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

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Abstract

The development of Self Compacting Concrete is progressive milestone in the historical backdrop of development industry bringing about transcendent utilization of SCC overall these days. It has numerous points of interest over typical concrete as far as enhancement in productivity, decrease in labor and generally speaking cost, amazing completed product with magnificent mechanical reaction and toughness. Fuse of fibers further upgrades its properties exceptionally identified with post crack behavior of SCC. Henceforth the point of the present work is to make a near study of mechanical properties of self-uniting concrete, reinforced with various sorts of fibers. The factors include in the study are type and diverse level of fibers. The fundamental properties of new SCC and mechanical properties, durability, break vitality and sorptivity were considered. Microstructure study of different blends is done through checking electron magnifying instrument to study the hydrated structure and security advancement among fiber and blend.

The fibers utilized in the study are 12 mm since quite a while ago slashed glass fiber, carbon fiber and basalt fiber. The volume division of fiber taken are 0.0%,0.1%,0.15%,0.2%,0.25% ,0.3%. The project contained two phases. First stage comprised of advancement of SCC blend structure of M30 review and in the second stage, distinctive fibers like Glass, basalt and carbon Fibers are added to the SCC blends and their crisp and solidified properties were resolved and looked at.

The study demonstrated exceptional enhancements in all properties of self-compacting concrete by including fibers of various sorts and volume parts. Carbon FRSCC showed best execution pursued by basalt FRSCC and glass FRSCC in solidified state while poorest in crisp state attributable to its high water ingestion. Glass FRSCC showed best execution in new state. The present study reasons that regarding generally speaking exhibitions, ideal measurements and cost Basalt Fiber is the best choice in enhancing in general nature of self-compacting concrete.

Key words: self-compacting concrete, steel fiber, mechanical properties, volume fraction, fracture energy

Introduction

1.0 Self-Compacting Concrete

Self-compacting concrete was initially created in Japan and Europe. It is a concrete that can stream and fill all aspects of the edge of the formwork, even within the sight of thick reinforcement, simply by methods for possess weight and without the need of for any vibration or other kind of compaction.

The development of Self Compacting Concrete by Prof. H.Okamura in 1986 has caused a noteworthy effect on the development business by conquering a portion of the challenges identified with crisply arranged concrete. The SCC in crisp frame reports various challenges identified with the expertise of specialists, thickness of reinforcement, type and design of a structural section, siphon capacity, isolation obstruction and, for the most part compaction. The Self Consolidating Concrete, which is wealthy in fines content, is appeared to be all the more enduring. To begin with, it began in Japan; quantities of research were recorded on the worldwide improvement of SCC and its miniaturized scale social framework and quality viewpoints. However, the Bureau of Indian Standards (BIS) has not taken out a standard blend strategy while number of development frameworks and scientists completed an across the board research to discover appropriate blend structure preliminaries and self-conservative capacity testing approaches. Crafted by Self Compacting Concrete resembles to that of conventional concrete, containing, fastener, fine aggregate and coarse aggregates, water, fines and admixtures. To change the rheological properties of SCC from conventional concrete which is an amazing distinction, SCC ought to have more fines content, super plasticizers with thickness adjusting operators to some degree.

When contrasted with conventional concrete the benefits of SCC containing more quality like non SCC, might be higher because of better compaction, comparable elasticity like non SCC, modulus of

flexibility might be marginally lower in light of higher glue, somewhat higher wet blanket because of glue, shrinkage as typical concrete, better bond quality, imperviousness to fire comparable as non SCC, sturdiness better for better surface concrete.

Expansion of more fines substance and high water diminishing admixtures make SCC increasingly delicate with lessened sturdiness and it structured and assigned by concrete society that is the reason the utilization of SCC impressively in creation of pre-thrown products, spans, divider boards and so forth additionally in a few nations.

Notwithstanding, different examinations are done to investigate different qualities and structural utilizations of SCC. SCC has built up to be compelling material, so there is a need to direct on the standardization of self-merging attributes and its behavior to apply on various structural development, and its utilization in all dangerous and blocked off project zones for prevalent quality control.

Objective and Methodology

The objective of present research is to blend plan of SCC of review M30 and to investigate the impact of incorporation of cleaved basalt fiber, glass fiber and carbon fiber on new properties and solidified properties of SCC. New properties involve stream capacity, passing capacity, and consistency related isolation obstruction. Solidified properties to be examined are compressive quality, part rigidity, flexural quality, modulus of versatility, Ultrasonic heartbeat speed and crack vitality. Fiber-reinforced self-compacting concrete uses the stream capacity of concrete in crisp state to enhance fiber introduction and at the appointed time improving durability and vitality retention limit. In the previous couple of years there has been a lift in the improvement of concretes with various kinds of fibers added to it. In the present work the mechanical properties of a self-compacting concrete with hacked Basalt, glass and Carbon fiber of length 12mm, included different extents (i.e., 0%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%) will be examined in new and solidified state. With the assistance of filtering electron magnifying instrument (SEM) the microstructure of fibered concrete was likewise examined.

The crack vitality behavior is one parameter that is exceptionally helpful in computing the explicit break vitality, GF, is by methods for a uniaxial pliable test, where the entire pressure twisting bend is estimated.

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

Methodology

- Mix Design of self-compacting concrete of M30 review.
- Mixing of SCC and assurance of its crisp properties as far as flowability, passing capacity and isolation obstruction by utilizing Slump stream ,V-channel and L-box mechanical assembly .
- Casting of standard examples to decide compressive, malleable, flexural qualities and break vitality.
- Mixing of SCC impregnated with various fibers in various doses and assurance of their crisp properties as far as stream capacity, passing capacity and isolation obstruction by utilizing Slump stream, V-channel and L-box mechanical assembly.

- Casting of standard example to decide compressive, pliable, flexural qualities and crack vitality fusing glass fiber, basalt fiber and carbon fiber of various volume division going from 0.1% to 0.3%.
- Testing of standard examples for quality assurance after 7days and 28 days.
- Sorptivity test for assurance of retention limit of SCC shapes reinforced with various fibers following 28 days.
- Study of smaller scale structures by SEM of SCC reinforced with various fibers at various ages.

EXPERIMENTAL INVESTIGATION ON **SELF-COMPACTING CONCRETE GENERAL**

In this study, the mechanical behavior of fiber reinforced self-compacting concrete of M30 review arranged with basalt fiber, glass fiber and carbon fiber were contemplated. For each blend six quantities of 3D squares (150×150×150) mm, three quantities of chambers (150×300) mm and six numbers crystals (100×100×500) mm were cast and examinations were led to study the mechanical behavior, break vitality behavior, microstructure of plain SCC, basalt fiber reinforced SCC (BFC), glass fiber reinforced SCC (GFC), carbon fiber reinforced SCC (CFC). The observational arrangement was held up in different strides to achieve the accompanying points:

1. To get ready plain SCC of M30 review and get its new and solidified properties.
2. To get ready basalt, glass and carbon fiber reinforced SCC of M30 evaluations and study their crisp and solidified properties.
3. To investigate the load-deflection behavior of SCC, BFRSCC, GFRSCC and CFRSCC.
4. To analyze the break vitality behavior and the smaller scale structure of plain SCC, BFC, and GFC and CFC.

MATERIALS

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Cement
Portland slag cement of Konark mark accessible in the neighborhood showcase was utilized in the present investigations. The physical properties of PSC got from the exploratory examination were affirmed to IS: 455-1989.

Coarse Aggregate
The coarse aggregate utilized were 20 mm and 10 mm down size and gathered from Quarry nearRourkela.

Fine Aggregate
Regular waterway sand has been gathered from Koel River, Rourkela, Orissa and complying with the Zone-III according to May be 383-1970.

Silica Fume
Elkem Micro Silica 920D is utilized as Silica smolder. Silica rage is among a standout amongst the latest pozzolanic materials at present utilized in concrete whose expansion to concrete blends results in lower porosity, penetrability and draining in light of the fact that its fineness and pozzolanic reaction .

Admixture
The SikaViscoCrete Premier from Sika is super plasticizer and consistency changing admixture, utilized in the present study.

Water
Consumable water fitting in with IS: 3025-1986 section 22 &23 and IS 456-2000 was utilized in the examinations.

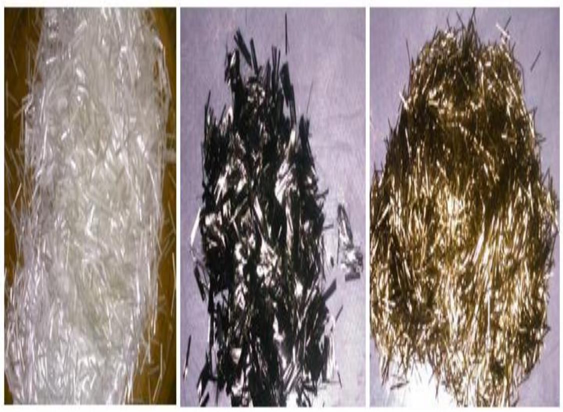
Glass Fiber
Alkali safe glass fiber having a modulus of flexibility of 72 GPA and 12mm length was utilized.

Basalt Fiber
Basalt fiber of 12mm length was utilized in the examinations.

Carbon Fiber
Carbon fiber of length 12mm was utilized in the examinations.

Table Mechanical Properties of Fibers

Fiber variety	Length (mm)	Density (g/cm^3)	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	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

MIX DESIGN OF PLAIN SCC AND TESTING

Calculation for M30 grade of SCC was done following EFNARC code 2005 in the mix design 10% of silica fume use as replacement for cement to achieve the target strength. Viscocrete admixture was used to reduce the water content and improve workability as per the requirement for SCC. To determine the fresh properties of the mix prepared conforming to SCC, different fresh tests like slump flow, L-Box, V-Funnel were performed. Results are given in table- 4.2.1. The experimental work was conducted at Structural Engineering lab of Civil Engineering Department of NIT, Rourkela. The work involved

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mixing, casting and testing of standard specimens.

Table Adopted Mix Proportions of SCC

Cement (kg/m^3)	Silica fume(kg/m^3)	Water(kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SP (kg/m^3)
450.33	45.03	189.13	963.36	642.24	5.553
1	0.10	0.42	2.14	1.42	0.012

Mixing Of Ingredients

The mixing of materials was properly mixing in a power operated concrete mixer. Adding coarse aggregate, fine aggregates, cement and mixing it with silica fume were properly mixing in the concrete mixer in dry state for a few seconds. Then the water added and mixing it for three minutes. During this time the air entraining agent and the water reducer are also added. Dormant period was 5mins. To obtain the basalt fiber reinforced SCC, glass fiber reinforced SCC, carbon fiber reinforced SCC the requiredfiber percentage was added to the already prepareddesign mix, satisfying the fresh SCC requirements.

Methods to determine the fresh properties of SCC

To determine the fresh properties of SCC, different methods were developed. Slump flow and V- Funnel tests have been proposed for testing the deformability and viscosity respectively. L-Box test have been propose for determine the segregation resistance.

Fig. Concrete Mixture Machine & Preparation of SCC Mix

3.2.2.1 Slump Flow Test And T_{50} Test

The slump flow test is used to determine the free flow of self-compacting concrete without obstacles.

Fig. Slump Flow Apparatus & Testing

- Six liter of concrete was prepared for the test.
- Then inside surface of the slump cone was moisten. The test platform was placed on the leveled surface then the slump cone coincident with the 200 mm circle on the platform and hold in position by standing on the foot pieces, ensuring that no leakage of concrete was occur under the cone.
- The cone was filled up with concrete without tamping. Then base was cleaned if any surplus concrete around the base of the cone.
- The cone was vertically lifted and allows the concrete to flow out freely. Immediately the stop watch was started, and reading was recorded for T50 test when concrete reached 500mm marked circle.
- Finally, the final diameter of the concrete spread was measured in two perpendicular directions. The average of the two diameters was measured. (This is slump flow in mm)

Analysis of the results: Higher slump flow value indicates the greater ability to fill the formwork under its own weight. A minimum value of 650mm is necessary for SCC. The T50 time is a subordinate indication of flow. A lower time means greater flow ability. The research suggested a time range of 2-5seconds for general housing applications

This test is performed to determine the filling ability (flow-ability) of self-compacting concrete.

Fig. V-Funnel Apparatus and Schematic Diagram

- Twelve liter of concrete was set up for the test. At that point saturate within surfaces of the channel were dampening.
- The V-channel mechanical assembly was put on leveled surface.
- The whole arranged SCC test was filled the channel with no packing or vibrating.
- Then after 10 sec of filling the snare entryway was opened and enable the concrete to stream out under gravity.
- Immediately the perusing was recorded by methods for stop watch till the release to completely total (the stream time) and light was seen from best through the channel.
- Again without cleaning or dampen within surfaces of the V-pipe contraption
- The whole arranged SCC test was filled the channel with no packing or vibrating.

A basin was set underneath.

- After 5 minutes of filling the snare entryway was opened and enables the concrete to stream out under gravity.

- Immediately the perusing was recorded by methods for stop watch till the release to completely total and light was seen from best through the pipe. (The stream time in secis T5test).

Analysis of results: The above test gives backhanded proportion of thickness. Time was estimated to release the concrete through the base opening. The criteria for SCC is time ought to be 10±3secs.

The test is for measuring the flow of the SCC and the blocking resistance.

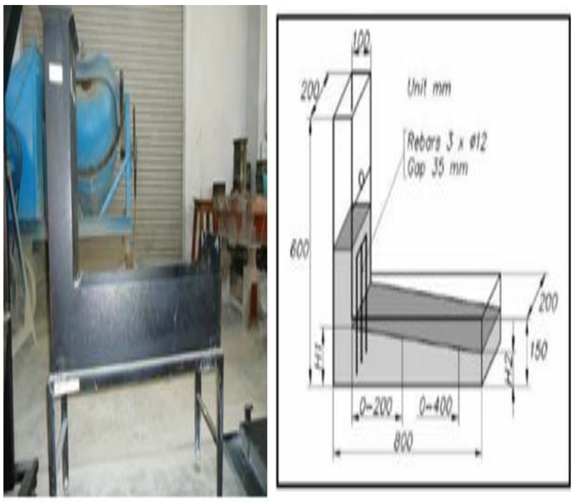

Fig. 3.2.3.3 L-Box Apparatus and Schematic Diagram

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- Fourteen liter of concrete wasprepared for the test.
- The mechanical assembly was set on the leveled surface. Within surfaces of the L-Box contraption was dampened.
- The vertical piece of the container was loaded up with concrete, which is left to rest for 10secs.
- Then the gate was opened.
- The remove "H1" and "H2" are estimated, when the SCC quits streaming.

Analysis of results: the height of the vertical fill (H1) and the height of the concrete in flat stage (H2) were estimated. The criteria to fulfill SCC is ⁄ ought to be at any rate 0.8.

Casting of Specimens

Eighty four numbers cubes(150×150×150)mm, forty two numbers cylinders(150×300)mm, eighty four numbers prisms(100×100×500)mm were threw and examinations were led to study the mechanical behavior, crack behavior, microstructure of plain SCC, basalt fiber reinforced SCC (BFC), glass fiber reinforced SCC(GFC), carbon fiber reinforced SCC(CFC).

Fig. Casting Of Specimens

Curing Of SCC Specimens

In the wake of throwing was done the 3D shapes were kept in room temp. For 24 hours then the molds were expelled and taken to the restoring tank containing new consumable water to fix the example for 7 days and 28days.

Fig. Curing Tank

RESULTS OF THE THE EXPERIMENTAL INVESTIGATIONS ON FRSCC

This section bargains in detail with the aftereffects of exploratory examinations and dialog did in various stages.

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

The principal phase of examinations was completed to create SCC blend of a base quality M30 review utilizing silica smoke and compound admixtures, and to study its crisp and solidified properties. For creating SCC of solidarity M30 review, the blend was planned dependent on EFNARC 2005 code utilizing silica smolder as mineral admixture. At long last, SCC blends which yielded palatable crisp properties and required compressive quality, were chosen and taken for further examination. In the second phase of examination SCC with various fiber substance with various volume division were blended. The blend extents are appeared in table 3.2.1.

Water/cement Ratio of Self-Compacting Concrete

To keep up the fundamental attributes of self-compacting concrete a water cement proportion of 0.42 was received and a % measurements of super-plasticizer Viscocrete of Sika mark were settled for all blends.

Mix Proportions and Fiber Content

The quantity of preliminary blends was set up in the research facility and fulfilling the prerequisites for the crisp state given by EFNARC 2005 code. The present work included readiness of M30 review SCC and to study its behavior when distinctive sorts of fibers were added to it. Plain SCC of M30 review was readied utilizing silica seethe as mineral admixture with sika viscocrete as admixture.

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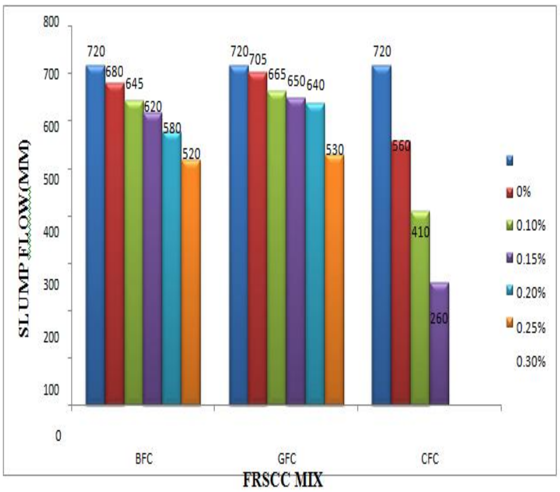
Table 4.1.1 Description of Mixes

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

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)



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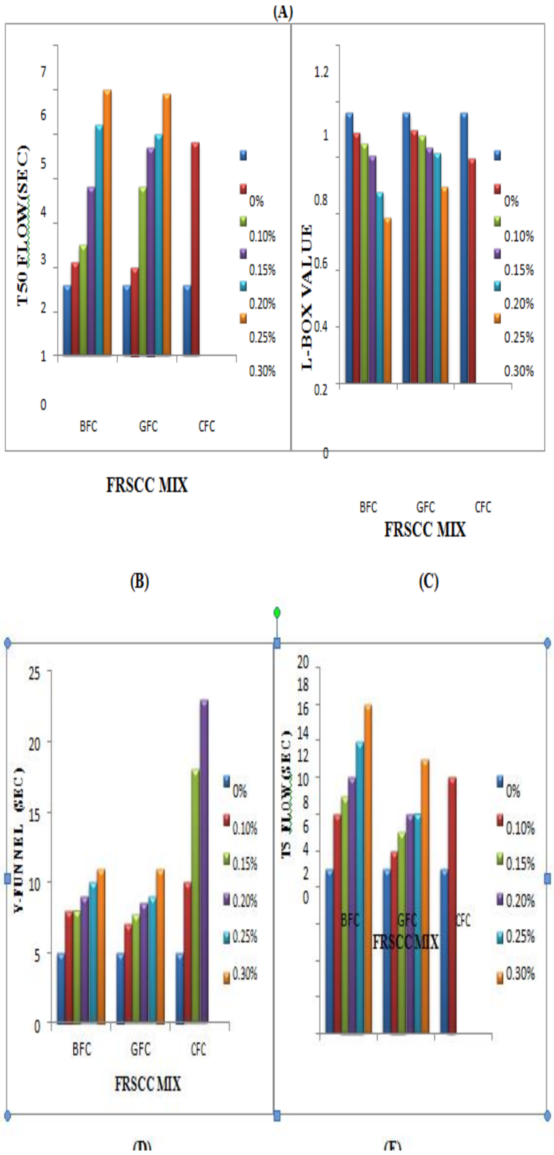

Fig. 4.2.1 (A),(B),(C),(D),(E) Variation of Fresh properties with FRSCC Mix

Properties in Fresh state:

The Table 4.2.1 and the Fig.4.2.1 show decrease of stream esteem inferable from incorporation of fibers. The explanation behind this wonder is that a system structure may shape because of the conveyed fiber in the concrete, which controls blend from isolation and stream.

Slump Flow

The droop stream diminishes with increment in fiber rate. The decline in stream esteem is watched most extreme 63.88% for carbon fiber, 26.38% for glass fiber and 27.77 % for basalt fiberw.r.t control blend. This is on the grounds that carbon fibers consumed more water from the blend and past 0.2% fiber expansion the blend did not fulfilled the standards of self-compacting concrete. Glass fibers assimilate least water.

T50 Flow

The T50 stream, which was estimated as far as time (seconds) increments as the droop stream esteem diminishes. The decline in droop esteem is because of the expansion in the level of fiber which

was clarified in past section. The most extreme time taken to stream was seen at 0.1% for carbon fiber, 0.3% for glass fiber and 0.3% for basalt fiber.

L-Box

The L-Box esteem increments as the droop stream esteem increments. The expansion in droop esteem is because of the increment in the level of fiber and the L-Box esteem additionally increments. The most extreme esteem got on account of control blend yet according to SCC determination 0.2% basalt fiber. 0.25% glass fiber and 0.1% carbon fiber satisfy the necessities.

V-Funnel and T5 stream

The V-Funnel test and T50 stream, which was estimated as far as time (seconds) and both the esteem estimated are reliant with one another. V-Funnel esteem and T5 stream increments as the droop stream esteem diminishes. The decline in droop esteem is because of the expansion in the level of fiber. It was seen that at 0.1% of carbon fiber, 0.2% of basalt fiber and 0.25% og glass fiber the SCC determination were fulfilled.

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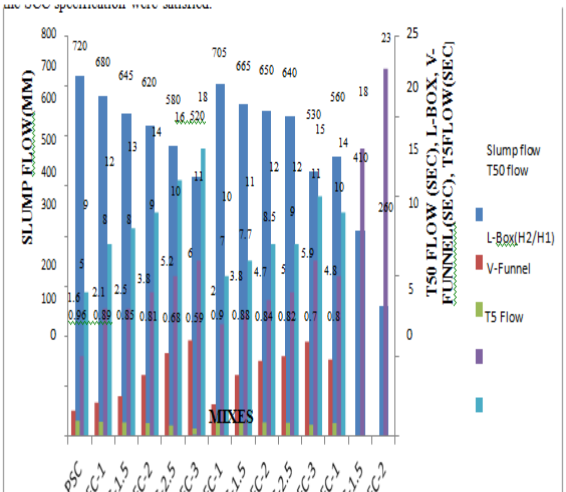

Fig. 4.2.2 Variation of Fresh Properties of FRSCC Mixes with Different Percentage of Fiber Mix

Hardened Properties

To look at the different mechanical properties of the FRSCC blends the standard examples were tried following 7 days and multi day of relieving. The outcomes are outlined in Table 4.3.1

Table-4.3.1 Hardened Concrete Properties of SCC and FRSCC

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

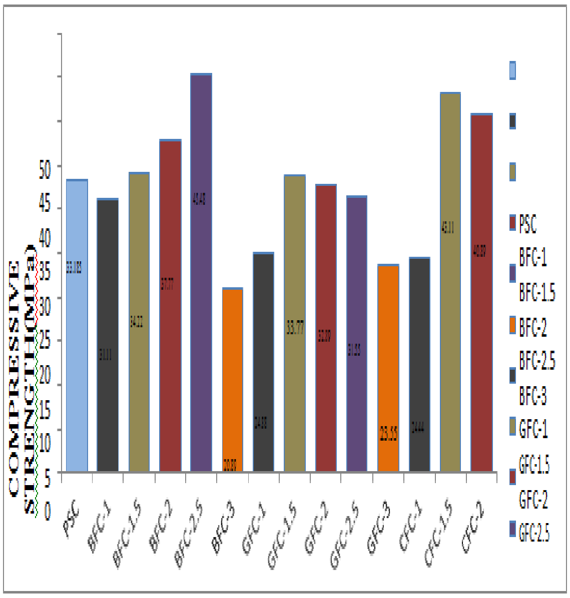

Fig. 4.3.1 Variation of 7-Days Compressive Strength for Different SCC Mixes

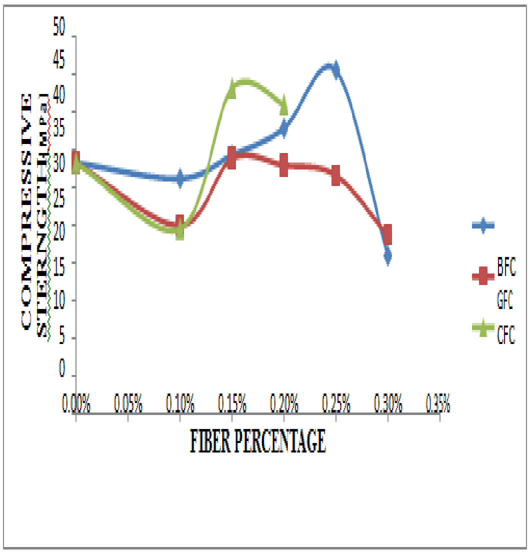

Fig. 4.3.2 Comparison of Different Percentages of Fiber Mixes with 7 days Compressive

The diagram demonstrates the ideal fiber content for most extreme quality in blends with various fibers. The most extreme quality of 43.11MPa was seen with 0.15% carbon fiber content, 45.48MPa was seen with 0.25% basalt fiber content and 33.77 MPa was seen with 0.15% glass fiber content. The most noteworthy 7-day compressive quality was watched for blend with 0.25 %basalt fiber and least for blend with 0.3% basalt fiber

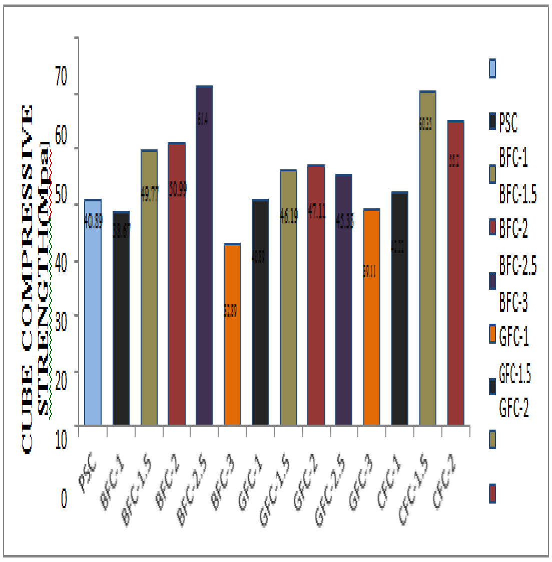

Fig. 4.3.3 Variation of 28days Compressive Strength for Different SCC Mixes

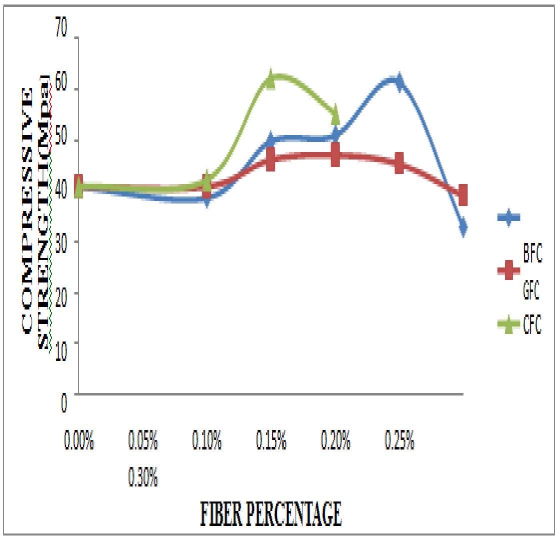

Fig. 4.3.4 Comparison of Different Percentages of Fiber Mixes with 28 days Compressive

The fig. demonstrates the ideal fiber content in blends with various fibers. The most extreme quality of 61.4 MPa was seen with 0.25% basalt fiber content, 60.35 MPa was seen with 0.15% carbon fiber content and 47.11 MPa was seen with 0.2% glass fiber content. The most astounding 28-days compressive quality was watched for blend with 0.25%basalt fiber and least for blend with 0.3%basalt fiber.

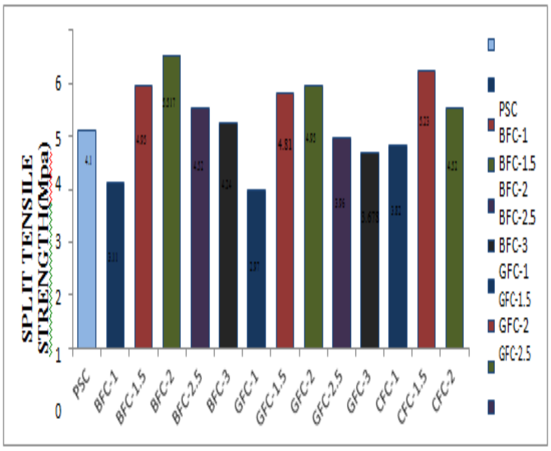

Fig. 4.3.5 Variation of Split Tensile Strength for Different SCC Mixes At 28days

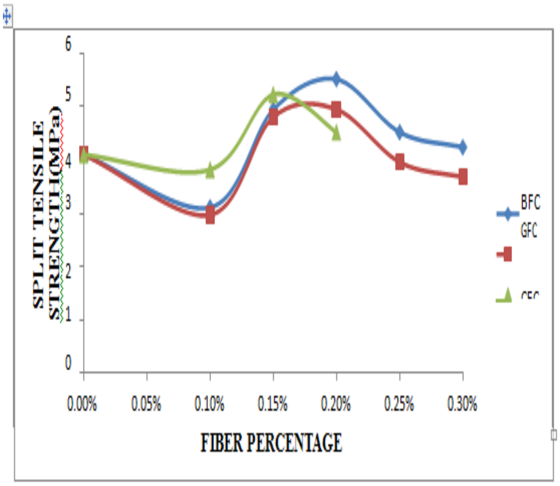

Fig. 4.3.6 Comparison of Different Percentages of Fiber Mixes with 28 days Split Tensile Strength

The Fig. demonstrates the ideal fiber content in blends with various fibers. The greatest quality of 5.517MPa was seen with 0.2% basalt fiber content, 5.23MPa was seen with 0.15% carbon fiber content and 4.95MPa was seen with 0.2% glass fiber content. The most noteworthy 28-days split elasticity was watched for blend with 0.2%basalt fiber and least for blend with 0.1% glass fiber.

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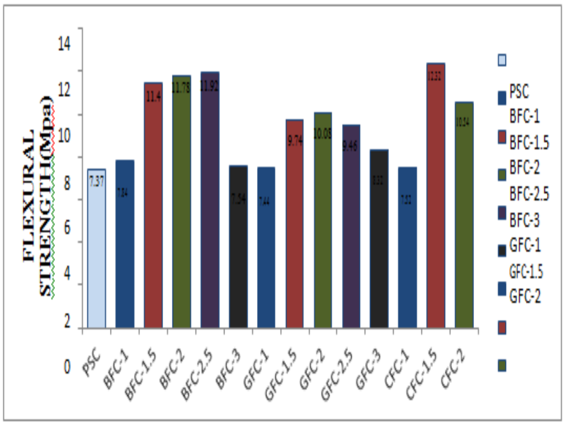

Fig. 4.3.7 Variation of Flexural Strength for Different SCC Mixes At 28days

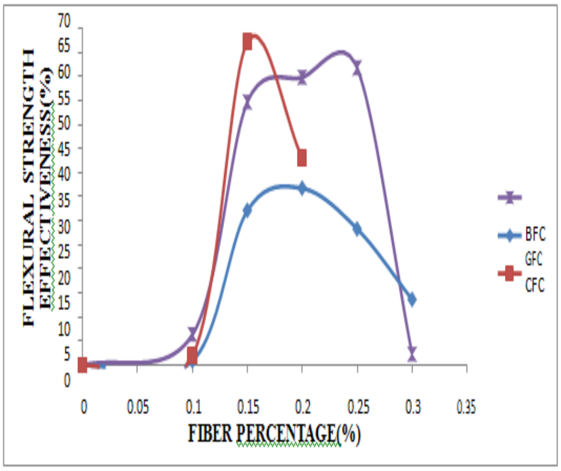

Fig. 4.3.8Flexural Strength-Effectiveness of FRSCC at 28-Days

The Fig. 4.3.8 demonstrates the ideal fiber content in blends with various fibers. The greatest quality of 12.32MPa was seen with 0.15% carbon fiber content, 11.92MPa was seen with 0.25% basalt fiber content and 10.08MPa was seen with 0.2% glass fiber content. The most astounding 28-days flexural quality was watched for blend with 0.15%carbon fiber and least for blend with 0.1%glass fiber.

Compressive Strength

7-Days Compressive Strength

Contrasted with the plain SCC the compressive quality reinforced with basalt fiber of volume part 0.15%, 0.2% and 0.25% expansion by 3.12%, 13.82% and 37.05% individually. Contrasted and the plain SCC the compressive quality reinforced with glass fiber of volume portion 0.15% expansion by 1.76%. In this study the 7 days compressive quality of glass fiber demonstrates no conspicuous enhancement. Contrasted and the plain SCC the compressive quality reinforced with carbon fiber of 0.15% and 0.2% expansion by 29.9% and 23.22% individually. Fig. demonstrates that for CFC and BFC has higher compressive quality at 7 days at volume part of 0.15% to 0.25%.

28-Days Compressive Strength

From Fig..Compared with plain SCC, 0.15% of BFC, GFC and CFC increment 21.72%, 10.52% and 47.6% individually. For 0.2% of BFC, GFC and CFC increment 24.7%, 15.21% and 35% individually. For 0.25% of BFC and GFC increments 50.16% and 11% individually. In this study, Fig.4.2.4 demonstrates that the ideal measurements for BFC are 0.25%, for GFC is 0.2% and for CFC is 0.15%.

Split Tensile Strength

The rate enhancement of split elasticity for basalt fiber over plain SCC is 20.44%, 34.56%, 10.24% and 3.41% while including 0.15%, 0.2%, 0.25% and 0.3% separately. The rate enhancement of split rigidity for glass fiber over plain SCC is 17.31%, 20.73% while including 0.15% and 0.2% separately. The rate enhancement of split elasticity for carbon fiber over plain SCC is 27.56% and 10.24% individually. The expansion is because of the fiber as clarified previously.

Flexural Strength

Table 4.3.1 and Fig. 4.3.7 shows flexural qualities of FRSCC blends following 28 days and fig.4.2.8 demonstrates the ideal

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fiber part bestowing most extreme flexural quality with various fibers. Of course, all FRSCC examples demonstrate an expansion in flexural quality with increment in fiber content. Contrasted and the plain SCC the improved level of the flexural quality of carbon FRSCC were seen in the scope of 2.03% to 67.16% while 0.15% gave most extreme quality. Increment in flexural quality were seen in extents from 0.95% to 36.77% for GFC with the fiber level of 0.1% to 03% ,the and improved rate flexural quality reaches from 2.37% to 61.736% were watched for basalt fiber with rate fiber ranges from 0.1% to 0.3%. Most extreme flexural quality 12.32MPa was watched for carbon FRCCC for 1.5% of fiber rate.

T

LOADS-DISPLACEMENT BEHAVIOR AND TOUGHNESS INDEX

The load deflection (vertical) diagrams obtained from electronic UTM clearly proved that addition of fibers to SCC increase ductility whereas control beam PSC exhibited brittle behavior. The maximum increment was observed from carbon fiber than the basalt and the lowest from the glass fiber. In each series the mix which gave maximum compressive strength rendered maximum ductility. The area below the load deflection curve represents toughness. Almost same

Table 4.5.1 Load-Displacement Result

Specimen	Ultimate load(KN)
PSC	12.800
BFC-1	15.540
BFC-1.5	20.690
BFC-2	22.420
BFC-2.5	22.540
BFC-3	15.810
GFC-1	15.650
GFC-1.5	19.580
GFC-2	19.620
GFC-2.5	17.900
GFC-3	17.590
CFC-1	15.950
CFC-1.5	23.330
CFC-2	19.980

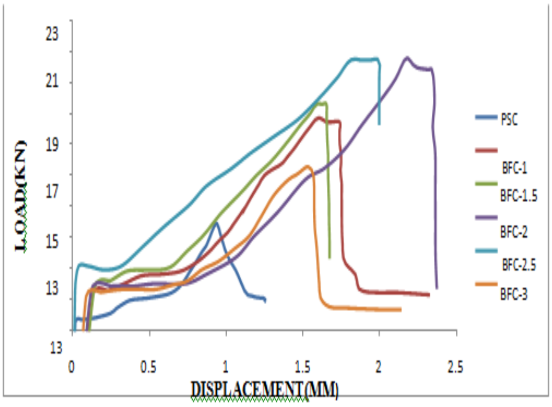

Fig. 4.5.5 Load-Displacement Curve For BFC

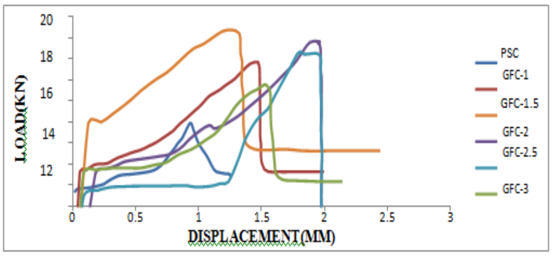

Fig. 4.5.6 Load-Displacement Curve For GFC

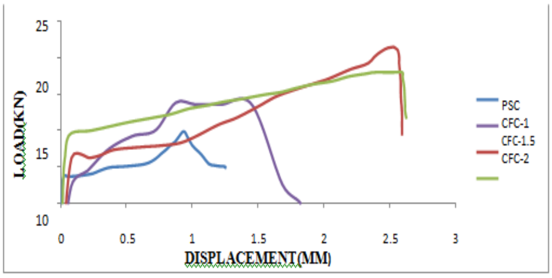

Fig. 4.5.7 Load-Displacement Curve For CFC

demonstrates the load-displacement bends of the plain SCC with various FRSCC tests. It is discovered that for the plain SCC, the load diminishes quickly with the expansion of deflection after pinnacle load (bend of PSC). While for the FRSCC, the decline patterns demonstrate flatter (bend of FRSCC). The spanning activity offered by the fibers can successfully enhance the strength and flexibility, and hence wiping out the sudden fragile break after pinnacle load exhibited in plain SCC. Table 4.5.1 presents the aftereffect of extreme load of plain SCC and FRSCC. It tends to be seen from table 4.5.1 that a definitive load taken by FRSCC increment contrasted with plain SCC. Basalt& carbon fiber indicates most evident enhancement

LOAD-CMOD BEHAVIOUR

The load versus crack mouth opening deflection charts got plainly demonstrated that expansion of fibers to SCC increment malleability while control beam PSC displayed weak behavior. The most extreme addition was seen from carbon fiber than the basalt and the least from the glass fiber. In every arrangement the blend which gave most extreme compressive quality rendered greatest pliability. The territory underneath the load deflection bend speaks to sturdiness. Relatively same pattern of behavior were seen from all blends.

The perceptions made amid the tests (LOAD-CMOD) were utilized to draw the LOAD-CMOD bends. A definitive load and the crack parameters were resolved.

Table 4.6.1 LOAD-CMOD RESULT FOR GFC

LOAD(KN)	CMOD(MM)					
	PSC	GFC-1	GFC-1.5	GFC-2	GFC-2.5	GFC-3
0	0	0	0	0	0	0
0.75	0	0	0.001	0	0	0
1	0	0	0.002	0	0	0
2	0.01	0.004	0.006	0	0	0
3	0.08	0.006	0.008	0	0.02	0
4	0.26	0.009	0.024	0	0.05	0.04
4.25	0.28	0.01	0.033	0	0.06	0.05
5		0.16	0.05	0	0.08	0.09
5.5		0.2	0.11	0	0.09	0.13
6		0.41	0.18	0	0.13	0.16
6.5			0.25	0.01	0.17	0.18
6.75			0.3	0.03	0.18	0.19
7				0.03	0.21	0.22
8				0.06	0.32	0.35
9				0.13	0.46	0.51
9.5				0.18	0.5	
10				0.22		
10.25				0.27		

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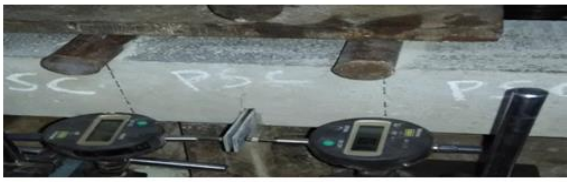

Fig 4.6.1 Crack Pattern of PSC

Fig. 4.6.2 Crack Pattern of GFC-1

Fig. 4.6.3 Crack Pattern of GFC-1.5

Fig.4.6.4 Crack Pattern of GFC-2.5

Fig 4.6.5 Crack Pattern of GFC-3

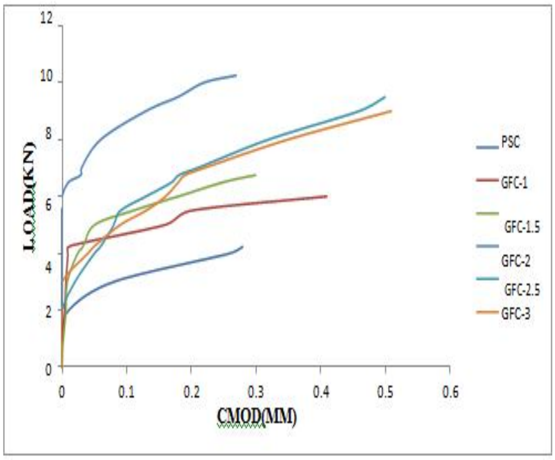

Fig. 4.6.6 LOAD-CMOD Curve For GFC

Table 4.6.2 LOAD-CMOD RESULT FOR BFC

LOAD(KN)	CMOD(MM)					
	PSC	BFC-1	BFC-1.5	BFC-2	BFC-2.5	BFC-3
0	0	0	0	0	0	0
2	0.01	0	0.004	0	0	0
3.25	0.1	0.01	0.009	0	0	0
4	0.26	0.05	0.019	0.01	0	0.02
4.25	0.28	0.06	0.023	0.015	0	0.05
6		0.1	0.053	0.06	0.08	0.13
6.25		0.3	0.059	0.09	0.1	0.16
6.5		0.36	0.065	0.15	0.12	0.19
6.75			0.08	0.18	0.14	0.36
7			0.1	0.21	0.17	
7.75			0.33	0.28	0.23	
8					0.26	
9.75					0.36	
10.5					0.43	
10.75					0.45	

Fig. 4.6.7 Crack Pattern of BFC-1

Fig. 4.6.8 Crack Pattern of BFC-1.5

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Fig. 4.6.9Crack Pattern of BFC-2

Fig. 4.6.10Crack Pattern of BFC-2.5

Fig. 4.6.11Crack Pattern of BFC-3

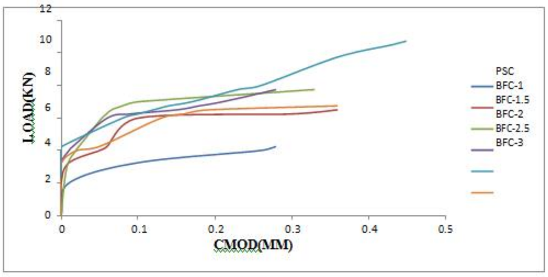

Fig. 4.6.12LOAD-CMOD Curve For BFC

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Fracture Behavior of Basalt Fiber Reinforced SCC (BFC)

From table 4.6.2 and fig 4.6.12 it is seen that the break behavior of BFC is more than PSC in all fiber substance. When contrasted with PSC the expansion in extreme load for BFC was around 52.94%, 82.35%, 82.35%, 152.9% and 58.8% while including 0.1%, 015%, 0.2%, 0.25%, 0.3%

fibers separately. As the fiber content expanded, the break behavior was additionally observed to be expanded for BFC. Fig.4.6.7 to fig. 4.6.11 demonstrates the crack pattern of BFC

Table 4.6.3 LOAD-CMOD RESULT FOR CFC

LOAD(KN)	CMOD(MM)			
	PSC	CFC-1	CFC-1.5	CFC-2
0	0	0	0	0
2	0.01	0	0	0
3	0.08	0	0	0
4	0.26	0.01	0	0
4.25	0.28	0.02	0	0
4.75		0.05	0	0.02
5		0.07	0	0.02
6		0.13	0	0.07
6.5		0.18	0.01	0.08
7		0.2	0.03	0.13
8		0.25	0.06	0.21
9			0.12	0.3
9.5			0.15	0.35
10			0.21	
11			0.3	
11.75			0.34	

Fig.4.6.13Crack Pattern of CFC-1

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Fig.4.6.14Crack Pattern of CFC-1.5

Fig. 4.6.15Crack Pattern of CFC-2

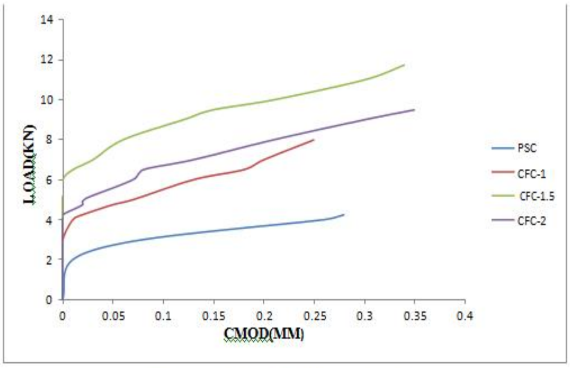


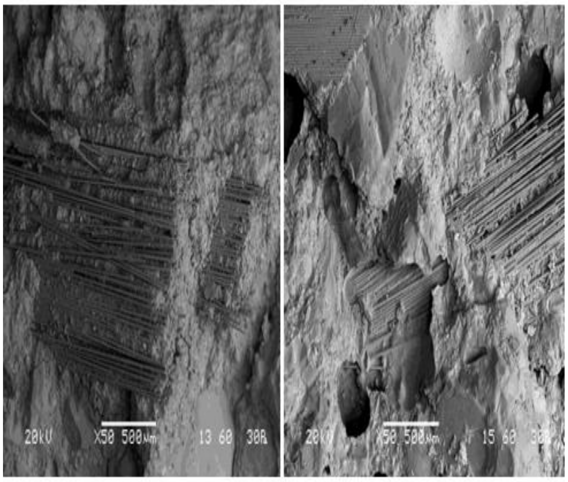
Fig. 4.6.16LOAD-CMOD Curve For CFC

Fracture Behavior of Carbon Fiber Reinforced SCC (CFC)

From table 4.6.3 and fig 4.6.16 it is seen that the crack behavior of CFC is more than PSC in all fiber substance. When contrasted with PSC the expansion in extreme load for BFC was around 88.23%, 176.47% and 123.53% while including 0.1%, 015% and 0.2% fibers individually. As the fiber content expanded, the crack behavior was likewise observed to be expanded for CFC. Fig. demonstrates the crack pattern of CFC.

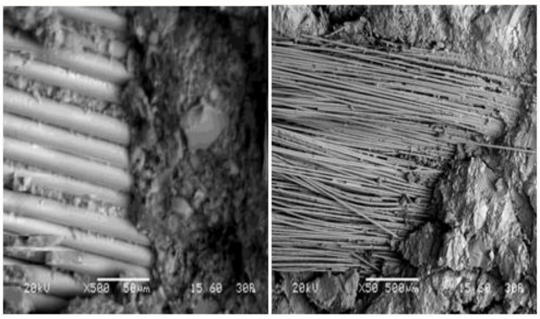
MICROSTRUCTURE BEHAVIOR

SEM test is the actual way to study the microstructure of the hydrated cement based products. To assessment the bond characteristics of BFC, GFC & CFC mix at 7 and 28days, the microstructure of FRSCC was studied by means of SEM



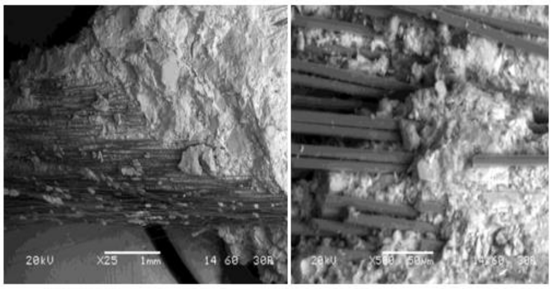
(A) (B)

Fig.4.7.1 SEM photographs for (A) 7-Days & (B) 28 days concrete & basalt fiber matrix



(A) (B)

Fig.4.7.2 SEM photographs for (A) 7-Days & (B) 28 days concrete & glass fiber matrix



(A) (B)

Fig.4.7.3 SEM photographs for (A) 7-Days & (B) 28 days concrete & carbon fiber matrix
Fig.4.7.1 to 4.7.3 shows the photographs of microstructure of fiber surfaces and hydrated concrete matrix. It is observed from fig that basalt and carbon fiber SCC surfaces covered with densely hydrated concrete matrix than GFC.
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SORPTIVITY

Sorptivity is a proportion of the hairlike power applied by the pore structure making liquids be drawn into the body of the material. It is determined as the rate of

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slender ascent in a concrete crystal set in 2 to 5 mm profound water. For one-dimensional stream, the connection between ingestion and sorptivity is given by, k = where, is the combined water ingestion per unit region of inflow surface, k is the sorptivity and t is the slipped by time. The test was led in the research facility.

At chose interims of 30min, 1hr, 2hr, 6hr, 24hr and 48hr; the example was expelled and was weighed in the wake of smearing off abundance water. The gain in mass per unit region over the thickness of water (gain in mass/unit zone/thickness of water) versus the square base of time was plotted. The slant of the best fitting line was accounted for as the sorptivity.

Table 4.8.1 Capillary Water Absorption Test Results

Sample	Initial Wt.(gm.)	Weight(gm.)					
		30min	1hr	2hr	6hr	24hr	48hr
GFC	7499	7509	7510	7512	7514	7519	7521
BFC	7471	7483	7486	7488	7490	7496	7500
CFC	7604	7618	7620	7623	7626	7632	7640

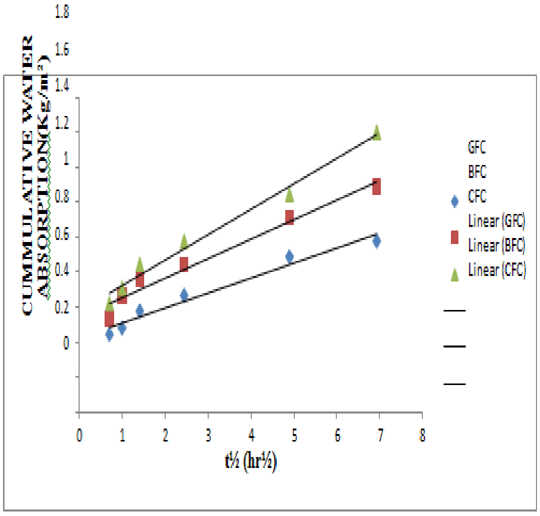

Fig. 4.8.1 Capillary Water Absorption at Different Time Interval

The narrow water ingestion in wording time (square foundation of time in hours) is plotted in Fig. The water retention for CFC tests is the higher than BFC and GFC tests, which is because of the extra water consumed by the fibers. The higher sorptivity esteem was acquired for examples containing CFC fibers.

Conclusion

From the present study the accompanying ends can be drawn

1. Addition of fibers to self-compacting concrete causes loss of essential qualities of SCC estimated as far as droop stream, and so on.
2. Reduction in droop stream was watched greatest with carbon fiber, at that point basalt and glass fiber individually. This is on the grounds that carbon fibers consumed more water than others and glass assimilated less.
3. Carbon fiber expansion over 2% made blend brutal which did not fulfill the angles like droop esteem, T50 test and so on required for self-compacting concrete.
4. Addition of fibers to self-compacting concrete enhance mechanical properties

like compressive quality ,split rigidity, flexural quality and so on of the blend.

5. There was an ideal level of each sort of fiber, gave most extreme enhancement in mechanical properties of SCC.
6. Mix having 0.15% carbon fiber, 0.2% of glass fiber and 0.25% of basalt fiber were seen to expand the mechanical properties to most extreme.
7. 0.15% expansion of carbon fiber to SCC was seen to expand the 7-days compressive quality by 29.9%, 28-days compressive quality by 47.6%, split rigidity by 27.56%, flexural quality by 67.16%.
8. 0.25% expansion of basalt fiber to SCC was seen to build the 7-days compressive quality by 37.05%, 28-days compressive quality by 50.16%, split rigidity by 34.56%, flexural quality by 61.736%.
9. 2% expansion of glass fiber to SCC was seen to build the 7-days compressive quality by 1.76%, 28-days compressive quality by 15.21%, split rigidity by 20.73%, flexural quality by 36.77%.
10. The FRSCC blends showed increment in pliability estimated through load deflection outlines. The basalt fiber reinforced SCC displayed greatest addition than carbon and glass FRSCC.
11. The load versus crack mouth opening displacement graphs for FRSCC displayed increment in break vitality properties of the blends. This is attributable to crack capturing system of the fibers in the matrix. In such manner the carbon fiber showed best execution, at that point the basalt and after that glass fiber.
12. The SEM analysis of microstructure of FRSCC showed great physical security between a wide range of fiber and the hydrated matrix. A thick structure of matrix was seen in each blends attributable to expansion of silica smolder. No obvious variety was seen between blend of 7days and 28 days.
13. Capillary assimilation of water by FRSCC blends were controlled by sorptivity test. The higher sorptivity coefficient was watched for carbon FRSCC blends since carbon fibers ingested more water. Slightest qualities were seen by basalt FRSCC.

14. The execution of carbon fiber reinforced SCC blends was superior to basalt FRSCC and glass FRSCC blends. At that point carbon fiber FRSCC displayed best mechanical properties with relatively bring down volume portion however its impact on SCC crisp properties was simply invert. Its consideration diminished stream capacity, deformability since it retains more water. Other downside is that it is costliest than other two kinds of fibers.
15. GlassFRSCC displayed enhancement in every single mechanical property particularly in early ages, with higher volume division. It indicated better exhibitions in crisp state. Aside from being least expensive its execution in crisp state however shown least quality, most elevated sorptivities. The tiny study (SEM) showed preferable bond advancement over other two sorts in early days.
16. Basalt FRSCC showed better properties in crisp state and solidified state contrasted with the Glass FRSCC. As far as the cost it is less expensive than carbon subsequently basalt fiber execution is by and large best contrasted and glass and carbon fiber.

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