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STUDY ON MECHANICAL PROPERTIES OF FIBER ADDED SELF-COMPACTING CONCRETE

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Abstract: **Self-Compacting Concrete is the new concept which is rebellion idea in the construction world that increases the usage of SCC all over the world . This SCC has more advantages when compared to traditional cement concrete in terms of giving high increment at productivity, reduction of labours and total expenses, gives good complete product having very good mechanical properties and durability of product.**

Those fibers are glass, carbon and basalt fibers , hence individual volume fraction of these fibers are taken as 0.0%,0.1%,0.15%,0.2%,0.25% ,0.3%. The project is categorised into two parts. Initial part contained the preparation of M30 grade SCC mix design and secondary part has various fibers like Carbon, Glass and Basalt Fibers were added to mixes of SCC and their hardened and fresh properties were calculated.

Index Terms **– Fibers, scc, concrete, strength of ssc.**

CHAPTER 1
INTRODUCTION

1.0 Self-Compacting Concrete

In the countries of Europe and Japan this SCC is actually evolved . This SSC can have the ability to occupy each and every inch in the formwork and even though it has heavy desnse reinforcement it can fill all the space because of its flowability nature. Due to its self weight it can flow in the formwork and there is no need to use any vibrator or any other compaction technique for compaction.

Using the high amount of fines and HRWR admixtures resulting SCC with more sensitivity and decreased toughness. This SCC is designed and designated by concrete society ,So this is the reason for usage of Self-consolidating concrete is huge in the areas of preparation for pre-casting objects ,bridge decks, wall panels etc and also using in other countries all over the world.

Anyway, many researches and investigations were conducted to find the characteristics and its applications on site. This SCC has better characteristics So we can use this SCC in all the difficult project reinforcement areas with good quality control. Here it can be used in the not accessible formworks without losing its quality.

1.1 Fiber Reinforced Self-Compacting Concrete

Many advance techniques came in the concrete technology which provides the availability of different grades ,design mixes of cement with other admixtures.

Anyway it has new useful methods along with few complications also . These complications were considered as disadvantages for the çementitious máterial, which has negligible tênsile strength..

1.1.1 Alkali Resistance Glass Fibers

Glass fiber is extracted from the molten glass from which we are going to prepare glass filaments. These filaments are cooled and solidified after extraction from molten glass. From these glass filaments we are going to prepare the glass fiber..

1.1.2 Basalt Fibers

This fiber is extracted from the basalt rock by melting it at 1400^0 C , that melted liquid comes out form small nozzels to make the continous filaments of basalt fibers. Chemical composition of Basalt is similar to glass fiber. This basalt is good alkaline resistance, acidic and salt resistance also which makes this basalt as friendly material for concrete used for structures at bridge and shoreline.

1.1.3 Carbon Fibers

Usage of this fiber is to minimize cracks and shrinkages . Its going to rises the structure properties like tensile , flexural and load toughness along with impact resistance. Using these fibers can reduce the electrical resistance and improves the freeze-thaw durability and dry shrinkage. Carbon has the following characteristics like low density, high thermal conductivity, good chemical stability and exceptional abrasion resistance.

1.2 Fracture Energy Behaviour

This ductility is calculated using fracture behaviour of Fiber RSCC to find out fracture energy. Normal concept that extent of energy absorbed by the specimen to broke into to pieces. Hence energy to fracture area equation gives the value (projected on a plane perpendicular to the tensile stress direction).Extracted value is going to taken as Specific energy. From the plot its concluded the area under load displacement curve increases then fracture energy also increases.

1.3 Objective and Methodology

Main objective is to conduct research the M30 grade mix design for SCC ,to study influence of addition of basalt, glass & carbon fibers on fresh state and hardened state properties related to SCC. Properties of SCC at fresh state consist of segregation resistance belongs to viscosity, flow ability, passing ability. Properties of self compacted concrete at hardened state were compressive, split tensile and flexural strength, modulus of elasticity, Ultrasonic pulse velocity and fracture energy etc. This fiber added SCC uses in fresh state flow ability to increases the better orientation of fibers and at the appropriate time increases toughness and energy absorbing capacity. There is improvement in finding new techniques and development of SCC from the last few years.

1.4 Methodology

- Need Design mix of SCC of grade M30.
- Prepare the mixture for SCC and evaluate the fresh properties like flow ability , segregation resistance and passing ability with help of slump flow, v funnel, L box apparatus.

CHAPTER- II
LITERATURE REVIEW

2.0 BRIEF RIVIEW

Around the world, SCC with addition of fibers are now being researched and used to increase the tensile and flexural strength of structural concrete elements. As stated below, the literature review has been separated as 3 sections: super plasticizers, SCC preparation, and Fiber-Reinforced SCC.

2.1 SUPER PLASTICIZERS

2.1.1 M Ouchi, et al. (1997) The influence and impact of super plasticizers shows on the flow-ability and viscosity of self-consolidating concrete have been specifically mentioned by the authors. Author provided an outline of the impact of super plasticizer on the fresh properties of concrete based on experimental research. The author discovered that his investigations were highly useful to evaluate content of Super Plasticizer required to matching the fresh qualities of concrete.

2.1.2 GaoPeiwei., et al. (2000) The authors have explored a specific sort of concrete that uses the same materials and components as regular concrete. Mineral and chemical admixtures with Viscosity Modifying Agents (VMA) were important in order to manufacture high performance concrete. The goal is to reduce the cement content of HPC. The first step is to protect priceless natural resources, followed by a reduction in cost and energy, to gain along with long-term strength and durability as the ultimate objective as per author.

2.1.3 Neol P Mailvaganamet al. (2001) The hydration process was explored and analysed by the author to determine how the characteristics of chemical and mineral admixtures interact with binding material molecules. The dosages are determined based on the performance of the admixtures with concrete, including the kind and percentage of admixtures, their composition, the cement's specific surface area, the type and quantities of various aggregates, and the water/cement ratio.

CHAPTER- III: EXPERIMENTAL INVESTIGATION ON SELF-COMPACTING CONCRETE

3.0 GENERAL

Here , SCC of grade M30 reinforced with different fibers like basalt fiber, glass fiber and carbon fiber whose mechanical properties studied here. Each mixture has six cubes of dimensions (150×150×150) in mm, four cylinders of dimensions (100×200) in mm and six prisms of dimensions (100×100×500) in mm were casted and investigation was started to study the fresh properties , mechanical properties and fracture energy behaviour of basalt fiber reinforced SCC (BFC), glass added SCC (GFC), carbon added SCC (CFC). The investigation held on SCC with different fibers by following steps:

1. Plain SCC of M30 grade is prepared and fresh and hardened properties of plain SCC is calculated.
2. Study the fresh and hardened properties of M30 grade of SCC mixture with addition of fibers glass, basalt and carbon fibers.
3. Need to study the load-deflection behaviour of SCC, Basalt fiber, Glass fiber & Carbon fiber SCCs.

3.1 MATERIALS

3.1.1 Cement

PSC(Portland slag cement) type of Bharathi cement which taken from the Nellore market to do investigation and study over this project. This Portland slag cement of Bharathi cement selected as per the physical properties from IS: 455-1989.

3.1.2 Coarse Aggregate

These coarse aggregate of 20 mm and 10 mm were taken from construction site near Nellore.

3.1.3 Fine Aggregate

Sand was taken from the Penna river in Nellore.

3.1.4 Silica Fume

Elkem Micro Silica 920D used as Silica fume. Silica fume is among one of the most recent pozzolanic materials. present days its using in concrete addition of this silica fume to concrete mixture shows the changes in lower porosity, permeability and bleeding because its fineness and pozzolanic reaction.

Table 3.1.1 Mechanical Properties of Fibers

Fiber Variety	Length (mm)	Density (g/cm^3)	Elastic modulus(GPa)	Tensile strength(MPa)	Elongation 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	7-9	<0.1
CARBON	12	1.80	243	4600	1.7	—

(A) (B) (C)

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

3.2 MIX DESIGN OF PLAIN SCC AND TESTING OF ITS FRESH AND HARDENED PROPERTIES

By using guidelines of EFNARC code 2005, SSC mix of M30 grade is prepared with help for following method and in which we used 10 percent of silica fume in the whole weight of cement to gain the target strength. Admixture is used to increase the workability of SCC and to reduce the high water percentage in the SCC mix ,here Viscocrete is used as admixture as per our requirement. Tests like Slump flow, L-Box, V-Funnel were conducted to calculate the fresh properties of Mix of SCC. Results are given in table- 4.2.1.

3.2.(b) Mix Design Of M30 grade SCC by Nan Su Mix Design Method:

Coarse Aggregates Specific gravity : 2.75
Loose coarse aggregate Bulk density :1321.5 kg/m^3
Fine Aggregates Specific gravity : 2.64
Fine coarse aggregate Bulk density : 1350 kg/m^3
Cement Specific gravity : 3.15
Volume ratio of Fine Aggregates : 59.5 %
Volume ratio of Coarse Aggregates : 40.5 %
Super plasticizer Specific gravity : 1.1
Assumed Package Density Factor (PDF) = 1.20

Volume ratio of Coarse Aggregates : 40.5 %

Super plasticizer Specific gravity : 1.1

Assumed Package Density Factor (PDF) = 1.20

Step-1: Calculation of Contents of Coarse Aggregates and Fine Aggregates

Here fine and coarse aggregates were studied whose data is going to be used in this following calculations.

Package Density Factor(PDF)= 1.2

F_a/T_a : density of fine aggregates to total density of aggregates ,

Where this ratio F_a/T_a values lies in between the limits of 50 – 70 Percent.

C_C = Coarse aggregates content in kg/m^3

C_F = Fine aggregates content in kg/m^3

Formulas for calculating the Content of aggregates as follows,

C_C = PF x D_{CA} x (1- F_a/T_a)

= 1.2 x 1321.5 x (1-0.595)

= 642.24 kg/m^3

C_F = PF x D_{FA} x (F_a/T_a)

= 1.2 x 1350 x 0.595

= 963.9 or 964 kg/m^3

Step-2: Calculation of Cement Content

Increase in cement content helps to get durability and strength of concrete , but adding the Cement more than its optimum dosage causes some affect to concrete , so we need to add cement with in the certain limit by using correction factor(C.F) the formula . Here we are using 33 grade OPC for this study. Need to find optimum content of cement required as follows

f_{ck} = Design Compressive strength for M30 grade .

Taking water cement ratio as 0.43

C_{Cement} = Cement content in kg/m^3

C_{Cement} **= (** f_{ck} /0.146) C.F C.F= correction factor(2.1916)

= (30/0.146) x 2.1916

= 450.32 kg/m^3

Step-3: Calculation of Water Content:

Water cement (w/c) ratio properties for normal concrete and SCC is completely similar, Hence increase in w/c ratio decreases the compressive strength of concrete. To calculate the water Content follow the given equation.

C_w = Water Content

w/c = water cement ratio

C_w = (w/c) x C_{cement}

= 0.43 x 450.32

= 193.6 kg/m^3

Step-4: Calculation of Chemical Admixture:

Chemical admixtures are the Super plasticizers which are also called as HRWR(High- Range Water educers), these super plsaticizers used for workability increment purpose. This Admixture should be used in the range of 500ml to 1500ml for every 100kgs of cement.

The optimum dosage of admixtures which we are adding to cement could be 0.5% to 2% Of weight of cement which reduces the water content up to some extent to provide workability.

SP = a % (C_{cement})

a% = percentage of super plasticizer added to cement

SP = 1.23 % (450.33)

= 5.553 kg/m^3

Step-5: Mix Proportions

Cement	:	450.33 kg/m^3
Fine Aggregates	:	963.9 kg/m^3
Coarse Aggregates	:	642.24 kg/m^3
Super Plasticizer	:	5.553 kg/m^3
Water Content	:	193.6 kg/m^3

This Mix Proportion is used for SCC mix preparation. **Table 3.2.1 Adopted Mix Proportions of SCC from Nan Su method:**

Cement (kg/m^3)	Silica fume(kg/m^3)	Water(lit/m^3)	FA (kg/m^3)	CA (kg/m^3)	SP (lit/m^3)
450.33	4.5	193.6	963.9	642.24	5.553
1	0.10	0.43	2.14	1.42	0.012

3.2.1 Mixing Of Ingredients

A power operated concrete mixer is used to mix all the ingredients perfectly as per the mix proportions which we get from above method. Coarse aggregate, fine aggregates, cement and silica fume were added and mixed properly for few seconds in dry condition to make mixture in the concrete mixer. Add the water and mix it for 3 to 4 mins. While mixing the mixture add the air entraining agent and HRWR(High Range Water Reducer) also. Dormant period was 5mins.

3.2.2 Methods to determine the fresh properties of SCC

To find the fresh properties of SCC, different methods were there. Slump flow and V-Funnel tests were used to find flowability and viscosity. L-Box test was conducted to calculate the segregation resistance.

Fig.3.2.1 Concrete Mixture Machine & Preparation of SCC Mix

3.2.2.1 Slump Flow Test And T_{50} Test

The slump flow test conducted to calculate the free flowability of SCC without obstructions.

Fig. 3.2.3.1 Slump Flow Apparatus & Testing

- As per the above mix proportions ,whole Concrete was prepared for 3kgs of cement for test .

Analysis of the results: : Maximum slump flow value shows the great ability to occupy the formwork by its self weight. A minimum value of 650mm is necessary for SCC. The T_{50} time is a subordinate indication of flow. Less time shows higher flow ability. The time range of slump for should be in between 2-5 seconds for general housing applications.

3.2.2.2 V-Funnel Test

This test is Executed to find the flow-ability of SCC.

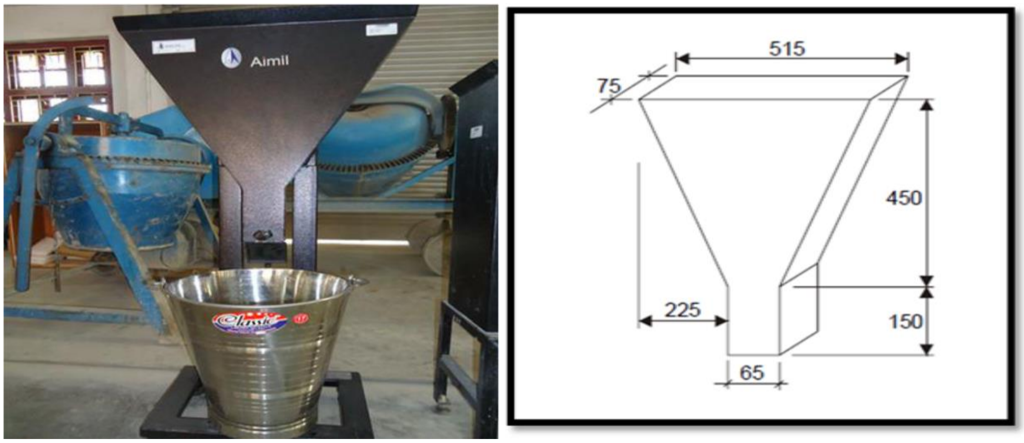


Fig.3.2.3.2 V-Funnel Apparatus & Schematic Diagram

- Six kgs of cement concrete mixture was prepared . Apply the oil inside the Funnel for lubrication.
- Placed V-funnel apparatus on the levelled surface or platform.
- Closed the trap door or cap for funnel and Fill the SCC in the V-funnel with out using tamping or vibrator.
- A bucket is placed under the funnel's trap door ,The trap door was opened after the 10 secs of filling the funnel with concrete and let concrete to flow by gravity.
- Immediately readings were recorded by using stopwatch till the complete discharge comes out. (the flow time) its recorded until the complete mixture comes out.

Analysis of results: This test gives indirect measure of viscosity. Time was recorded while discharging the concrete through the bottom opening. The time for SCC should be 10±3secs.

3.2.2.3 L-Box Test

The test is for measuring the flow of the SCC under the blocking resistance(rebars).

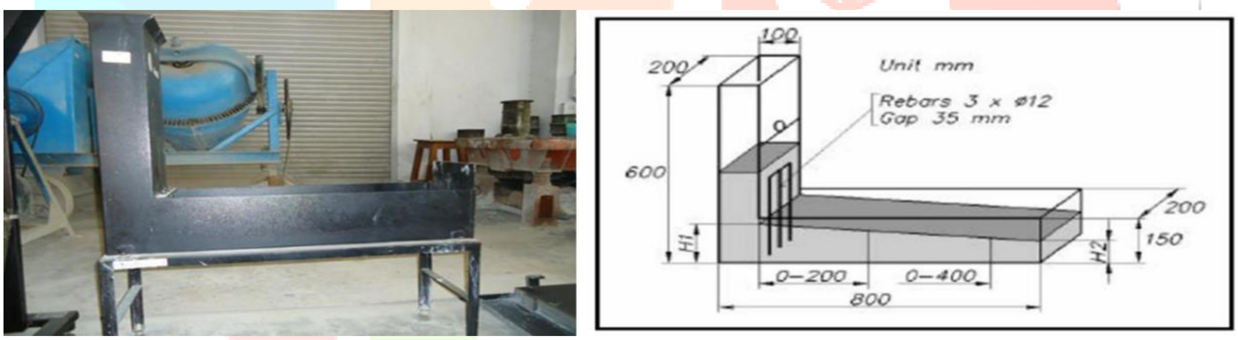


Fig. 3.2.3.3 L-Box Apparatus & Schematic Diagram

- 7kgs of cement concrete was prepared for the test as per mix proportion.
- Kept apparatus on the leveled platfrom or surface. The lubrication is applied to inner surface of the L-Box .
- Poured concrete in the vertical Box of L-Box by closing the gate to stop the flow into horizontal box as shown in fig. Left the concrete mix for 10 secs in the vertical box.
- When gate was opened concrete mixture flows from the vertical box to horizontal box. From this Remianed mixture H_1,H_2 were calculated.
- The distance "H_1" and "H_2" are measured form deposited mixture of SCC remained in L-box apparatus.

Analysis of results:

The height of the concrete in vertical fill (H_1) & the concrete height in Horizontal box (H_2) were Measured as shown in fig . The Passing ability value for SCC is atleast 0.8.

Passing ability=H2/H1

3.2.3 Casting of Specimens

Twenty four cubes(150×150×150)mm, sixteen cylinders(100×200)mm, twenty four prisms(100×100×500)mm were prepared and investigation was conducted to study the mechanical behaviour, fracture energy and fracture behaviour for basalt added SCC (BFC), glass added SCC(GFC), carbon added SCC(CFC).

Fig. 3.2.4 Casting Of Specimens

3.2.4 Curing Of SCC Specimens

After completion of casting these specimens were kept at room temperature for 24 hours , then these moulds were removed and placed these specimens in fresh water tank to cure for 7 days and 28 days.

Fig. 3.2.5 Curing Tank

3.2.5 Testing Of Hardened SCC

These specimens were tested after completion of specific time its 7 days and 28 days. These specimens were tested with help of procedures in IS: 516-1959.

3.2.5.1 Compression Test

For each mix six cubes of (150×150×150) mm were casted to calculate the compressive strength, after the completion of curing period of specimens. These total twenty four cubes were casted to calculate the compressive strength after 7-days and 28-days. Dimensions of the cube maintained as per the IS code 10086-1982.

Fig: 3.2.6.1 Compression Test Set-Up

3.2.5.2 Split Tension Test

For each mix three cylinders of (100×200) mm were casted to calculate the split tensile strength, after the completion of curing period. Total 16 cylinders were casted to calculate the split tensile strength of specimens after 28 days.

Fig: 3.2.6.2 Split tensile Test Set-Up

Split tensile strength = $2P / \pi LD$

Where, P = Load acting on the specimen

L = Length of the cylinder

D = diameter of the cylinder

3.2.5.3 Flexural Strength

The flexural strength test was carried out on a prism specimen of dimension 100mm×100mm×500mm as per IS specification. So total twenty four numbers prisms were cast to measure the flexural strength after 28-days. The flexural strength of specimen shall be calculated as:

Flexural strength = pL/bd^2

Where p = load applied on the prism (KN)

L = length of the prism from supports (mm)

b = width of the prism (mm)

d = depth of the prism (mm)

3.3 PREPARATION FIBER REINFORCED SELF-COMPACTING CONCRETE

3.3.1 Addition Of Fibers To SCC Mixes

These glass, carbon and basalt fibers were added to SCC at the individual volume fraction of 0.0%,0.1%,0.15%,0.2%,0.25% ,0.3% were added to the prepare SCC mixes. In the present study and glass fiber added SCC (GFC) was prepared. Similarly, by adding the percentages of basalt fibers ,basalt fiber added SCC (BFC) prepared and the addition of percentages of carbon fibers, carbon fiber with SCC (CFC) was prepared. After the addition of fibers to mixture of SCC some tests were conducted to find out the required properties for fiber added SCC in both fresh and hard state.

Fig. 3.3.1 Addition of Fiber to the SCC Mix

3.4 Ultrasonic Pulse Velocity Test

With This test instrument wave pulse using transmitter is introduced into the concrete in one direction and sensing the arrival of the pulse wave from another direction , its accurately measured the time taken by the pulse wave to travel form transmitter to receiver .

Fig. 3.4.1 UPV Test Set-up

3.5 STUIDES ON LOAD-DEFELCTION BEHAVIOUR OF SCC & FRSCC MIXES

The inclusion of fiber improve the bridging nature between particles of concrete mixture. This prism is tested in UTM to know the properties of prism of SCC. The load-deflection curve for different specimens of different fiber mixes were plotted and compared to analyze.

Fig. 3.5.1 Loading Arrangement for Load-Displacement Test

CHAPTER- IV
RESULTS OF THE EXPERIMENTAL INVESTIGATIONS ON FRSCC

This chapter deals with the studies on the results of experiments executed on different fiber added SCCs in different stages.

.4.1 PREPARATION OF SCC AND FRSCC & ITS STUDIES ON FRESH AND HARDENED PROPERTIES

4.1.1 Water/cement Ratio of Self-Compacting Concrete

To adopt the best SCC mixture with out loosing all its strengths and properties here water content and its admixtures plays key role, we were using optimum amount of w/c ratio is 0.42 and optimum % of super plasticizer Viscocrete of Sika brand. uses for all the Mix proportions of SCC with all the different fractions of different fibers.

4.1.2 Mix Proportions and Fiber Content

The count of trial mixes was prepared in the laboratory and which are obeying the requirement for fresh state as per the guidelines of EFNARC 2005 code.

Table 4.1.1 Percentage of Types of Fibers for SCC

Designation	Fiber content (%)	Description
PSC	0.0%	Plain self-compacting concrete
BFC-1	0.1%	0.1% Basalt fiber reinforced SCC
BFC-1.5	0.15%	0.15%Basalt fiber reinforced SCC
BFC-2	0.2%	0.2%Basalt fiber reinforced SCC
BFC-2.5	0.25%	0.25%Basalt fiber reinforced SCC

BFC-3	0.3%	0.3%Basalt fiber reinforced SCC
GFC-1	0.1%	0.1%Glass fiber reinforced SCC
GFC-1.5	0.15%	0.15%Glass fiber reinforced SCC
GFC-2	0.2%	0.2%Glass fiber reinforced SCC
GFC-2.5	0.25%	0.25%Glass fiber reinforced SCC
GFC-3	0.3%	0.3%Glass fiber reinforced SCC
CFC-1	0.1%	0.1%Carbon fiber reinforced SCC
CFC-1.5	0.15%	0.15%Carbon fiber reinforced SCC
CFC-2	0.2%	0.2%Carbon fiber reinforced SCC

4.2 Results and Discussion

Following are the Fresh properties results of the different concrete mixes after conducting the Slump flow, V-Funnel & L-Box tests.

Table 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	0.90	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	0.82	9	12	Result Satisfied

GFC-3	530	5.9	0.70	11	15	Too high viscosity Blockage (RNS)
CFC-1	560	4.8	0.80	10	14	Result Satisfied
CFC-1.5	410	-_	-	18	-	Too high viscosity Blockage (RNS)
CFC-2	260	-	-_	23	_-	Too high viscosity Blockage (RNS)

4.2.1 Properties in Fresh state:

The Table 4.2.1 and the Fig.4.2.1 shows the addition of fibers reduces the flow values of the mixture of SCC with different percentage of fibers. The decreased flow values shows that addition and uniform distribution of fibers in the concrete mixture reduces the flow values and segregation of mixture.

4.2.1.1 Slump Flow

As per the values from the tables observed that decrease in slump value with increment in the amount of fibers content. Decrement of flow value is observed more for basalt fibers added SCC, flow values are less for glass and carbon fibers w.r.t control mix. This is because basalt fibers absorbed more water from the mix than the other fibers and beyond the maximum % of fiber addition to mix not satisfys the guidelines of SCC. Among all carbon fiber added SCC absorbs very less amount of water.

4.2.1.2 T50 Flow

The T50 flow is determined in seconds of time. T50 flow value increases with decrement of the slump value. Decrement in slump value caused because of addition of fibers than its optimum fiber percentage. Maximum T50 flow value in seconds for basalt fiber at 0.3 % followed by glass fiber of 0.3% and 0.1% for carbon fiber.

4.2.1.3 L-Box

Increased slump flow values shows the increment in L-Box values. The slump value increases because of the decrease in the percentage of fiber which shows the increment in L-Box values also. Addition of fibers more than the optimum percentage reduces the slump flow and addition of fibers below the optimum % can show improvement in slump flow and L-box values. Maximum L-Box values obtained for fibers at 0.2% of basalt ,0.25% of glass and 0.1% of carbon fiber which fulfills the requirements as per EFNARC 2005 code.

4.2.1.4 V-Funnel & T5 flow

The V-Funnel test & T50 flow, which was measured in terms of time (seconds) & both values which calculated were dependent on one on one. Both V-Funnel & T5 flow values increment is inversely proportional to the slump flow values. The slump value decreased because of increment in fiber content. Maximum V-Funnel and T5 flow values were observed at 0.1%,0.2%, 0.25% of carbon, basalt and glass fiber satisfies SCC specs.

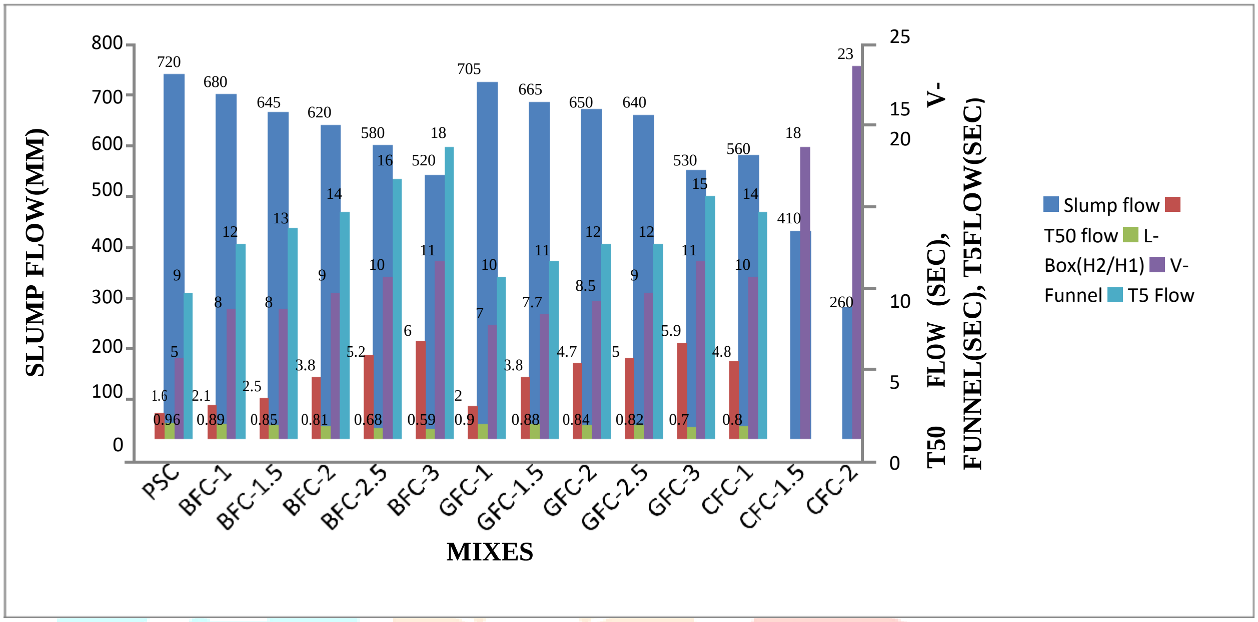


Fig. 4.2.2 Variation of Fresh Properties of FRSCC Mixes with Different Percentage of Fiber Mix

4.3 Hardened Properties

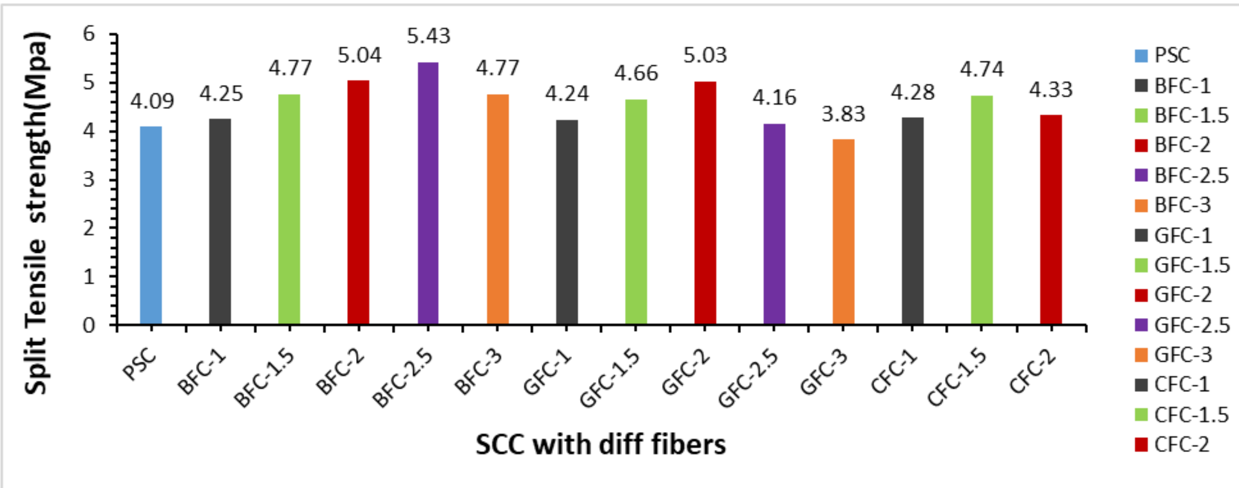
Many mechanical properties of the Fiber added SCC are going to compare after these cubes , cylinders and prisms tested after 7 & 28 day of curing. Results of compressive , split tensile and flexural strength of specimens are shown in Table 4.3.1.

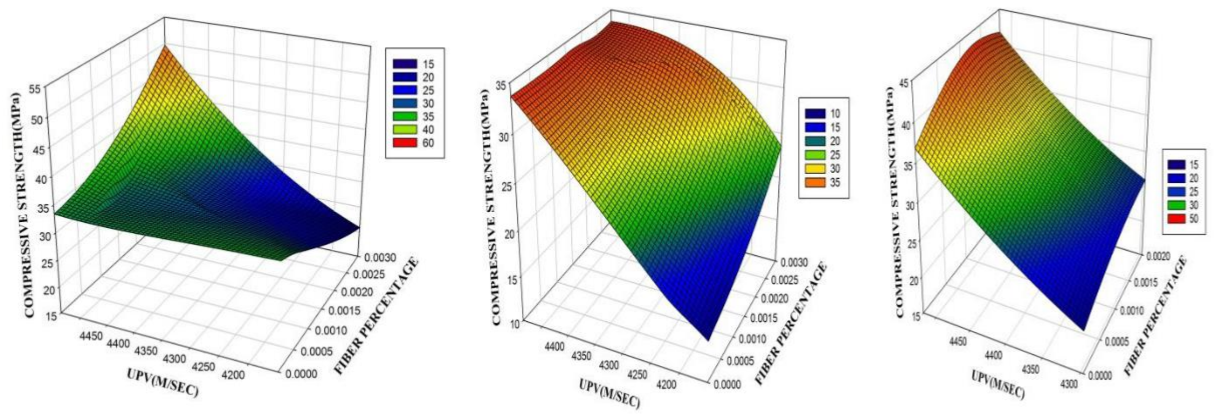
TABLE-4.3.1 Hardened Concrete Properties of SCC and FRSCC

Mixes	7-Days compressive strength (MPa)	28-Days compressive strength (MPa)	28-Days Split tensile strength (MPa)	28-Days flexural strength (MPa)
PSC	33.19	40.89	4.09	7.36
BFC-1	33.60	41.32	4.25	7.64
BFC-1.5	34.31	41.97	4.77	7.81
BFC-2	35.41	42.92	5.04	8.03
BFC-2.5	36.06	43.57	5.43	8.28
BFC-3	34.86	41.87	4.77	7.12
GFC-1	33.39	41.09	4.24	7.38
GFC-1.5	33.73	41.41	4.66	7.66
GFC-2	33.28	41.11	5.03	7.77
GFC-2.5	32.05	39.88	4.16	7.18

GFC-3	30.24	39.48	3.83	6.93
CFC-1	33.69	41.36	4.28	7.24
CFC-1.5	34.30	42	4.74	8.02
CFC-2	34.07	39.22	4.33	7.60

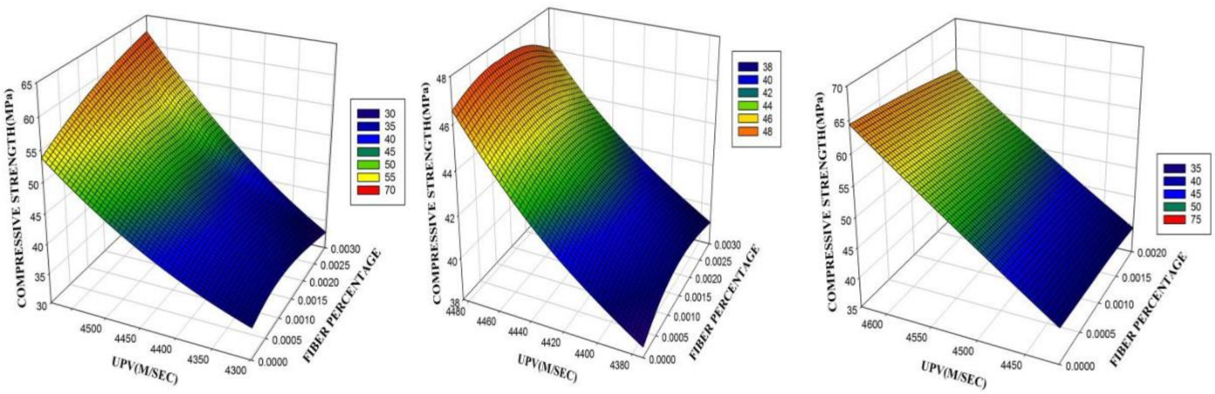
Fig. 4.3.5 Variation of Split Tensile Strength for Different SCC Mixes At 28days





(A) **(B)** **(C)**

Fig.4.4.1 Comparison between 7days Avg. UPV vs. Fiber percentage vs. Compressive Strength of (A) Basalt (B) Glass (C) Carbon FRSCC



(A) (B) (C)

Fig. 4.4.2 Comparison between 28 days Avg. UPV vs. Fiber percentage vs. Compressive Strength of (A) Basalt (B) Glass (C) Carbon FRSCC

The above graphs shows that correlation curves of diff Fiber RSCCs which is regression analysis of UPV values & compressive strength calculated at 7 and 28 days were in the which type of relation with each other to be found.

This correlation curve shows that how the both axis values like compressive strength & UPV values are dependent with each other using graph ,the relation between these both axis values are going to be defined based on **Correlation Coefficient(R)** range values of curve as follows.

Range	Interpretation
0<R<0.2	no or negligible Correlation
0.2<R<0.4	low degree of Correlation
0.4<R<0.6	moderate degree of Correlation
0.6<R<0.8	marked degree of Correlation
0.8<R<1	high correlation

4.5 LOADS-DISPLACEMENT BEHAVIOR

Executing load deflection behaviour test with the help for electronic UTM, that produces load displacement(vertical) diagrams shows that addition of fibers increases the ductility, on the other hand plain SCC shows brittle nature under load deflection test. Better results observed at for carbon fiber added SCC than basalt and least values for glass fiber added SCC. Greater the compressive strength shows greater the ductility also .Area under the load deflection curve shows the toughness, for all the types of fiber added SCC mixes curve is almost similar pattern.

Fig.4.5.1 Crack Pattern of PSC

Fig. 4.5.3Crack Pattern of GFC

Time(hrs)	Time in seconds	Square root of time ($t^{1/2}$)	water Absorption (*I*) in *mm*			
			GFC	BFC	CFC	PSC
0.5	1800	42.4	0.123	0.148	0.111	0.153
1	3600	60.0	0.136	0.185	0.173	0.16
2	7200	84.9	0.16	0.21	0.21	0.167
6	21600	147.0	0.185	0.235	0.222	0.184
24	86400	293.9	0.247	0.309	0.235	0.212
48	172800	415.7	0.272	0.358	0.259	0.221

Table 4.8.2 Capillary Water Absorption graph values

We are going to plot the graph between the gained mass(*I*) of specimen per unit area over the density of water (gain in mass/unit area/density of water) versus the square root of time ($t^{1/2}$) was plotted by taking the values from the above table . The slope of the best formed fitting line was considered as the sorptivity.

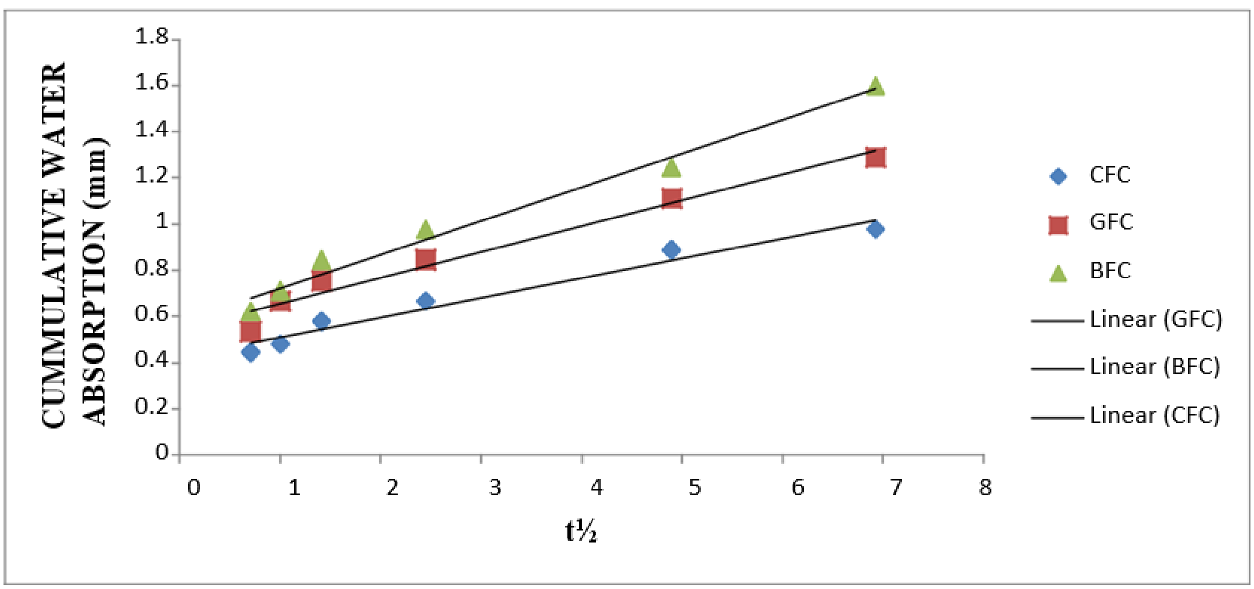


Fig. 4.6.1 Capillary Water Absorption at Different Time Interval

To define capillary water absorption graph is plotted between the root of time and mass of water absorbed by the specimens as shown in Fig. 4.8.1. The amount of water absorbed and slope of linear line in the graph for basalt fiber added SCC is the higher than glass & carbon added SCC samples, because of excess water absorbed by the fibers added to the SCC. The slope of each line shows the Sorptivity of specific specimen containing fibers. The maximum sorptivity is noted for the specimens which contains Basalt fiber, hence its sorptivity value is defined by the slope of the linear lines of each fiber formed in the plotted graph . Sorptivity value of basalt fiber is higher if the slope of the linear line of basalt is higher. Sorptivity value depends on the slope of linear lines of each type of fiber.

CHAPTER- V
CONCLUSION

These points were concluded after conducting & completion of the project.

1. SCC losses some core properties and characteristics shown by slump cone etc, after the inclusion of different fibers to the SCC.

2. Observed that decreased in the value of slump flow is higher in the basalt followed by glass and carbon fiber added SCC. because carbon fiber doesn’t hold the complete concrete mixture that causes the maximum slump flow where basalt and glass has less slump flow.

3. Addition of fibers more than its optimum dosage % make this mixture worst which not obeys the conditions of SCC for slump value, T50 test etc.

4. Mechanical properties of fiber added SCC was improved when compared to plain SCC.

5. Mechanical properties were improved up to certain percentage more than mechanical properties of plain SCC after the addition of fibers at optimum percentage to SCC.

6. Mechanical properties were increased up to maximum after the addition of fibers at its optimum percentages of 0.15% of carbon, 0.15% of glass and 0.25% of basalt.

7. Compressive strength at 7 and 28 days were 3.34%and 2.71%, split tensile strength and flexural strength were 15.89% and 8.97%, So the maximum increment in the compressive strength, split tensile and flexural strength were noticed after the addition of fiber carbon of 0.15%.

8. 7-days compressive strength is increased by 8.65% after the addition of 0.25 % basalt fiber to SCC and 28-days compressive strength by 6.55%, split tensile strength by 32.76%, flexural strength by 12.5%.

9. Addition of glass fiber Of 0.15% to SCC increases the compressive strength at 7-days 28 days were 1.63% ,1.27% and 13.94% , 4.08% were split tensile and flexural strength .

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