International Journal of Research
Available at https://journals.pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 04
April 2019

A Study on Mechanical Properties and Fracture Behaviour of Chopped Fiber Reinforced Self Compacting Concrete

Lakavath Ramesh & B.Bulli Babu
[1](M.Tech, Structural Engineering, Chalapathi Institute of Technology)
[2](Associate Professor, Civil Department, Chalapathi Institute of Technology)

ABSTRACT

The growth of Self Compacting Concrete is revolutionary landmark in the history of construction industry resulting in predominant usage of SCC worldwide nowadays. It has many advantages over normal concrete in terms of enhancement in productivity, reduction in labor and overall cost, excellent finished product with excellent mechanical response and durability. Incorporation of fibers further enhances its properties specially related to post crack behavior of SCC. Hence the aim of the present work is to make a comparative study of mechanical properties of self-consolidating concrete, reinforced with different types of fibers. The variables involve in the study are type and different percentage of fibers. The basic properties of fresh SCC and mechanical properties, toughness, fracture energy and sorptivity were studied. Microstructure study of various mixes is done through scanning electronic microscope to study the hydrated structure and bond development between fiber and mix.

The fibers used in the study are 12 mm long chopped glass fiber, carbon fiber and basalt fiber. The volume fraction of fiber taken are 0.0%,0.1%,0.15%,0.2%,0.25% ,0.3%. The project comprised of two stages. First stage consisted of development of SCC mix design of M30 grade and in the second stage, different fibers like Glass, basalt and carbon Fibers are added to the SCC mixes and their fresh and hardened properties were determined and compared.

The study showed remarkable improvements in all properties of self-compacting concrete by adding fibers of different types and volume fractions. Carbon FRSCC exhibited best performance followed by basalt FRSCC and glass FRSCC in hardened state whereas poorest in fresh state owing to its high water absorption. Glass FRSCC exhibited best performance in fresh state. The present study concludes that in terms of overall performances, optimum dosage and cost Basalt Fiber is the best option in improving overall quality of self-compacting concrete.

INTRODUCTION

Self-Compacting Concrete

Self-compacting concrete was originally developed in Japan and Europe. It is a concrete that is able to flow and fill every part of the corner of the formwork, even in the presence of dense reinforcement, purely by means of own weight and without the need of for any vibration or other type of compaction.

Fiber Reinforced Self-Compacting Concrete

There is an innovative change in the Concrete technology in the recent past with the accessibility of various grades of cements and mineral admixtures. However there is a remarkable development, some complications quiet remained. These problems can be considered as drawbacks for this cementatious material, when it is compared to materials like steel. Concrete, which is a „quasi-fragile material", having negligible tensile strength? Several studies have shown that fiber reinforced composites are more efficient than other types of composites. The main purpose of the fiber is to control cracking and to increase the fracture toughness of the brittle matrix through bridging action during both micro and macro cracking of the matrix. Debonding, sliding and pulling-out of the fibers are the local mechanisms that control the bridging action. In the beginning of macro cracking, bridging action of fibers prevents and controls the opening and growth of cracks. This mechanism increases the demand of energy for the crack to propagate. The linear elastic behavior of the matrix is not affected significantly for low volumetric fiber fractions.

At initial stage and the hardened state, Inclusion of fibers improves the properties of this special concrete. Considering it, researchers have focused on studied the strength and durability aspects of fiber reinforced SCC which are:

Glass fibers
Carbon fibers
Basalt fibers
Polypropylene fibers etc.

Fibers used in this investigation are of glass, basalt & carbon, a brief report of these fibers is given below.

Alkali Resistance Glass Fibers

Glass fibers are formed in a process in which molten glass is drawn in the form of filaments. Generally 204 filaments are drawn simultaneously and cooled, once solidify they are together on a drum into a strand containing of the 204 filaments. The filaments are treated with a sizing which shields the filaments against weather and abrasion effects, prior to winding. Different types of glass fibers like C-glass, E-glass, S-glass AR-glass etc. are manufactured having different properties and specific applications. Fibers used for structural reinforcement generally fall into E-glass, AR-glass and S-glass owing to alkali resistant. By far the E-glass is most used and least expensive. Glass fibers come in two forms (1) Continuous fibers (2) Discontinuous or chopped fibers Principal advantages are low cost, high strength, easy and safe handling, and rapid and uniform dispersion facilitating homogeneous mixes which in term produce durable concrete. Limitations are poor abrasion resistance causing reduced usable strength, Poor adhesion to specific polymer matrix materials, and Poor adhesion in humid environments.

Basalt Fibers

Basalt Fibers are made by melting the quarried basalt rock at about 14000C and extrude through small nozzles to create continuous filaments of basalt fibers. Basalt fibers have alike chemical composition as glass fiber but have better-quality strength characteristics. It is extremely resistant to alkaline, acidic and salt attack making it a decent candidate for concrete, bridge and shoreline structures. Compared to carbon and aramid fiber it has wider applications like in higher oxidation resistance, higher temperature range (-2690C to +6500C), higher shear and compressive strength etc. Basalt fibers are ascertained to be very efficient in conventional and SCC concrete mixes for improving their properties.

Carbon Fibers

Carbon fibers have low density, high thermal conductivity, good chemical stability and exceptional abrasion resistance, and can be used to decrease or reduce cracking and shrinkage. These fibers increase some structural properties like tensile and flexural strengths, flexural toughness and impact resistance. Carbon fibers also help to improve freeze-thaw durability and dry shrinkage. The adding of carbon fibers decreases the electrical resistance.

Fracture Energy Behavior

The ductility can be measured by fracture behavior of FRSCC and to determine fracture energy. The general idea of this type of test is to measure the amount of energy which is absorbed when the specimen is broken into two halves. This energy is divided by the fracture area (projected on a plane perpendicular to the tensile stress direction). The resulting value is assumed to be the specific fracture energy GF. From the plot we will conclude that more the area occupied by load-displacement curve more is the fracture energy.

In detail, this thesis is divided into five chapters. Though the current chapter deals with introduction & methodology of fiber reinforced self-compacting concrete (FRSCC), the 2nd chapter describes the literature review studied for this investigations on FRSCC. The 3rd chapter touches the experimental work already done on different kinds of FRSCC is taken up in these investigations. In the 4th chapter, the results of the experiments presented & discussion on results are discussed. In the last chapter, all the findings of the foregoing chapters are summed up.

Objective and Methodology

The objective of present research is to mix design of SCC of grade M30 and to investigate the effect of inclusion of chopped basalt fiber, glass fiber & carbon fiber on fresh properties and hardened properties of SCC. Fresh properties comprise flow ability, passing ability, and viscosity related segregation resistance. Hardened properties to be studied are compressive strength, splitting tensile strength, flexural strength, modulus of elasticity, Ultrasonic pulse velocity and fracture energy. Fiber-reinforced self-compacting concrete uses the flow ability of concrete in fresh state to improve fiber orientation and in due course enhancing toughness and energy absorption capacity. In the past few years there has been a boost in the development of concretes with different types of fibers added to it. In the present work the mechanical properties of a self-compacting concrete with chopped Basalt, glass & Carbon fiber of length 12mm, added in various proportions (i.e., 0%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%) will be studied in fresh and hardened state. With the help of scanning electron microscope (SEM) the microstructure of fibered concrete was also studied.

The fracture energy behavior is one parameter that is very useful in calculating the specific fracture energy, GF, is by means of a uniaxial tensile test, where the complete stress-deformation curve is measured.

The present studies are designed at making standard grade (M30) fiber reinforced SCC with glass fibers, basalt fibers & carbon fibers and study their mechanical & structural behavior.

Methodology

Mix Design of self-compacting concrete of M30 grade.

Mixing of SCC and determination of its fresh properties in terms of flowability, passing ability and segregation resistance by using Slump flow ,V-funnel and L-box apparatus .

Casting of standard specimens to determine compressive, tensile, flexural strengths and fracture energy.

Mixing of SCC impregnated with different fibers in different dosages and determination of their fresh properties in terms of flow-ability, passing ability and segregation resistance by using Slump flow, V-funnel and L-box apparatus.

Casting of standard specimen to determine compressive, tensile, flexural strengths and fracture energy incorporating glass fiber, basalt fiber and carbon fiber of different volume fraction ranging from 0.1% to 0.3%. Testing of standard specimens for strength determination after 7days and 28 days. Sorptivity test for determination of absorption capacity of SCC cubes reinforced with different fibers after 28 days.

Study of micro structures by SEM of SCC reinforced with different fibers at different ages.

EXPERIMENTAL INVESTIGATION ON SELF-COMPACTING CONCRETE

GENERAL

In this study, the mechanical behavior of fiber reinforced self-compacting concrete of M30 grade prepared with basalt fiber, glass fiber and carbon fiber were studied. For each mix six numbers of cubes (150×150×150) mm, three numbers of cylinders (150×300) mm and six numbers prisms (100×100×500) mm were cast and investigations were conducted to study the mechanical behavior, fracture energy behavior, microstructure of plain SCC, basalt fiber reinforced SCC (BFC), glass fiber reinforced SCC (GFC), carbon fiber reinforced SCC (CFC). The observational plan was held up in various steps to accomplish the following aims:

To prepare plain SCC of M30 grade and obtain its fresh and hardened properties.

To prepare basalt, glass & carbon fiber reinforced SCC of M30 grades and study their fresh and hardened properties.

To analyze the load-deflection behavior of SCC, BFRSCC, GFRSCC & CFRSCC.

To examine the fracture energy behavior & the micro structure of plain SCC, BFC, and GFC & CFC.

MATERIALS

Cement

Portland slag cement of Konark brand available in the local market was used in the present studies. The physical properties of PSC obtained from the experimental investigation were confirmed to IS: 455-1989.

Coarse Aggregate

The coarse aggregate used were 20 mm and 10 mm down size and collected from Quarry.

Fine Aggregate

Natural river sand has been collected from Koel River, Rourkela, Orissa and conforming to the Zone-III as per IS-383-1970.

Silica Fume

Elkem Micro Silica 920D is used as Silica fume. Silica fume is among one of the most recent pozzolanic materials currently used in concrete whose addition to concrete mixtures results in lower porosity, permeability and bleeding because its fineness and pozzolanic reaction .

Admixture

The SikaViscoCrete Premier from Sika is super plasticizer and viscosity modifying admixture, used in the present study.

Water

Potable water conforming to IS: 3025-1986 part 22 &23 and IS 456-2000 was employed in the investigations.

Glass Fiber

Alkali resistant glass fiber having a modulus of elasticity of 72 GPA and 12mm length was used.

Basalt Fiber

Basalt fiber of 12mm length was used in the investigations.

Carbon Fiber

Carbon fiber of length 12mm was used in the investigations.

International Journal of Research
Available at https://journals.pen2print.org/index.php/ijr/

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 04
April 2019

Table 3.1.1 Mechanical Properties of Fibers

Fiber variety	Length (mm)	Density (g/cm3)	Elastic modulus(GPa)	Tensile strength(MPa)	Elong. At break(%)	Water absorption
Basalt	12	2.65	93-110	4100-4800	3.1-3.2	<0.5
Glass	12	2.53	43-50	1950-2050	07-Sep	<0.1
Carbon	12	1.8	243	4600	1.7	

(A) (B) (C)

Fig.3.1.1 (A) Glass Fiber (B) Carbon Fiber (C) Basalt Fiber

Fig.3.1.1 (A) Glass Fiber (B) Carbon Fiber (C) Basalt Fiber

RESULTS OF THE EXPERIMENTAL INVESTIGATIONS ON FRSCC

This chapter deals in detail with the results of experimental investigations and discussion carried out in different stages.

PREPARATION OF SCC AND FRSCC AND STUDIES ON FRESH AND HARDENED PROPERTIES

The first stage of investigations was carried out to develop SCC mix of a minimum strength M30 grade using silica fume and chemical admixtures, and to study its fresh and hardened properties. For developing SCC of strength M30 grade, the mix was designed based on EFNARC 2005 code using silica fume as mineral admixture. Finally, SCC mixes which yielded satisfactory fresh properties and required compressive strength, were selected and taken for further investigation. In the second stage of investigation SCC with different fiber contents with different volume fraction were mixed. The mix proportions are shown in table 3.2.1.

Water/cement Ratio of Self-Compacting Concrete

To maintain the basic characteristics of self-compacting concrete a water cement ratio of 0.42 was adopted and a % dosage of super-plasticizer Viscocrete of Sika brand were fixed for all mixes.

Mix Proportions and Fiber Content

The number of trial mixes was prepared in the laboratory and satisfying the requirements for the fresh state given by EFNARC 2005 code.

The present work involved preparation of M30 grade SCC and to study its behavior when different types of fibers were added to it. Plain SCC of M30 grade was prepared using silica fume as mineral admixture with sika viscocrete as admixture.

Table 4.1.1 Description of Mixes

Designation	Fiber content (%)	Description
PSC	0.00%	Plain self-compacting concrete
BFC-1	0.10%	0.1% Basalt fiber reinforced SCC
BFC-1.5	0.15%	0.15%Basalt fiber reinforced SCC
BFC-2	0.20%	0.2%Basalt fiber reinforced SCC
BFC-2.5	0.25%	0.25%Basalt fiber reinforced SCC
BFC-3	0.30%	0.3%Basalt fiber reinforced SCC
GFC-1	0.10%	0.1%Glass fiber reinforced SCC
GFC-1.5	0.15%	0.15%Glass fiber reinforced SCC
GFC-2	0.20%	0.2%Glass fiber reinforced SCC
GFC-2.5	0.25%	0.25%Glass fiber reinforced SCC
GFC-3	0.30%	0.3%Glass fiber reinforced SCC
CFC-1	0.10%	0.1%Carbon fiber reinforced SCC
CFC-1.5	0.15%	0.15%Carbon fiber reinforced SCC
CFC-2	0.20%	0.2%Carbon fiber reinforced SCC

4.2 Results and DiscussionTable

4.2.1 Results of the Fresh Properties of Mixes

sample	Slump flow 500-750mm	T_{50} flow 2-5sec	L-Box(H_2/H_1) 0.8-1.0	V-Funnel 6-12sec	T5 Flow +3sec	Remarks
PSC	720	1.6	0.96	5	9	Low viscosity (Result Satisfied)
BFC-1	680	2.1	0.89	8	12	Result Satisfied
BFC-1.5	645	2.5	0.85	8	13	Result Satisfied
BFC-2	620	3.8	0.81	9	14	Result Satisfied
BFC-2.5	580	5.2	0.68	10	16	High viscosity Blockage (RNS)
BFC-3	520	6	0.59	11	18	Too high viscosity Blockage (RNS)
GFC-1	705	2	0.9	7	10	Result Satisfied
GFC-1.5	665	3.8	0.88	7.7	11	Result Satisfied
GFC-2	650	4.7	0.84	8.5	12	Result Satisfied
GFC-2.5	640	5	0.82	9	12	Result Satisfied
GFC-3	530	5.9	0.7	11	15	Too high viscosity Blockage (RNS)
CFC-1	560	4.8	0.8	10	14	Result Satisfied
CFC-1.5	410	_	_	18	_	Too high viscosity Blockage (RNS)
CFC-2	260	_	_	23	_	Too high viscosity Blockage (RNS)

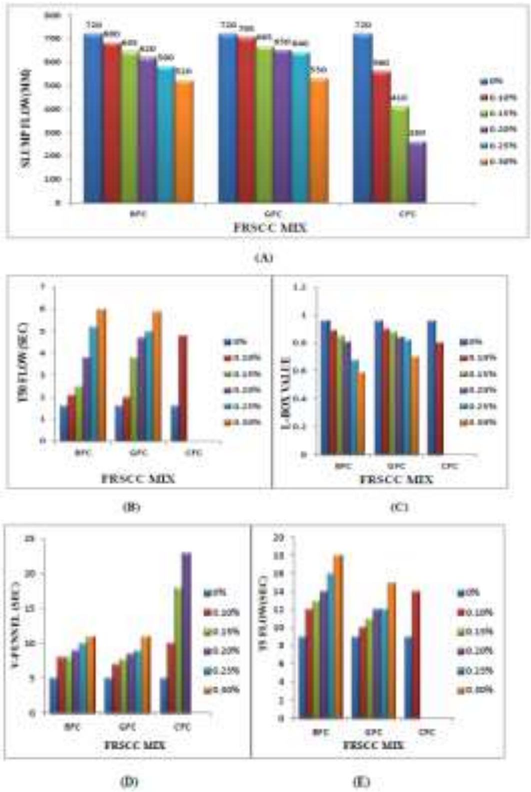


Fig. 4.2.1 (A),(B),(C),(D),(E) Variation of Fresh properties with FRSCC Mix

Properties in Fresh state:

The Table 4.2.1 and the Fig.4.2.1 indicate reduction of flow value owing to inclusion of fibers. The reason for this phenomenon is that a network structure may form due to the distributed fiber in the concrete, which restrains mixture from segregation and flow.

Slump Flow

The slump flow decreases with increase in fiber percentage. The decrease in flow value is observed maximum 63.88% for carbon fiber, 26.38% for glass fiber and 27.77 % for basalt fiberw.r.t control mix. This is because carbon fibers absorbed more water from the mix and beyond 0.2% fiber addition the mix did not satisfied the norms of self-compacting concrete. Glass fibers absorb lowest water.

T50 Flow

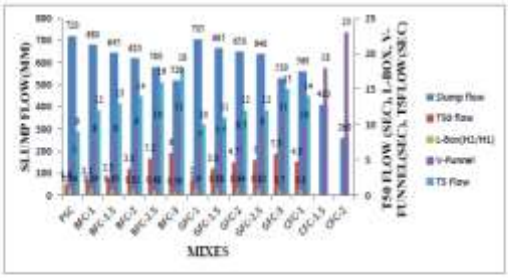
The T50 flow, which was measured in terms of time (seconds) increases as the slump flow value decreases. The decrease in slump value is due to the increase in the percentage of fiber which was explained in previous section. The maximum time taken to flow was observed at 0.1% for carbon fiber, 0.3% for glass fiber and 0.3% for basalt fiber.

L-Box

The L-Box value increases as the slump flow value increases. The increase in slump value is due to the increase in the percentage of fiber as well as the L-Box value also increases. The maximum value obtained in the case of control mix but as per SCC specification 0.2% basalt fiber. 0.25% glass fiber & 0.1% carbon fiber fulfill the requirements.

V-Funnel & T5 flow

The V-Funnel test & T50 flow, which was measured in terms of time (seconds) & both the value measured are dependent with each other. V-Funnel value and T5 flow increases as the slump flow value decreases. The decrease in slump value is due to the increase in the percentage of fiber. It was observed that at 0.1% of carbon fiber, 0.2% of basalt fiber and 0.25% og glass fiber the SCC specification were satisfied.



Hardened Properties

To compare the various mechanical properties of the FRSCC mixes the standard specimens were tested after 7 days and 28 day of curing. The results are summarized in Table 4.3.1

Table- 4.3.1 Hardened Concrete Properties of SCC and FRSCC

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 04
April 2019

Mixes	7-Day compressive strength (MPa)	28-days compressive strength (MPa)	28-days split tensile strength (MPa)	28-days flexural strength (MPa)
PSC	33.185	40.89	4.1	7.37
BFC-1	31.11	38.67	3.11	7.84
BFC-1.5	34.22	49.77	4.95	11.4
BFC-2	37.77	50.99	5.517	11.78
BFC-2.5	45.48	61.4	4.52	11.92
BFC-3	20.89	32.89	4.24	7.54
GFC-1	24.88	40.89	2.97	7.44
GFC-1.5	33.77	46.19	4.81	9.74
GFC-2	32.89	47.11	4.95	10.08
GFC-2.5	31.55	45.33	3.96	9.46
GFC-3	23.55	39.11	3.678	8.32
CFC-1	24.44	42.22	3.82	7.52
CFC-1.5	43.11	62.22	5.23	12.32
CFC-2	40.89	55.2	4.52	10.54

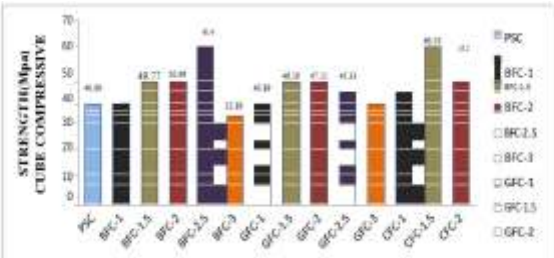


Fig. 4.3.3 Variation of 28days Compressive Strength for Different SCC Mixes

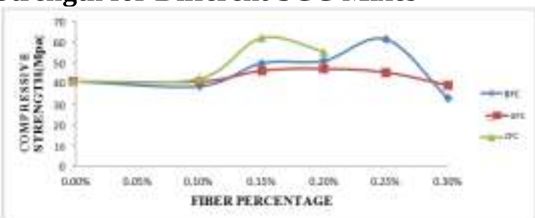


Fig. 4.3.4 Comparison of Different Percentages of Fiber Mixes with 28 days Compressive Strength

The fig.4.3.4 shows the optimum fiber content in mixes with different fibers. The maximum strength of 61.4 MPa was observed with 0.25% basalt fiber content, 60.35 MPa was observed with 0.15% carbon fiber content and 47.11 MPa was observed with 0.2% glass fiber content. The highest 28-days compressive strength was observed for mix with 0.25%basalt fiber and lowest for mix with 0.3%basalt fiber.

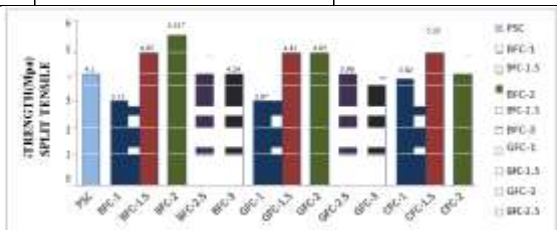


Fig. 4.3.5 Variation of Split Tensile Strength for Different SCC Mixes At 28days

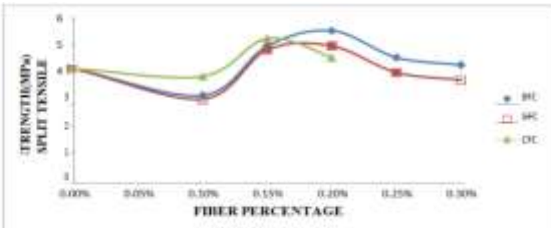


Fig. 4.3.6 Comparison of Different Percentages of Fiber Mixes with 28 days Split Tensile Strength

The Fig. 4.3.6 shows the optimum fiber content in mixes with different fibers. The maximum strength of 5.517MPa was observed with 0.2% basalt fiber content, 5.23MPa was observed with 0.15% carbon fiber content and 4.95MPa was observed with 0.2% glass fiber content. The highest 28-days split tensile strength was observed for mix with 0.2%basalt fiber and lowest for mix with 0.1% glass fiber.

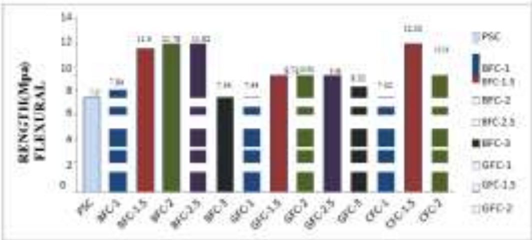


Fig. 4.3.7 Variation of Flexural Strength for Different SCC Mixes At 28days

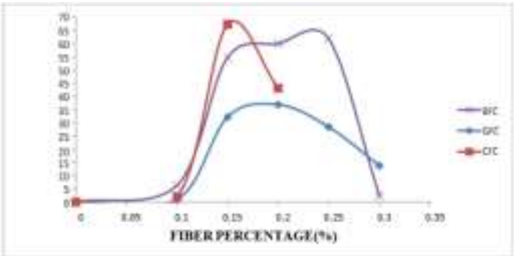


Fig. 4.3.8Flexural Strength-Effectiveness of FRSCC at 28-Days

The Fig. 4.3.8 shows the optimum fiber content in mixes with different fibers. The maximum strength of 12.32MPa was observed with 0.15% carbon fiber content, 11.92MPa was observed with 0.25% basalt fiber content and 10.08MPa was observed with 0.2% glass fiber content. The highest 28-days flexural strength was observed for mix with 0.15%carbon fiber and lowest for mix with 0.1%glass fiber.

Compressive Strength

4.3.1.1 7-Days Compressive Strength

Compared to the plain SCC the compressive strength reinforced with basalt fiber of volume fraction 0.15%, 0.2% and 0.25% increase by 3.12%, 13.82% and 37.05% respectively. Compared with the plain SCC the compressive strength reinforced with glass fiber of volume fraction 0.15% increase by 1.76%. In this study the 7 days compressive strength of glass fiber shows no obvious improvement. Compared with the plain SCC the compressive strength reinforced with carbon fiber of 0.15% and 0.2% increase by 29.9% and 23.22% respectively. Fig. 4.3.1 shows that for CFC and BFC has higher compressive strength at 7 days at volume fraction of 0.15% to 0.25%.

4.3.1.2. 28-Days Compressive Strength

From Fig.4.3.5.Compared with plain SCC, 0.15% of BFC, GFC and CFC increase 21.72%, 10.52% and 47.6% respectively. For 0.2% of BFC, GFC and CFC increase 24.7%, 15.21% and 35% respectively. For 0.25% of BFC and GFC increases 50.16% and 11% respectively. In this study, Fig.4.2.4 shows that the optimum dosages for BFC are 0.25%, for GFC is 0.2% & for CFC is 0.15%.

Split Tensile Strength

The percentage enhancement of split tensile strength for basalt fiber over plain SCC is 20.44%, 34.56%, 10.24% & 3.41% when adding 0.15%, 0.2%, 0.25% & 0.3% respectively. The percentage enhancement of split tensile strength for glass fiber over plain SCC is 17.31%, 20.73% when adding 0.15% & 0.2% respectively. The percentage enhancement of split tensile strength for carbon fiber over plain SCC is 27.56% & 10.24% respectively. The increase is due to the fiber as explained before.

Flexural Strength

Table 4.3.1 & Fig. 4.3.7 shows flexural strengths of FRSCC mixes after 28 days and fig.4.2.8 shows the optimum fiber fraction imparting maximum flexural strength with different fibers. As expected, all FRSCC specimens show an increase in flexural strength with increase in fiber content. Compared with the plain SCC the enhanced percentage of the flexural strength of carbon FRSCC were observed in the range of 2.03% to 67.16% while 0.15% gave maximum strength. Increase in flexural strength were observed in ranges from 0.95% to 36.77% for GFC with the fiber percentage of 0.1% to 03% ,the and enhanced percentage flexural strength ranges from 2.37% to 61.736% were observed for basalt fiber with percentage fiber ranges from 0.1% to 0.3%. Maximum flexural strength 12.32MPa was observed for carbon FRCCC for 1.5% of fiber percentage.

CONCLUSION

From the present study the following conclusions can be drawn

1. Addition of fibers to self-compacting concrete causes loss of basic characteristics of SCC measured in terms of slump flow, etc.

2. Reduction in slump flow was observed maximum with carbon fiber, then basalt and glass fiber respectively. This is because carbon fibers absorbed more water than others and glass absorbed less.

3. Carbon fiber addition more than 2% made mix harsh which did not satisfy the aspects like slump value, T50 test etc. required for self-compacting concrete.

4. Addition of fibers to self-compacting concrete improve mechanical properties like compressive strength ,split tensile strength, flexural strength etc. of the mix.

5. There was an optimum percentage of each type of fiber, provided maximum improvement in mechanical properties of SCC.
6. Mix having 0.15% carbon fiber, 0.2% of glass fiber and 0.25% of basalt fiber were observed to increase the mechanical properties to maximum.
7. 0.15% addition of carbon fiber to SCC was observed to increase the 7-days compressive strength by 29.9%, 28-days compressive strength by 47.6%, split tensile strength by 27.56%, flexural strength by 67.16%.
8. 0.25% addition of basalt fiber to SCC was observed to increase the 7-days compressive strength by 37.05%, 28-days compressive strength by 50.16%, split tensile strength by 34.56%, flexural strength by 61.736%.
9. 2% addition of glass fiber to SCC was observed to increase the 7-days compressive strength by 1.76%, 28-days compressive strength by 15.21%, split tensile strength by 20.73%, flexural strength by 36.77%.
10. The FRSCC mixes exhibited increase in ductility measured through load deflection diagrams. The basalt fiber reinforced SCC exhibited maximum increment than carbon and glass FRSCC.
11. The load vs. crack mouth opening displacement diagrams for FRSCC exhibited increase in fracture energy properties of the mixes. This is owing to crack arresting mechanism of the fibers in the matrix. In this regard the carbon fiber exhibited best performance, then the basalt and then glass fiber.
12. Correlation graph between compressive strength and avg. UPV values for 28 days indicated good correlation for carbon FRSCC (R^2= 1), basalt FRSCC (R^2 =0.9845) and glass FRSCC (R^2=0.9748). These values represent sound concrete having uniform distribution of fibers and concrete ingredients, dense structure in all FRSCC mixes.
28 The SEM analysis of microstructure of FRSCC exhibited good physical bond between all types of fiber and the hydrated matrix. A dense structure of matrix was observed in each mixes owing to addition of silica fume. No apparent variation was observed between mix of 7days and 28days.
14. Capillary absorption of water by FRSCC mixes were determined by sorptivity test. The higher sorptivity coefficient was observed for carbon FRSCC mixes because carbon fibers absorbed more water. Least values were observed by basalt FRSCC.
15. The performance of carbon fiber reinforced SCC mixes was better than basalt FRSCC and glass FRSCC mixes. Then carbon fiber FRSCC exhibited best mechanical properties with comparatively lower volume fraction but its effect on SCC fresh properties was just reverse. Its inclusion reduced flow-ability, deformability because it absorbs more water. Other drawback is that it is costliest than other two types of fibers.
16. Glass FRSCC exhibited improvement in all mechanical properties especially in early ages, with higher volume fraction. It showed better performances in fresh state. Apart from being cheapest its performance in fresh state but displayed minimum strength, highest sorptivities. The microscopic study (SEM) exhibited better bond development than other two types in early days.
17. Basalt FRSCC exhibited better properties in fresh state and hardened state compared to the Glass FRSCC. In terms of the cost it is cheaper than carbon hence basalt fiber performance is overall best compared with glass and carbon fiber.

REFERENCES

[1]. **Ouchi M. And Okamura H.** "Mix-Design for Self-Compacting Concrete", Concrete Library of JSCE, No.25, June **1995**(ND), pp107-120.
[2]. **Ouchi M. And Okamura H.** "Effect of Super plasticizer On Fresh Concrete", Journal of Transportation Board, **1997**, pp37-40.
[3]. **Khayat. K.H.** "Workability, Testing and Performance of Self-consolidating Concrete" Technical Paper Title No. 96-M43, ACI Journal/May-June **1999**, pp346-353.
[4]. **Victor C. Li, H.J.Kong, and Yin-Wen Chan** "Development of Self-Compacting Engineered Cementitious Composites" The University of Michigan, Ann Arbor-MI 48109-2125, USA**,(1999).**
[5]. **Gaopeiwei, Deng Min and FengNaiqui**"The Influence of SP and Superfine Mineral Powder on the Flexibility, Strength and Durability of HPC". Cement and Concrete Research. **2000**, vol.31, pp703-706.
[6]. **Neol P Mailvaganam**. "How Chemical Admixtures Produce their Effects in Concrete", Indian Concrete Journal, May **2001**, pp331- 334.
[7]. **Nan Su, Kung-Chung Hsu, His-Wen Chai** "A Simple Mix Design method for Self-Compacting Concrete" Journal of Cement and Concrete Research 31**(2001)**pp 1799-1807.

[8]. Sonebi. M and Bartos. P.J.M "Filling ability and Plastic Settlement of Self Compacting Concrete" Materials and Structures, Vol.35 September-October **2002** pp462-469.

[9]. Hajime Okamura and Masahiro Ouchi ; Invited Paper on "Self Compacting Concrete"-Journal of Advanced Concrete Technology Vol.1, No.1, pp5-15, April **2003** Japan Concrete Institute.

[10]. RavindraGettu, Hannah Collie, CamiloBernad, Tomas Garcia and Clotie D Robin "Use of High Strength Self Compacting Concrete in Prefabricated Architectural Elements", International Conference on Recent Trends in Concrete, Technology and Structures INCONTEST 2003 Coimbatore, September 10-12, **2003**, PP355-363.

[11]. Raghuprasad P. S. "Comparative Study on Different types of Blended Cement with Different Grade O.P.0 Concrete - An Experimental Approach", ICACC-2004. Proceedings of International Conference on Advances in Concrete and Construction. 16-18 December **2004**, Hyderabad, Vol.II, pp637- 646.

[12]. Lachemi M and Hossain K. M. A. "Self-Consolidating Concrete incorporating New Viscosity Modifying Admixtures" Cement & Concrete Research 34**(2004)**, pp 185-193.

[13]. Amit Mittal, Kaisare M.B and Shetty R.G "Use of SCC in a Pump House at TAPP 3 &, 4, Tarapur", The Indian Concrete Journal, June **2004**, pp30-34.

[14]. Frances Yang "Self - Consolidating Concrete", CE 241: Concrete **2004**; Report # 1, March 9, 2004.

[15]. Anne-MiekePoppe and Geert De Schutter, "Creep and Shrinkage of Self Compacting Concrete", International Conference on Advances in Concrete, Composites and Structures, SERC, Chennai, January 6-8, **2005**, pp329-336.

[16]. "The European Guidelines for Self—Compacting Concrete" (Specification, Production and Use) May **2005**..

[17]. SeshadriSekhar.T, Sravana. P and SrinivasaRao.P, "Some Studies on the Permeability Behavior of Self Compacting Concrete" AKG Journal of Technology, Vol.1, No.2**.(2005)**

[18]. AnirwanSenguptha and Manu Santhanam "Application Based Mix Proportioning for Self Compacting Concrete", 31st Conference On Our World in Concrete 85 Structures, Singapore, August 16-17, **2006**, pp353-359.

[19]. Borsoi. A, Collepardi. M, Collepardi. S, Croce. E.N., Passuelo .A "Influence of Viscosity Modifying Admixture on the Composition of SCC "Supplementary volume of Eighth CANMET/ACI International Conference on Super-plasticizers and other Chemical Admixtures in Concrete, October 29-November 1, **2006**, Sorrento, Italy pp253-261.

[20]. Giri Prasad. G, SeshagiriRao. M.V and Rama Rao. G.V. "Computation of Stress-Strain Behavior of Self-Compacting Concrete in Higher Grade" International Journal of Scientific Computing, Vol.3, No.2 July-December **2009**pp 193-197.

[21]. M. Vijayanand, NicolaeAngelescu, K.U. Muthu, C.G. Puttappa & H.SudarsanaRao, "Flexural Characteristics Of Steel Fiber Reinforced Self Compacting Concrete Beams" The Scientific Bulletin of VALAHIA University – MATERIALS and MECHANICS – Nr. 5 (year 8) **2010**

[22]. Cunha. V.M.C.F, Barros. J.A.O and Sena-Cruz. J.M. "An Integrated Approach for Modeling the Tensile Behavior of Steel Fiber Reinforced Self-Compacting Concrete" - Cement and Concrete Research 41 **(2011)** pp64-76.

[23]. Mustapha Abdulhadi, —A comparative Study of Basalt and Polypropylene Fibers Reinforced Concrete onCompressive and Tensile Behavior", International Journal of Engineering Trends and Technology (IJETT) – Volume 9 Issue 6- March **2012**

[24]. M.g. Alberti, A. Enfedaque, J.C Galvez, "On The Mechanical Properties & Fracture Behavior Of Polyefin Fiber-Reinforced Self-Compacting Concrete", Construction & Building Material 55 (**2014**) 274-288

[25]. Chaohua Jiang, Ke Fan, Fei Wu, Da Chen, "Experimental study on the mechanical properties and microstructure of chopped basalt fiber reinforced concrete", Materials and Design 58 **(2014)** 187–193

Sri.B.Bulli Babu
(P.H.D, M.Tech, Associate Professor)

Lakavath Ramesh
(M.Tech, Structural engineering)