shows 29.36 % increase in compressive strength when compared to the control mix because it obtain benefits from both fibers. Maximum flexure strength with the use of both fibers in self compacting concrete can be achieved at 0.1 % use of polypropylene fibers and 1.0% carbon steel fibers as 71.58 %.

KEYWORDS: self compacting concrete, carbon steel fibers, polypropylene fibers, workability, compressive strength, flexure strength.

INTRODUCTION: self compacting concrete is considered as a concrete that can be placed and compacted by its self weight and at the same time it is cohesive enough to be handled without segregation and bleeding. It can fill all the formworks even in congested reinforcement with little or no vibration effort. The self compacting concrete is first introduced in the late 1980's from Japan.

There are many advantages of self compacting concrete. SCC can place faster than normal concrete that's why it reduces the cost of placing of concrete. It improves the finish of surface in architectural point of view. The time period of construction can be reduced by use of SCC. Due to reduction in construction time period, it reduces the cost of construction.

There are two types of fibers are used in this study: carbon steel fibers and polypropylene fibers. Carbon steel fiber is different than normal steel fibers. The base material of carbon steel fiber is carbon steel wire whereas in normal steel fiber base material is cast iron wire. The tensile strength of carbon steel fiber is two to three times more than that of normal steel fibers. Carbon steel fibers increase the compressive strength, flexure strength and tensile strength of concrete. Whereas polypropylene fibers act as a bridge to retard cracks and crack propagation.

MATERIALS USED IN THESE WORKS:

Cement: ordinary Portland cement 53 grade and specific gravity 3.15 is used in my works.

Fly ash: Fly Ash is available in dry powder form. It is procure from thermal power stations in balasinor, Gujarat. The light gray in color.

Fine Aggregate: I use locally available river sand from himatnagar conforming in Indian standard (is 383) specific gravity 2.64.

Coarse Aggregate: Locally available quarry stone in good strength, passing through a 12.5 mm and retain in 10mm sieve, specific gravity 2.68.

Water: Ordinary portable water without acidity and Alkanet available in well or pump.

Super Plasticizer: CONTECH CONFLOW SP is used to reduce the frictional properties of concrete.

Polypropylene fibers: polypropylene fibers of 12 mm length are used in my work and my purchase from fiber zone Ahmadabad.

Carbon steel fibers: carbon steel fibers of 35mm in length and 0.5mm in diameter and hooked at the end are used in my works.

Carbon steel fiber: Carbon steel fiber is a metallic fiber, which provides good compressive strength and flexure strength to the concrete. It passes two to three times higher tensile strength in comparison to the normal steel fiber. There are three types of carbon steel fibers: hooked end fiber, straight fibers and zigzag shaped fiber based on its shape. I used hooked end carbon steel fiber of 0.5 mm diameter and 35 mm length in this study. The aspect ratio of fiber is 70 mm.

Table 1 properties of carbon steel fibers.

Chemical composition	Details	Physical properties	Details
C	0.05	Base material	Carbon wire
Si	0.14	Fiber type	Hooked end
Mn	0.44	Diameter	0.5mm
P	0.026	Length	35mm
S	0.2	Tensile strength	1000-1400 N/MM2
Cr	0.12		
Ni	0.17		
Cu	0.28		
Mo	0.038		
N	0.007		

Polypropylene fiber: Polypropylene fiber is non metallic fiber. Polypropylene fiber is acting as a bridge retard. It reduces the crack and crack propagation of a concrete. The effect of polypropylene on compressive strength and flexure strength is less due to its low modulus of elasticity and high elongation. I use 12 mm long fibrillated polypropylene fibers in my works.

Table 2 properties of polypropylene fibers.

Properties	Details
Base material	100% virgin polypropylene
Fiber type	Fibrillated
Melt point	165º C
Length	12 MM
Surface	Coated for dispersion and adhesion
Color	
Water absorption	

Mix design for self compacting concrete

For self compacting concrete, rational mix design is necessary. To develop self-compacting concrete using cement with various quantities of fly ash from partially replacing fine and coarse aggregate. Use of admixtures to produce high strength self-compacted concrete of M30 grade concrete.

Table 3 mix design for M30 grade self compacting concrete

Trial	Cement	Fly a	Fine aggreg	Course aggregate	Wate	w/c	Flow	7 days N/M	28 days N/M

m i x	Kg	s h k g	ate kg	Kg	r li t e r		m m	M2	M2
3	37 5	1 5 0	790	750	2 0 4 . 7	0 . 3 9	6 1 0	26. 66	36. 8

Test on self compacting concrete:

Slump-flow test:

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It measures horizontal flow of concrete. It was first developed in Japan for use in assessment of underwater concrete. In this test the diameter of the concrete circle is a measure of the filling ability of the concrete. This test can also use at a site. The apparatus used in this test is a slump cone, which has a base diameter of 200 mm, top diameter is 100 mm and height of slump cone is 300 mm. A base plate of at least 700 mm x 700 mm is needed.

Fig.1 slump-flow test

Table 4 Slump Flow Test Result

Grade	M30	EFNARC criteria
Slump Flow in mm	680mm	600mm to 800mm
T50 Time in Sec	3.8sec	2 sec to 5 sec

V-funnel TEST:

The V-funnel test was developed in Japan and this test is used to determine the filling ability of the concrete with maximum size of aggregate 20 mm size. The equipment consists of a V-shaped funnel, shown in Figure 4.2. The funnel is filled with concrete and the time taken by it to flow through the apparatus measured. This test gives account of the filling capacity.

Fig.2 V-funnel test

Table 5 V-Funnel Test Result

Grade	M30	Acceptable criteria
Time in sec	10sec	6 to 12 sec

L BOX TEST

The test was developed by the technology research center in Japan. The test is also called a "box-shaped" test .The test is give the indication about the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall in to two compartments. An opening with a sliding gate is fitted between the two sections and reinforcing bars with normal diameter of 12mm are installed at the gate with centre-to-centre spacing of 50mm. Hence clear distance between bars is 35 mm.

Table 6 L-BOX Test Result

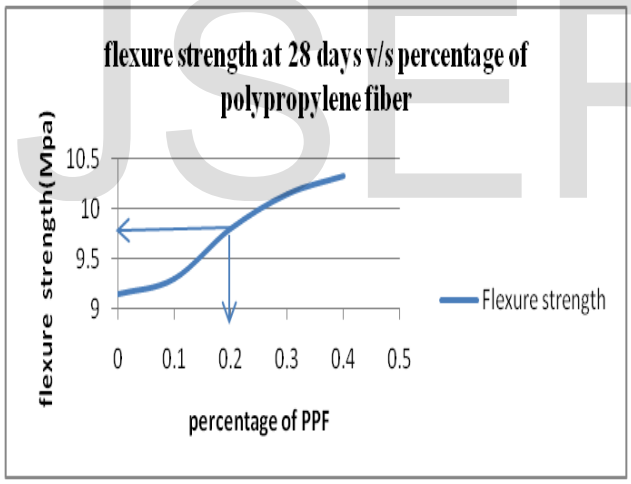
Grade	M30	Acceptable criteria
H2/H1	0.83	0.8 to 1.0

Following result are obtained from this study

Table 7 Compressive and Flexure Strength Result of Self Compacting Concrete with Polypropylene Fibers

N	%		Compressive strength	Flexure strength	Workability

o.	of PP	% Of CFS	7 days curing N/mm2	28 days curing N/mm2	28 days curing N/mm2	In mm
K0	0	0	26.85	36.8	9.15	680
K1	0.1	0	26.70	37.2	9.30	655
K2	0.2	0	27.18	38.2	9.80	605
K3	0.3	0	26.52	36.40	10.15	580
K4	0.4	0	25.18	34.38	10.32	520

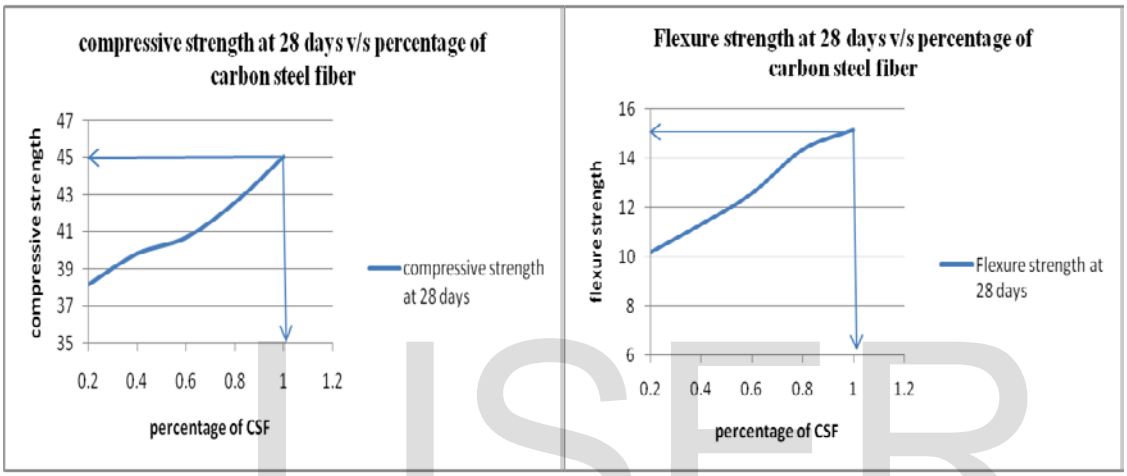


Graph 1 flexure strength v/s various percentage of polypropylene

Table **8 compressive strength and flexure strength test result of concrete with carbon steel fibers**

No.	% Of PP	% Of CSF	Compressive strength		Flexure strength	Workability in mm
			7 days curing N/mm2	28 days curing N/mm2	28 days curing N/mm2	

K 5	0	0. 2	27.50	38.2	10.20	665
K 6	0	0. 4	29.30	39.8	11.3	660
K 7	0	0. 6	31.40	40.70	12.55	650
K 8	0	0. 8	32.45	42.60	14.35	635
K 9	0	1. 0	34.66	45.05	15.15	610

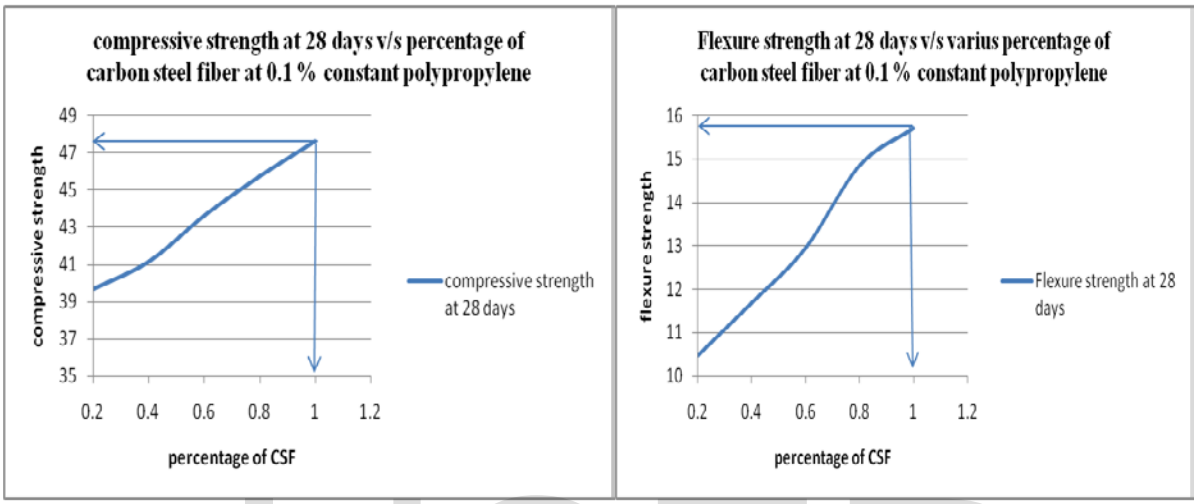


Graph 2 compressive and flexure strength v/s various percentage of carbon steel fibers

Table 9 compressive strength and flexure strength of SCC at 0.1 % polypropylene fibers and various amount of carbon steel fiber

No	% of PP	% Of CSF	Compressive strength		Flexure strength	Workability in mm
			7 days curing N/mm2	28 day curing N/mm2	28 days curing N/mm 2	
K10	0 . 1	0 . 2	28.30	39.70	10.48	640
K11	0 . 1	0 . 4	29.80	41.15	11.70	625
K12	0 .	0 .	32.30	43.60	12.95	615

	1	6				
K13	0.1	0.8	33.20	45.72	14.85	608
K14	0.1	1.0	34.84	47.60	15.70	600

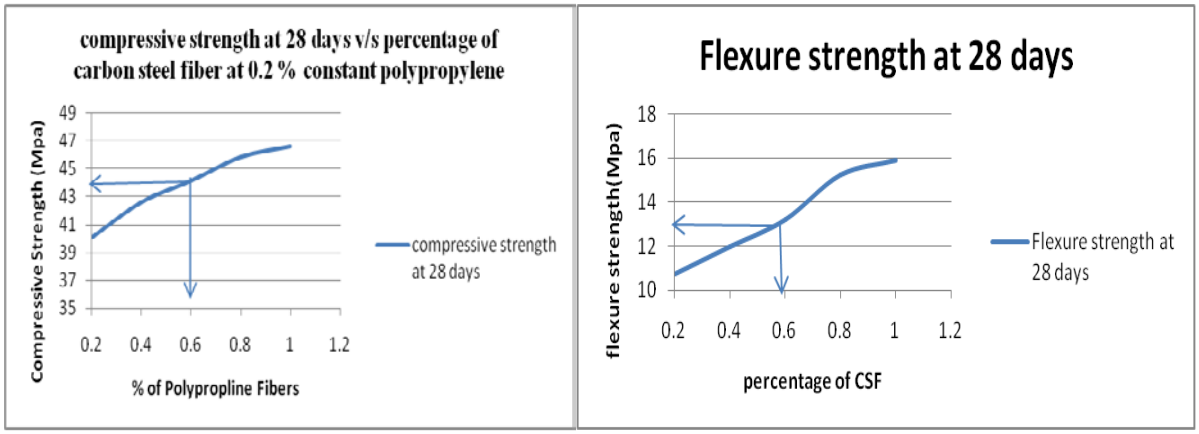


Graph 3 compressive and flexure strength v/s various percentage of carbon steel fibers at 0.1 % polypropylene constant

Table 10 compressive strength and flexure strength of SCC at 0.2 % polypropylene and various amounts of carbon steel fibers.

No	% Of PP	% Of CSF	Compressive strength		Flexure strength	Workability in mm
			7 days curing N/mm2	28 day curing N/mm2	28 days curing N/mm2	
K15	0.2	0.2	29.45	40.10	10.72	625
K16	0.2	0.4	30.50	42.60	11.95	615
K17	0.2	0.6	32.80	44.10	13.18	608
K1	0.	0.	33.90	45.82	15.22	595

8	2	8				
K19	0.2	1.0	35.45	46.60	15.90	580



Graph 4 compressive strength of SCC v/s various amount of carbon steel fibers at 0.2 % polypropylene constant

Conclusion:

Based on the experimental investigation concerning the effect of polypropylene fibers and carbon steel fibers on compressive strength, Flexural strength & workability test of self-compacted concrete, the following observations are made.

The polypropylene fiber dose not contributes on compressive strength and flexure strength much better but it reduce the cracks and crack propagation. From the results of the workability tests for SCC and hybrid fiber reinforce self compacting concrete, it can be concluded that Polypropylene fiber had greater role in reducing the workability of the SCC in compare to the carbon steel fibers which may be due to smaller diameter subsequently larger surface area and light weight of polypropylene that demands high paste content in the SCC.

Maximum compressive strength with use of polypropylene fibers in self compacting concrete can be achieve at 0.2 % use of polypropylene fiber as 3.80 % increase in compressive strength of self compacting concrete.

Maximum flexure strength with use of polypropylene fibers in self compacting concrete can be achieve at 0.2 % use of polypropylene fibers as 7.15 % within acceptable criteria of EFNARC.

Carbon steel fiber reinforced self compacting concrete shows 22.41 % increase in compressive strength compared to control mix.

Maximum flexure strength with use of carbon steel fibers can be achieve at 1.0 % use of carbon steel fibers as 65.57 % increase when compared to the control mix.

There is no problem with use of 0.1 % polypropylene fibers and 1.0% carbon steel fibers in self compacting concrete. If we use contains of both polypropylene fibers and carbon steel fibers more than the 1.1 % it will reduces the workability of self compacting concrete then the acceptable criteria as described in EFNARC.

Polypropylene – carbon steel fiber reinforce self compacting concrete shows 29.36 % increase in compressive strength when compared to the control mix because it obtain benefits from both fibers.

Maximum flexure strength with use of both fibers in self compacting concrete can be achieve at 0.1 % use of polypropylene fibers and 1.0% carbon steel fibers as 71.58 %.

References

Stal T. et al," Workability And Compressive Strength of Steel Polypropylene Hybrid Fiber Reinforced Self-Compacting Concrete.", International Journal for Science and Emerging Technologies with Latest Trends,Vo.6, No.1, 2013, pp.7-13.

Abbas Al-Ameri," The Effect Of Steel Fiber On Some Mechanical Properties OfSelf Compacting Concrete", American Journal of Civil Engineering, Vol.1, No.3, 2013, pp.102-110

B. Krishna Rao and Professor V. Ravindra."Steel Fiber Reinforced Self Compacting Concrete Incorporating Class F Fly Ash", International Journal of Engineering Science and Technology, Vol.2, No.9, 2010, pp. 4936-4943.

Shah D.L. and Modhere C.D," Parameter-Study on the Influence of Steel and Polyester Fibers in the Self-Compacting Concrete", The Pacific Journal of Science and Technology, Vol.10, No.2, 2009.

IS: 2386 (Part III) -1963, Methods of Test for Aggregates for Concrete, Part III: Specific gravity, density Voids, the absorption and bulking, First Reprint March 1971, Bureau of Indian Standards, and New Delhi.

IS: 2386 (Part I) -1963, Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape, Tenth Reprint March 1993, Bureau of Indian Standards, New Delhi.

Indian Standard Plain and Reinforced Concrete Code of Practice. IS 456:2000, Bureau of Indian Standards, New Delhi

IS 10262-1982. Recommended Guidelines for Concrete Mix Design, Fifth Reprint March-1998, Bureau of Indian Standards, New Delhi.

'European Federation of National Associations Representing producers and applicators of specialist building products for Concrete' EFNARC.