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Experimental Study on Toughness Property of Fiber Reinforced Self Compacting Concrete (FRSCC)

Kakula Sasidhar, V.Vasugi.

***Abstract*-The objective of this work is to investigate the toughness property of the fiber reinforced self compacting concrete (FRSCC) through experimental studies. In this work, different (0.5%, 1.0%, 1.5%, and 2%) percent of steel fibers are added by volume of concrete and (0.5% & 1.0%) percent of poly-propylene are added by mass of binding material. To achieve the self compacting concrete (SCC) mix design has been done according to the EFNARC guidelines. The limitations also achieved according to the European guidelines. By using different types of fibers the toughness property of the FRSCC has been studied. To find the toughness of FRSCC the JSCE SF-4 method is used. It has been observed that the toughness increased with increase in percentage (%) of fibers up to 1.5%. While, increase in percentage (%) fiber content beyond 1.5% resulted in lower toughness for the steel fibers. It give the only the limitation of steel fiber for SCC is up to 1.5% of volume of concrete. The comparative study also reported for mechanical properties of fiber reinforced self compacting concrete.**

*Keywords— **JSCE SF-4, Poly-propylene fiber, Steel fiber, Self compacting concrete, toughness property.***

I. INTRODUCTION

Self compacting concrete (FSCC) is new design and casting of non conventional architecturally details and shapes. It is required to use the super plasticizers and viscosity modifier admixture (VMA) to obtain the flow ability and to reduce the segregation respectively. To improve the flow ability of SCC, large quantity of finer material like quarry dust powder, silica fume, fly ash and traditional roof tile powder have been used [1-3]. SSC also require large volume of paste content and less volume of aggregate content. Usage of baggase ash as a replacement by mass and lime stone as fine aggregate enhanced the workability and hardened properties of SCC [4].

KAKULA SASIDHAR
VIT University,
Chennai, India

Prof. V.VASUGI
VIT University
Chennai, India

Domone (2005) has reported the limitation of mineral admixture advocating the use of fly ash up to 30% replacement to cement in self-compacting concrete [5]. The effect of recycled course aggregate (max. 20 mm size) with 60:40 ratio on mechanical & permeability properties of SCC has been studied and reported to be less [6-7]. To analyze the characteristics of SCC with different percentage of super plasticizer and mineral admixtures the Slump, L-box and V-funnel tests are used for SCC [8-9]. There are many mix design procedure [10] for FRSCC, this paper take the limitations of EFNARC guideline. There are many types of fibers are used in the recent studies like metallic and synthetic fibers. By using different fibers, the properties (Compressive, Flexural, Fatigue and Fracture energy) [11-15] of SCC is improved. The toughness of fiber reinforced concrete as per ASTM C1018 and JCI-SF4 reported in literature [16-17]. This paper deals with the toughness property of the fiber reinforced self compacting concrete (FRSCC) through experimental studies according to JCI-SF4 method. Commercially available steel and poly-propylene (PP) fibers are used in different proportions as follow; 0.5%, 1.0%, 1.5% and 2.0% of steel fibers by volume and the polypropylene fiber with 0.5% and 1.0% by percentage of binder material.

II. EXPERMENTAL STUDY

A. Materials

Portland cement of 53 grade of specific gravity 3.15 and Class-F fly ash are used as binder material. The course aggregate used are 20 mm and 10 mm. River sand is used as fine aggregate. The specific gravity of course aggregate and fine aggregate is 2.74. Poly carboxylic ether (GELENIUM-B233, BASF Co.) with 1.1 g/cm^3 specific gravity (at 20 ^oC) has been used as super plasticizer (SP). Two types of reinforcing fibers viz.; poly-propylene, steel has been used. The properties of the fibers used are shown in Table 1.

B. Mix Design And Methodology

The mix design has been prepared according to IS 10262-2009 for M25 grade of concrete. About 30% of fly ash as cement replacement by mass. Steel fibers are added on basis of volume of concrete in 0.5%, 1.0%, 1.5% and 2.0% and polypropylene fiber with 0.5% and 1.0% are added by mass of binder material (cement + fly-ash). The mix design details are shown in Table 2.

TABLE 1. PROPERTIES OF FIBERS

Materials	Steel Fiber	Poly-Propylene Fiber
Length (mm)	50	25
Dia. (mm)	1	0.1
Aspect Ratio	50	250
Tensile Strength (MPa)	1.25×10^3	0.55×10^3
Elasticity Modulus (GPa)	200	8
Specific Gravity (g/cm^3)	7.48	0.9

TABLE 2. DETAILS OF MIX DESIGN

Material (Kg/m^3)	0.5% of PP Fiber	1.0% of PP Fiber	0.5% of Steel Fiber	1.0% of Steel Fiber	1.5% of Steel Fiber	2.0% of Steel Fiber
Cement	358	358	358	358	358	358
Fly-ash	154	154	154	154	154	154
Fine aggregate	758	758	758	758	758	758
Course aggregate	652	652	652	652	652	652
Water Content	183	183	183	183	183	183
Super plasticizer	3.07	3.07	3.07	3.07	3.07	3.07
Fiber	2.55	5.11	12	24	36	48

III. TESTS AND RESULTS

The slump-flow diameter of SCC is 640 mm and time to reach 500 mm dia. is 4 sec. The test results obtained on L-Box and V-funnel are shown in Table.3 [21]. For a given load-deflection curve, toughness is the area under the load deflection curve measured up to a specified deflection L/150.

Fig.1: Slump test (Flow ability)

Fig.2. L-Box Test (Passing Ability)

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TABLE 3. CHARECTERSTIC PROPERTIES OF SCC

Test	Result	Limitation Acc to EFNARC
Slump (Flow ability)	640 mm	Range (550-650) mm
T_{500}	4 Sec.	
L-Box (Passing ability)	H2/H1 = 0.79	≥ 0.75
V-Funnel (Viscosity)	25 Sec.	30 Sec.

A. *Tests on hardened concrete*

The compressive strength of concrete increased with an increase of the percentage of volume of steel fibers as shown in Fig.3. However there is small decrement in strength for 2.0% of volume of steel fiber. Addition of steel fibers aids in converting the properties of brittle concrete to a ductile material. For split tensile strength addition of steel fibers to concrete increased the strength marginally.

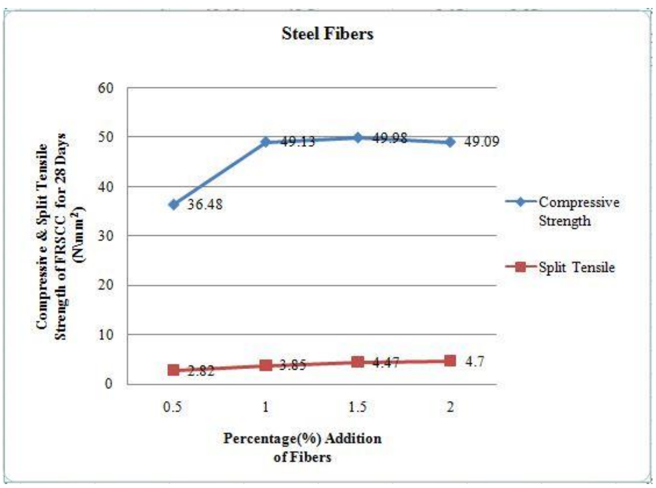

Fig.3: Compressive & Split Tensile strength of Steel fibers for 28 Days

Similar to the observation made with steel fiber, the addition of poly-propylene (PP) fibers increased the compressive strength of concrete with an increase in the percentage of PP as shown in Fig.4. As compared with the steel fiber the compressive strength of FRSCC is lower for the additions of PP. While, the additions of PP (1%) resulted in lower split tensile strength of concrete.

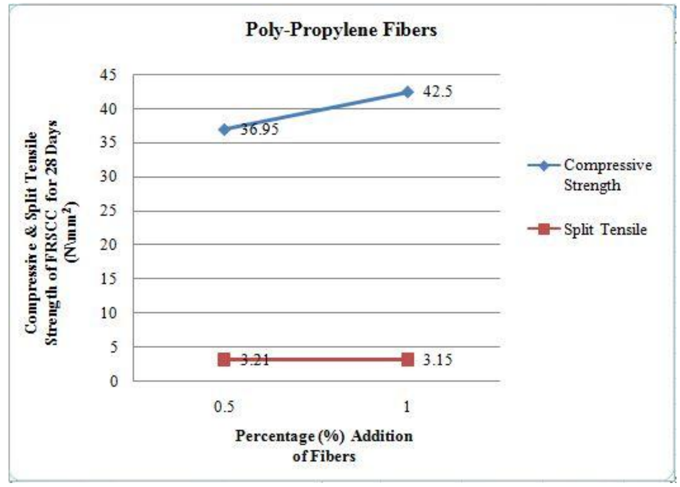

Fig.4. Compressive & Split Tensile strength of PP fibers for 28 Days

1) *Flexural Strength of FRSCC*

It is observed from Fig.5 that the strength of concrete is increased when the percentage of volume of steel fibers is increased. However there is small decrement of strength for 2.0% of volume of steel fibers. Addition of steel fibers aids in converting the properties of brittle concrete to a ductile material. Form Fig.6 poly-propylene (PP) fibers the flexural strength of concrete is increased gradually.

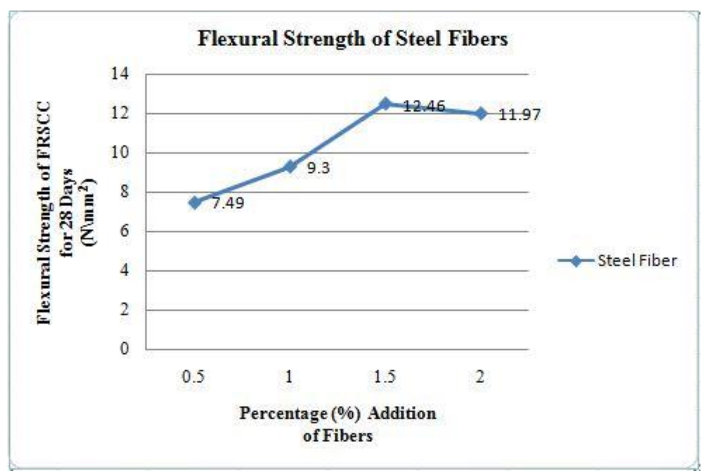

Fig.5: Flexural Strength of Steel fibers concrete for 28 Days.

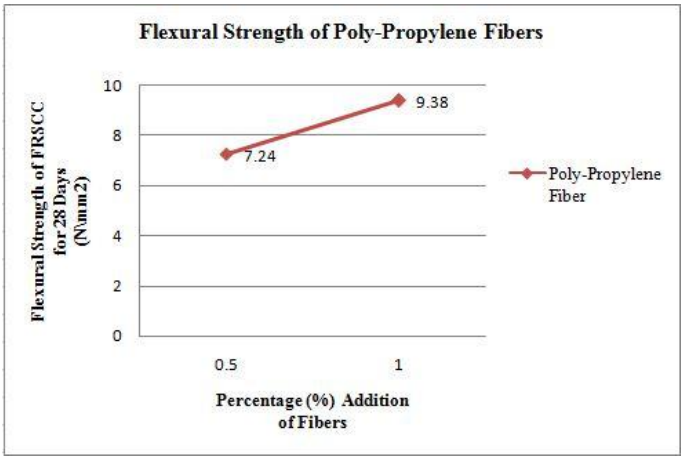

Fig.6: Flexural Strength of PP fibers concrete for 28 Days

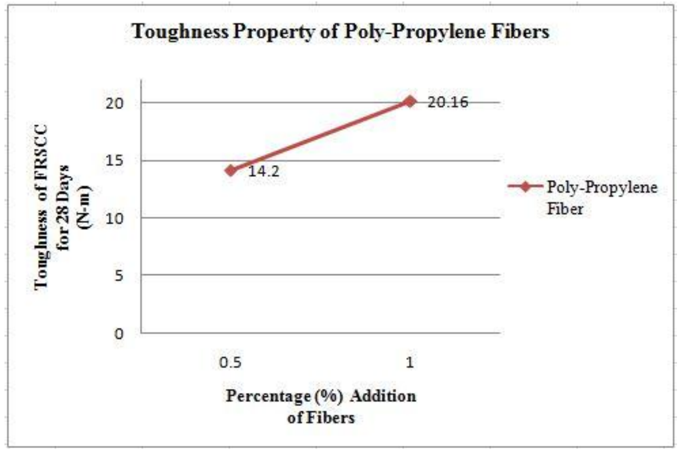

Fig.8: Toughness property of PP FRSCC for 28 Days.

2) *Toughness property of FRSCC*

The energy absorption capacity of fiber reinforced self compacting concrete results are show in Figs.7&8. The toughness of the steel fiber SCC shows good results. To find the toughness the area load-deflection curve up to the deflection of L/150. Fig.7 shows the toughness is gradually increased up to 2.0% when the steel fibers are added. Fig.8 shows the gradual increment of toughness for poly-propylene (PP) fibers. The steel fibers have more ductile property so it absorbs more energy compared to poly-propylene fibers.

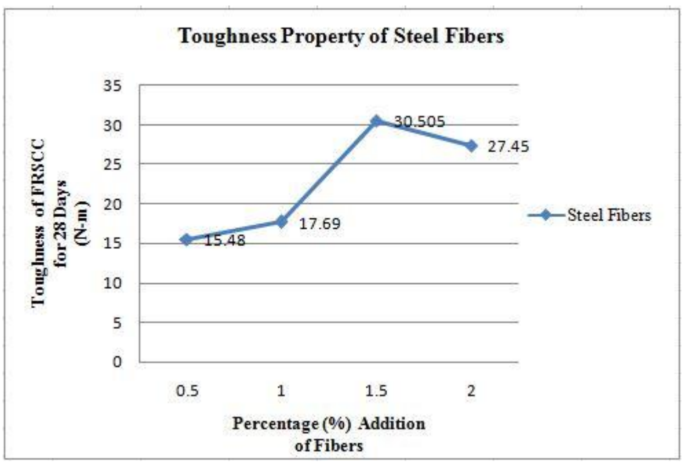

Fig.7: Toughness property of Steel FRSCC for 28 Days.

IV. CONCLUSION

It is concluded from the scope of this study that self compacting concrete with addition of fibers as follow:

- The characteristic properties of FRSCC satisfied the European guideline for SCC.
- The flowablity obtained (640 mm), according to EFNARC (SP1 550-650mm).
- Addition of (up to 1.5%) steel fibers to SCC, although compressive strength was improved 49.98 MPa, for 2% of steel fibers it decreased slightly 49.09 MPa.
- By adding the poly-propylene fibers (0.5% and 1.0%) to fresh concrete the compressive strength is increased by 15%.
- Split tensile strength of steel fibers increased gradually for different volume of fibers 4.7 MPa. For poly-propylene (1.0%) fibers split tensile strength was reduced slightly compared with (0.5%) addition of fibers.
- The flexural strength of concrete for poly-propylene fiber (12.46 MPa) increased gradually for steel fibers marginal decrement (3.9%) by adding 2% volume.
- The toughness of the steel fibers RSCC is higher as compared to that of PP RSCC.
- From the above it is concluded that the limitation of steel fiber for SCC is up to 1.5% of volume of concrete.
- For poly-propylene fiber the limitation is 1.0% of mass of binder material.

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