EXPERIMENTAL STUDIES ON SELF COMPACTING CONCRETE USING BASALT FIBER AND CARBON FIBER

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Abstract : Concrete is second most widely used material other than water,its more versatile but madern day engineering structures require more demanding concrete owing to the huge apllied load on smaller area and increasing adverse environmental conditions.In this work tried to utilize fibers as a strength enhancement agent in SCC to obtain higher strength with good workability. The present work ,to experimental studies of strength and SCC characteristics of basalt fiber and carbon fiber reinforced concrete of M30 grade and superplasticizer.The mix proportions for self-compacting concrete were arrived at by performing mix design and then fine-tuning using EFNARC guidelines.The basalt and carbon fiber percentage was varied from 0.05% ,0.10% ,0.15% by weight of concrete.And also to taken the data for hardened concrete properties like compressive strength ,split tensile strength,flexural strength.

Keywords : Cement, Fly ash, super plasticizer, Basalt fiber, Carbon fiber, Self-compacting concrete, physical properties, Concrete properties, workability, M30 Concrete.

1. INTRODUCTION:

Current scenario in the building industry shows increased construction of large and complex structures,which often leads to difficult concreting conditions.When large quantity of heavy reinforcement is to be placed in reinforced concrete members it is difficult to ensure that the form work gets completely filled with concrete that is fully compacted without voids or honeycombs.Vibrating concrete in congested locations may cause some risk to labour and there are always doubts about the strength and durability of concrete placed in such locations.One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of Self Compacting Concrete (SCC).

Self-compacting concrete (SCC) was developed in Japan by Okamura in the late 1980's to be mainly used for highly congested reinforced concrete structures in seismic regions.it has been described as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labour, it has proved beneficial economically because of a number of factors, including:

- faster construction
- reduction in site manpower
- better surface finishes
- easier placing
- improved durability
- greater freedom in design
- thinner concrete sections
- reduced noise levels

Self Compacting Concrete (SCC) was the concept to address the issues like long production times, unhealthy work environment in cast in-situ concrete technology. The SCC can flow through and fill the gaps of congested reinforcement and corners of moulds without any need for vibration and compaction during the placing process. The excellent user-friendly characteristics of SCC are of great attraction today in traditional construction industry also. But it is not yet utilized in house buildings to a large extent with the conception that the use of higher fines and chemical admixtures in SCC leads to more material cost and higher strengths than the required for NVC, and also higher paste volume and lower coarse aggregate content known to increase the drying shrinkage of SCC.

Therefor,the use of fibers into SCC mixes has been presented by many researchers. Depending on many parameters such as maximum aggregate size,fiber volume,fiber type,fiber geometry,and fiber aspect ratio,fiber inclusion to concrete reduces the workability of concrete.Reduction of workability in FRC is a handicap on-site applications.However, the FRC and SCC together producing an superior properties in not only hardened but also fresh state.Same is the reason behind Present Study.

1.1 Basalt fiber

Basalt fiber is a natural material that is found in volcanic temperature comprised between 1500^0 and 1700^0C. Its state is strongly influenced by the temperature rate of quenching process that leads to more or less complete crystallization. Another feature of the basalt fiber is their good compatibility with the matrix materials even if there are some research focused on the surface treatment of these fiber in order to modify their surface morphology and improve their wettability with the matrix material.

Fig.1: Basalt Fiber

1.2 Carbon fiber

The density of carbon fiber is very less, and having high thermal conductivity, great chemical stability and remarkable resistance to abrasion, and can be utilized to reduce or decrease splitting and shrinkage. Some structural properties like tensile strength and flexural strength , resistance to impact and flexural toughness can be increased by adding these fibers. Addition of carbon fibers also help to enhance freeze-thaw durability and dry shrinkage.

Fig.2: Carbon Fiber

1.3 Objectives of the Study

In this article,two different types of fibers (Carbon fiber,basalt fiber) are used and the effect of fiber inclusion on the workability of FRC-SCC is studied.Slump flow,V-funnel, J-ring and L-box tests are performed to assess workability .Morever,the mechanical properties namely the compressive ,flexural and tensile strengths are also determined at various ages.Also to compare the properties of fibers reinforced self compacting concrete with conventional self compacting concrete.

2.MATERIAL USED AND ITS PROPERTIES

Materials used for the experiment includes Ordinary Portland Cement of grade 30, fine aggregate of size less than 4.75mm, coarse aggregate of size less than 20 mm, super plasticizer. In addition, basalt fiber and carbon fiber is add to the mix to improve the mechanical property of self compacting concrete. Table.no.1 shows the physical properties of the materials which are used in this study.

Table 1 : Physical Properties Of Materials

Sr.No	Materials	Properties	
1	Cement	Specific gravity	Fineness modulus
		3.12	6%
2	Fine aggregate	Specific gravity	Water absorption
		2.78	1.6%
3	Coarse aggregate	Specific gravity	Water absorption
		2.86	0.5%
4	Super plasticizer	Density	
		3.5	

2.1Properties of basalt fiber

- Provide more durability, high flexural and fatigue flexural strength, improved abrasion, spalling and impact resistance.
- Higher compressive and higher shear strength.
- Highly resistant to alkaline, acidic and salt attack.
- Higher oxidation resistance and radiation resistance.

2.2 Properties of carbon fiber

- High strength to weight ratio.
- Rigidity and corrosion resistance.
- Fatigue resistance.
- Good tensile strength but brittle.
- High thermal conductivity and fire resistant.

2.3 Mix proportion

Mix Ratio of 1:1.98:2.42 with 0.45 w/c ratio and 1% admixture by weight of cement is used for the present study. Trial mixes were prepared based on the directions of EFNARC and using Nan-Su method of mix design as a resource, to prepare SCC of strength of 30MPa. The mix proportions were achieved based on the trial mixes.

2.4 Mixing Procedure

For preparing normal SCC, tilting drum mixer were used. Cement and fly ash were added into the mixer and then it is dry mixed for 60 seconds. After that sand and coarse aggregates were added and then its mixed for 60 seconds. Water and superplasticizers were added at last and then mixed for almost 3 minutes. In case of fiber reinforced SCC, basalt fiber and carbon fibers were mixed properly with materials and following that above procedures are carried out.

2.5 Testing of Specimen

Workability is measured by filling fresh concrete into the slump cone and V-Funnel apparatus to find slump flow diameter.And also measured passing ability of fresh concrete into L-box apparatus and J-ring. Specimens are prepared by varying fiber content at a ratio of 0.05%, 0.10%, 0.15%, by weight of cement. Cube specimen of size 150mm x 150m x 150mm and cylinder specimen of diameter 150mm and height 300mm was chosen as per IS-516-1969. Compression test and split tensile tests were conducted to attain optimum value of fiber to be added to the concrete specimen. Result shows that the strength of the specimen increases first and then decreases with the addition of fiber. Reinforced beam specimen of size 15cmx15cmx70cm are casted and tested for flexure strength.

3. RESULT AND DISCUSSION

3.1 Results of Fresh Proporties

The test results for the filling ability (V-funnel,slump cone),passing ability (J-ring,L-box flow),Compressive strength, Split tensile strength, Flexural strength,Durability of different SCC mixtures are given in below tables and graphs.

Table 2 and Table 3 shows the various flow properties obtained for all the mixes

Table 2 : Fresh Property Result (Basalt fiber)

Designation (%)	Slump Flow(mm)	L-Box value (H_2/H_1)	T_{500} Flow (Sec.)	V-Funnel Flow (sec.)
PSC	730	0.96	2.6	5
BFC-0.05	690	0.89	2.9	8
BFC-0.10	645	0.85	3.1	9
BFC-0.15	615	0.81	3.8	10

Table 3 : Fresh Property Result (Carbon Fiber)

Designation (%)	Slump Flow(mm)	L-Box value (H_2/H_1)	T_{500} Flow (Sec.)	V-Funnel Flow (sec.)
PSC	739	0.97	2.9	7.6
CFC-0.05	706	0.89	3.1	8.3
CFC-0.10	701	0.91	3.6	8.7
CFC-0.15	681	0.88	3.8	12.32

From above table indicate the reduction of workability owing to inclusion of basalt fiber.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

3.2 Results of Hardened Properties

3.2.1 Compressive strength test

Compressive strength test was carried out on cube specimen of size 150mm x150mm x150mm. Three sets of specimens were casted by varying fiber content. The compressive strength of specimen with hybrid fiber is compared with conventional specimen. Table 3 shows test results of compression test for addition of different percentage of hybrid fiber ranging from 0.05% to 0.15% by weight of cement.

Table 4: Cube Compressive Strength Results(Basalt fiber)

Designation(%)	28th Day Compressive Strength (MPa)	56th Day Compressive Strength (MPa)
PSC	32.71	45.38
BFC-0.05	34.81	48.71
BFC-0.10	38.01	53.03
BFC-0.15	41.82	54.81

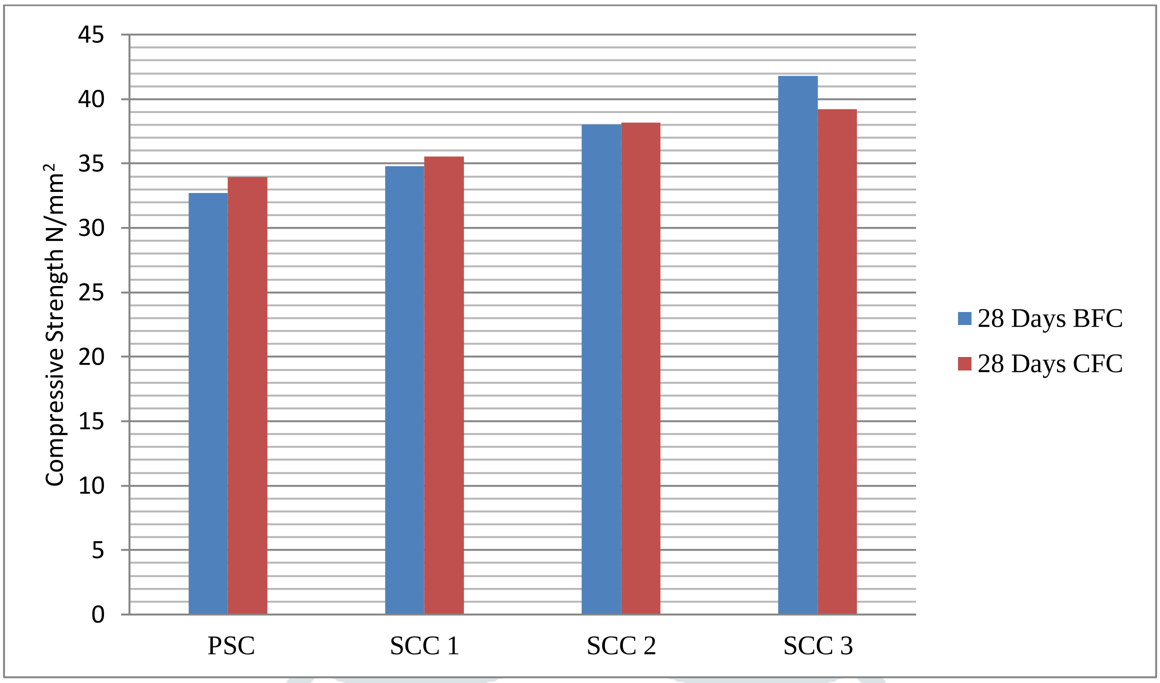

Chart 1 : Compressive Strength of cube at the end of 28th Days

Table 5 : Cube Compressive Strength Results (Carbon Fiber)

Designation(%)	28th Day Compressive Strength (MPa)	56th Day Compressive Strength (MPa)
PSC	29.86	41.98
CFC-0.05	32.86	40.26
CFC-0.10	37.26	43.87
CFC-0.15	34.51	42.84

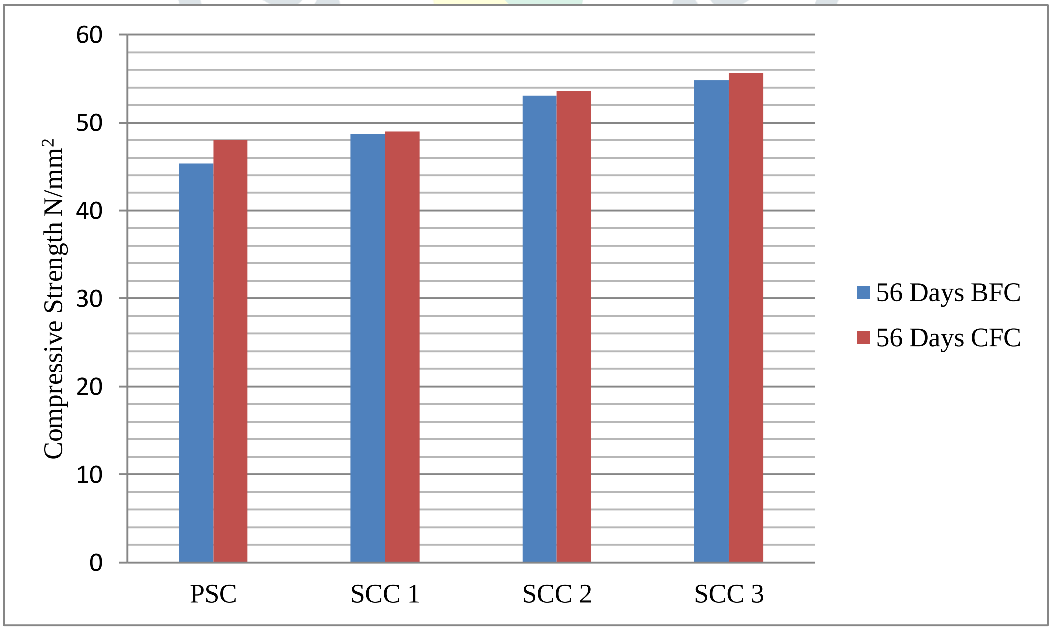

Chart 2 :Compressive Strength of cube at the end of 28th Days

3.2.2 Split Tensile Test

Tensile strength is a vital property of concrete because concrete structures are more vulnerable to tensile cracking. Split cylinder test is the standard test to determine the tensile strength of concrete. The test should be carried out in accordance with IS 5816-1970. The size of the specimen chosen was of 300mm height and 150mm diameter. Table 5 shows the result of split tensile strength.

Table 6 : Split Tensile Test (Basalt Fiber)

Designation(%)	28th Day Split Tensile Test in (MPa)	56th Day Split Tensile Test in (MPa)
PSC	3.82	4.59
BSF-0.05	4.02	5.45
BSF-0.10	4.80	5.97
BSF-0.15	5.82	6.46

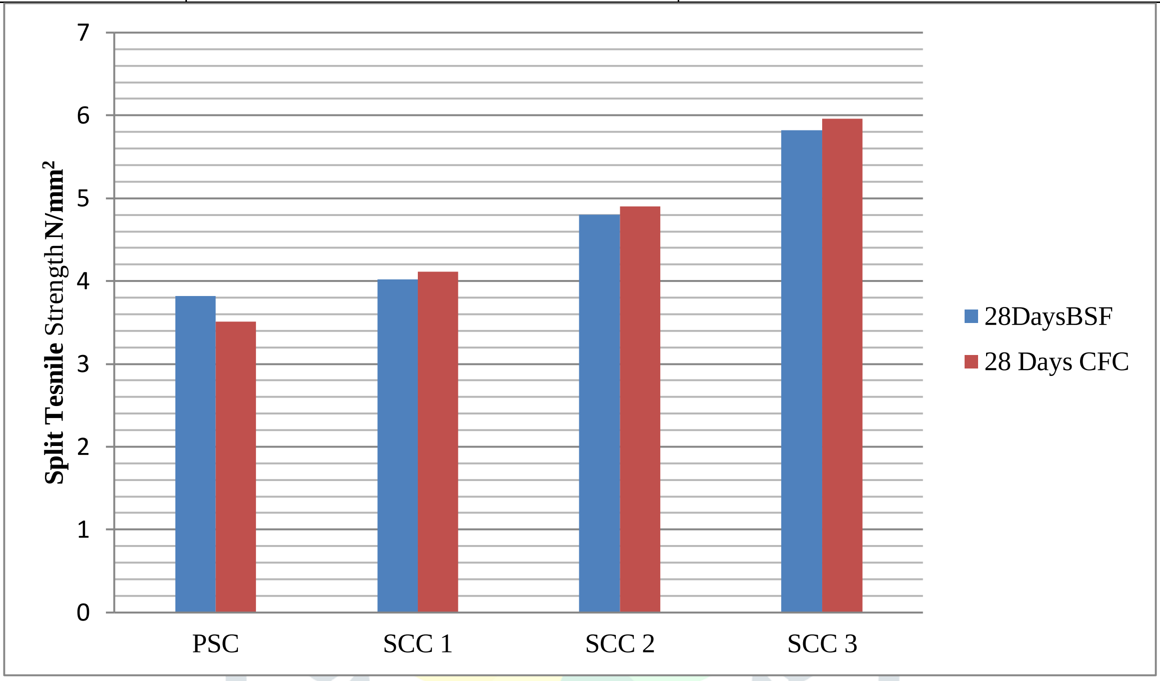

Chart 3 : Split Tensile Test at the end of 28th days

Table 7 :Split Tensile Test (Carbon fiber)

Designation(%)	28th Day Split Tensile Test in (MPa	56th Day Split Tensile Test in (MPa
PSC	3.51	4.66
CFC-0.05	4.11	5.40
CFC-0.10	4.9	5.93
CFC-015	5.96	6.51

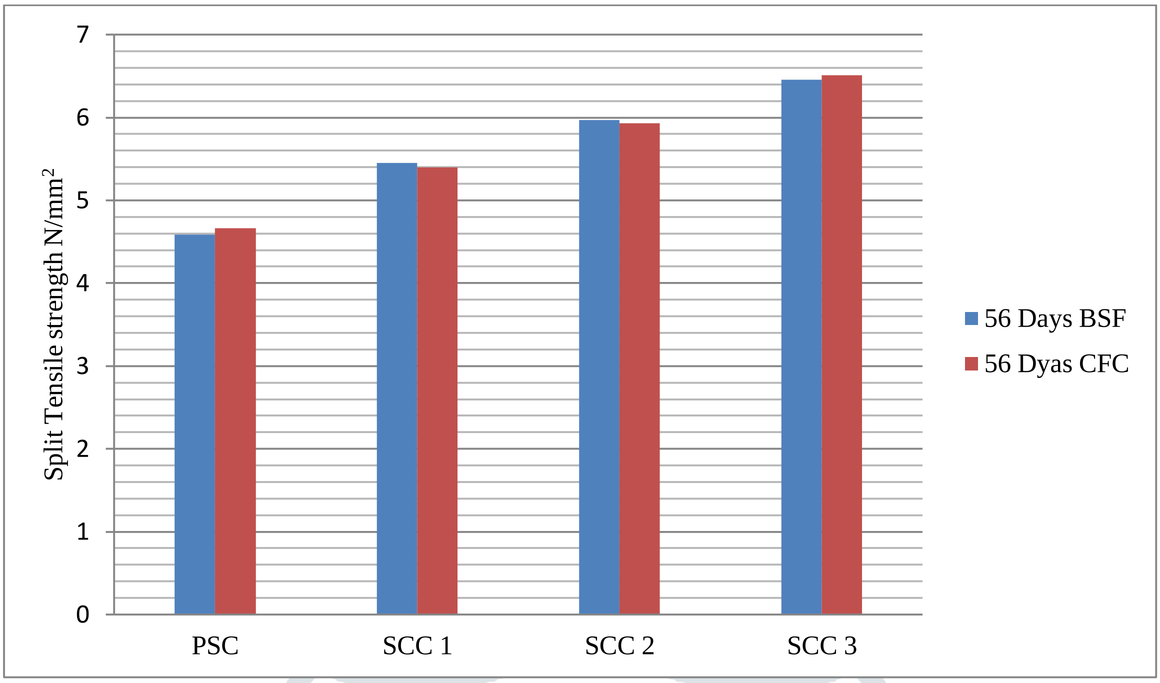

Chart 4: Split Tensile Test at the end of 56th days

3.3 Flexural Test

Table 8 : Flexural Strength Results (Basalt Fiber)

Designation (%)	28th Day Flexural Strength in(MPa)	56th Day Flexural Strength in (MPa)
PSC	6.96	8.29
BSF-0.05	**7.7**	8.53
BSF-0.10	9.06	9.93
BSF-0.15	11.16	12.18

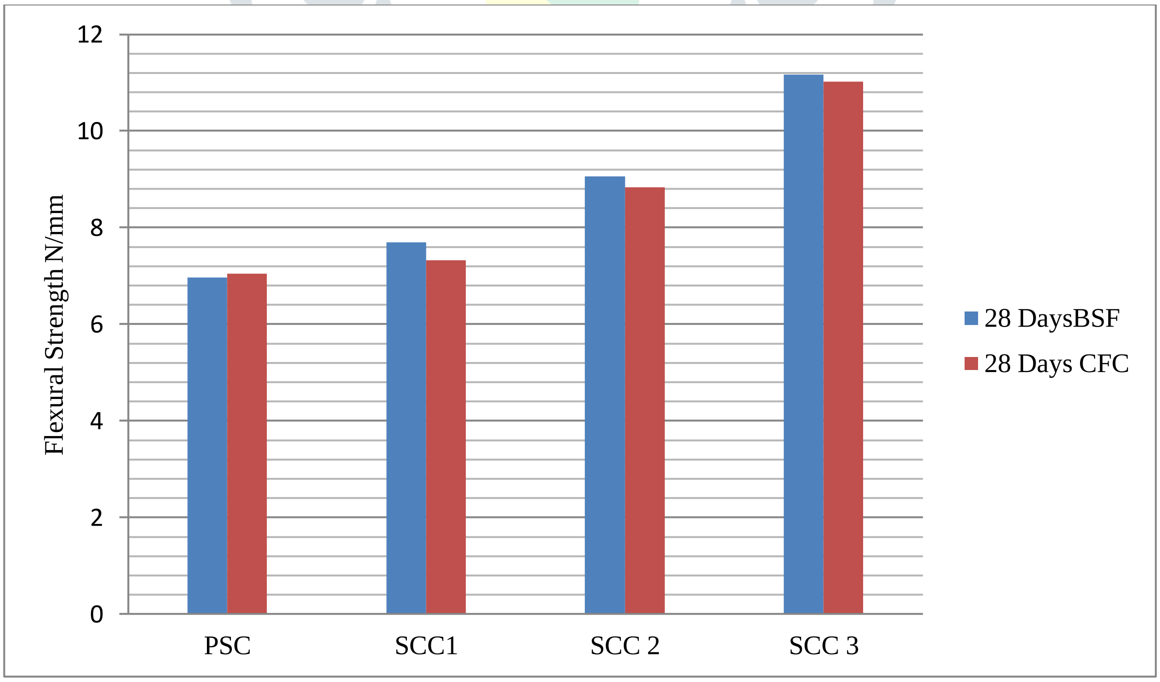

Chart 5: Flexural Strength at the end of 28th days

Table 9 : Flexural Strength Results (Carbon Fiber)

Designation (%)	28th Day Flexural Strength in(MPa)	56th Day Flexural Strength in (MPa)
PSC	7.05	8.17
CFC-0.05	7.33	8.67
CFC-0.10	8.83	9.29
CFC-0.15	11.02	11.95

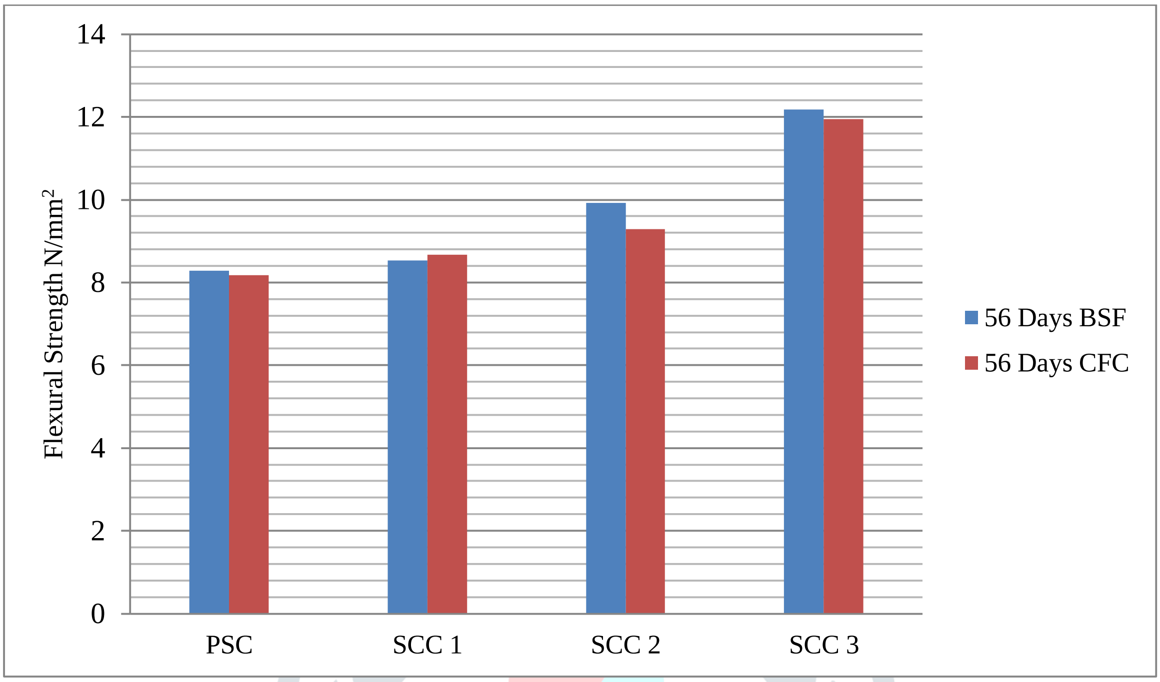

Chart 6: Flexural Strength at the end of 28th days

Discussions

As can be seen from Table 1,slump flow test results show that all mixes had enough deformability under their own weight, despite the fiber inclusion and had moderate viscosity,which necessary to avoid segregation.V-funnel measurement of some mixes exceeded the upper limit suggested by EFNARC however it should kept in mind that limits suggested by EFNARC are designed for plain Self-compacting concrete.

As Mentioned earlier ,the viscosity of the FRC-SCC as despited by the T_{500} measurements of the slump flow test,seemed to be affected by the fiber inclusion,having shorter slump flow results as compared to plain SCC .

In addition to the fresh properties ,some hardened properties of the FRC-SCC are also determined.These include the compressive ,Split tensile and Flexural strength of concrete at various ages as seen in graphs.And increase in compressive strengths was observed as the fibers content was increased in all mixes Compared with the mix having only plain SCC .

As for Split tensile strength,which is determined by the split tension test,the split tensile strength seemed to be affected by the fibers and the effect of fiber can be observed on the obtained test results.Higher split tensile strength occurred in mix 4 in which fibers were proportioned equally.On the other hand flexural strength only with Basalt fiber is higher than other mixes.

4.Conclusion

In this work discusses experimental program carried out to investigate the effects of fiber inclusion on the flow characteristics of FRC-SCC and mechanical properties in hardened state.Two different types of fibers were used and test were performed in both fresh and hardened states.It was observed that the flow behavior of FRC-SCC differs from that of plain SCC and also results obtained from some of the mixes exceeded that upper limits suggested by EFNARC,all mixes had good flowability and possessed self-compaction characteristics.

Reference

[1] Anvaj G.Senthil Kumar S.Manivel 2018, Experimental study on basalt fiber reinforced self compacting concrete enhanced with carbon fiber,Vol.116,No.14,pp.41-47.
[2] Amal Krishna Prof.Sarah Anil 2018, Basalt fiber reinforced self compacting concrete,Vol.05,Issue:04.
[3] Anne-Mieke Poppe and Greet De Schutter ,March (2005),“ Cement hydration in the presence of high filler contents” Cement and Concrete Research ,Volume 35,Issue 12,Pages 2290-2299.

[4]Bertil Persson,May (2003), “Sulphate resistance of self-compacting concrete”Cement and Concrete Research ,Volume 33,Issue 12,Pages 1933-1938.

[5] EFNARC 2005"The European Guidelines for Self-Compacting Concrete" (Specification, Production and Use).

[6]H.J.H Brouwers and H.J.Radix, June (2005), “Self-compacting concrete :Theoretical and experimental study”Cement and concrete Research ,Volume 35,Issue 11 ,Pages 2116-2136.

[7] M.Lachemi, K.M. A.Hossain ,V.Lambros,P.C. Nkinamubanzi and N.Bouzoubaa, July(2003) ,“Performance of new viscosity modifying admixtures in enhancing the rheological properties of cement paste” Cement and Concrete Research, Volume 34,Issue 2, Pages 185-193.

[8] Nan Su, Kung-Chung Hsu, His-Wen Chai,(2001), "A Simple Mix Design method for Self- Compacting Concrete" Journal of Cement and Concrete Research 31pp 1799-1807.

[9] Pramod K. Kolase, 2018. Experimental Study on Monotonic and Fatigue Behaviour of Polypropylene Fiber Reinforced Roller Compacted Concrete with Fly Ash. Road Materials and Pavement Design, Taylor and Francis, ISSN: 1468-0629 (Print) 2164-7402,

[10]Pramod K. Kolase. June 2016. Strength Properties of Roller Compacted Concrete Pavements Containing Fly ash and Triangular Polyester Fiber. International journal of Earth Sciences and Engineering, ISSN 0974-5904, Vol. 09, No. 03. PP. 314-322.

[11]Pramod K. Kolase. May 2017. Study on fiber reinforced ROCC using non destructive testing. Vol 8 Issue 5, PP. 657-666.

[12]Satheskumar.K Gobinath R.Ramachandran 2017, Structural behavior of self compacting concrete with basalt fiber,Vol.6,ISSN:2278-0181.

[13]S.Paulraj Dr.N.Balasundaram K.Sates Kumar M.Dharshna Devi 2017, “Experimental studies on strength and scc characteristics of basalt fiber reinforced concrete,Vol.8,Issue 1,pp.704-711.

[14] Satheskumar K. Karthik P. Vijayan V. Janani V.Comparitive “study on self compacting concrete using steel fiber and basalt fiber”.

[15] Steffen Grunewald and Joost C.Walraven, May (2001), “Parameter-study on the influence of steel fibers and coarse aggregate content on the fresh properties of self-compacting concrete” Cement and Concrete Research ,Volume 31,Issue 12,Pages 1793-1798.

[16]Tomasz Ponikiewski Jacek Katzer 2017,Fresh Mix Characteristics of self-compacting concrete reinforced by fiber Vol.2,pp.226-231.

[17]Wenzhong Zhu and John C.Gibbs, July (2004), “Use of different limestone and chalk powders in self-compacting concrete” Cement and Concrete Research ,Volume 35,Issue8,Pages 1457-1462.