EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE

[1]SHAIK IMAM MOHIDIN,[2]CH YUVARAJU

[1]M.Tech-Student, Structural Engineering, Amritasai Institute of Science and Technology, Paritala. India

[2]Professor, Department of Civil Engineering, Amritasai Institute of Science and Technology, Paritala. India

Abstract: Plain concrete has a low tensile strength, ductility and little resistance towards splitting. By adding firmly divided and consistently scattered fibers to concrete this splitting can be controlled to a limit and considerably enhances its static and dynamic properties. This paper presents impact on mechanical properties of fiber reinforced concrete, for example, density, workability, compressive strength and split tensile strength. The aspect ratio of the fiber is the proportion of its length to its diameter used. A composite is named as hybrid, if at least two sorts of fibers are soundly joined to create a composite that gets advantage from every one of the individual fibers and shows a synergetic reaction. Cube and cylindrical samples have been outlined with steel fiber reinforced concrete containing fibers of 1.0, 1.5, 2.0% volume division of hooked end steel fibers of 65 and 80 aspect rations. The test outcomes demonstrated that the compressive strength and split tensile strength of HFRC with two diverse aspect rations at same volume fraction demonstrates an improvement. However, inclusion of fiber to the concrete influences the workability of concrete and can be overwhelmed by utilizing super plasticiser.

In producing the specimens, the volume content of the fiber was held at 1%,1.5% & 2% (if only one type of fibre is been mixed) and if combination is mixed means the volume fraction is held at 0.5%+0.5%, 0.75%+0.75%& 1%+1%. an improvement was obtained from the hybrid mixes when compared to all the other samples.

Key words: fibre reinforcement, hybrid composite, compressive strength, tensile strength, crimpled & hooked fiber

I. INTRODUCTION:

Concrete is a construction material made out of cement (usually Portland cement) and additionally different cementations materials, for example, fly ash and slag cement, aggregate (coarse aggregate made of smashed rocks, for example, limestone, or granite, in addition to a fine aggregate, for example, sand), water, and synthetic admixtures. The paste fills the voids in the aggregate and after the concrete is put and vibrated it solidifies to shape a strong structural part. Concrete has high compressive strength and low tensile strength. Concrete solidifies and hardens subsequent to blending with water because of a chemical procedure known as hydration. The water responds with the cement, which bonds alternate segments together, in the end making a stone-like material.

Recent earthquakes in various parts of the world have uncovered again the significance of outline of reinforced concrete structures with high ductility. Strength and ductility of structures depend for the most part on enumerating of the reinforcement in beam-column joints. The stream of forces inside a beam-column joint might be hindered if the shear quality of the joint isn't enough given. Under seismic excitations, the beam column joint zone is subjected to even and vertical shear forces whose extents are ordinarily higher than those inside the adjoining bars and sections. Regular concrete loses its tensile protection after happening of various cracks. In any case, fiber concrete can manage a part of its protection following splitting to oppose more cycles of loading. Beam-column joints have a vital part in the structural integrity of the structures. Consequently they should be given sufficient firmness and quality to support the heaps transmitted from columns and beams. The development of plastic hinges in columns must be averted since it influences the whole structure. For sufficient ductility of beam-column joints, utilization of firmly divided hoops as transverse reinforcement was prescribed in the ACI-ASCE Committee 352 .report (ACI, 2002).

All in all, when fibers are added to concrete, tractable strain in the area of fibers enhances fundamentally. On account of SFRC, since concrete is thick even at the microstructure level, tensile strain would be considerably higher than that of the traditional SFRC. This, thusly, will enhance the breaking conduct, ductility and vitality assimilation limit of the composite. With a specific end goal to tap the capability of SFRC, the current group of information must be extended. Henceforth, an endeavor has been made to think about the conduct of SFRC beam-column joint under the positive cyclic loading.

The objective of the present investigation is to evaluate the mechanical properties, physical properties, crack studies and life estimation of hybrid fiber reinforced concrete and comparing with the conventional concrete.

II. MATERIAL USED:

Cement:

In this examination, Ordinary Portland cement of 53 Grade of Brand ULTRATECH confirming to IS 12269-1987 has been utilized.

Physical properties

Specific gravity	:	3.145
Consistency	:	31%
Initial setting time	:	88 min
Final setting time	:	176 min

Coarse aggregate:

In this examination, Coarse aggregates confirming to IS 383-1970 with particle size equal to or greater than 4.75mm.has been utilized.

Physical properties

Specific gravity : 2.6

Fine aggregate:

In this examination, Fine aggregates with particle size passing through 4.75mm and retaining on 75µ sieve has been utilized.

Physical properties

Specific gravity : 2.55

Water:

Water is needed for the purpose of hydration of cement and to provide workability during mixing and placing of concrete. For this experiment portable water with pH value of 7 and conforming to the specifications of IS456-2000 is used for making specimens as well as curing.

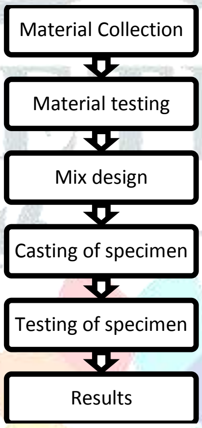
Fibers:

There are various distinctive sorts of steel fibers with various business names.

Physical properties :

S.No	Steel Fiber	Diameter (mm)	Length(mm)	Aspect Ratio
1.	Crimpled	0.90	45	50
2.	Hooked end	0.75	60	80
3.	Hooked end	0.90	60	65

III. METHODOLOGY



Compressive strength of concrete

A total number of 3 cube specimens each were casted under conventional concrete, after curing 28days, 56days and 90days testing was carried out. Compressive strength of the specimens is calculated using the following formula:

Compressive strength = Load/Area of cube

Spilt tensile strength of concrete

A total number of 3 cylindrical shaped samples were casted under conventional concrete; subsequent to curing 28days, 56days and 90days testing was carried out. Split tensile strength of the samples is ascertained utilizing the accompanying equation:

Split Tensile strength = $2P/\pi DL$

Details of specimens:

S.NO	Specifications	Number of Specimens		Volume Fraction (%)	Aspect Ratio (L/D)
		Cylinders	Cubes		
1	CC	3	3	----	----
2	CFRC1	3	3	1%	50
3	CFRC2	3	3	1.5%	50
4	CFRC3	3	3	2%	50
5	HFRC1	3	3	1%	80
6	HFRC2	3	3	1.5%	80
7	HFRC3	3	3	2%	80
8	HFRC4	3	3	1%	65
9	HFRC5	3	3	1.5%	65
10	HFRC6	3	3	2%	65
11	CHFRC1	3	3	(0.5%+0.5%)	50+80
12	CHFRC2	3	3	(0.75%+0.75%)	50+80

13	CHFRC3	3	3	(1%+1%)	50+80
14	CHFRC4	3	3	(0.5%+0.5%)	50+65
15	CHFRC5	3	3	(0.75%+0.75%)	50+65
16	CHFRC6	3	3	(1%+1%)	50+65

CC - Conventional concrete
CFRC1 - Crimped fiber alone (Aspect ratio 50 & volume fraction 1%)
CFRC2 - Crimpled fiber alone (Aspect ratio 50 & volume fraction 1.5%)
CFRC3 - Crimpled fiber alone (Aspect ratio 50 & volume fraction 2%)
HFRC1 - 80 alone (Aspect ratio 80 & volume fraction 1%)
HFRC2 - 80 alone (Aspect ratio 80 & volume fraction 1.5%)
HFRC3 - 80 alone (Aspect ratio 80 & volume fraction 2%)
HFRC4 - 65 alone (Aspect ratio 65 & volume fraction 1%)
HFRC5 - 65 alone (Aspect ratio 65 & volume fraction 1.5%)
HFRC6 - 65 alone (Aspect ratio 65 & volume fraction 2%)
CHFRC1 - (50+80) (Aspect ratio 50+80 & volume fraction 0.5%+0.5%)
CHFRC2 - (50+80) (Aspect ratio 50+80 & volume fraction 0.75%+0.75%)
CHFRC3 - (50+80) (Aspect ratio 50+80 & volume fraction 1%+1%)
CHFRC4 - (50+65) (Aspect ratio 50+65 & volume fraction 0.5%)
CHFRC5 - (50+65) (Aspect ratio 50+65 & volume fraction 0.75%+0.75%)
CHFRC6 - (50+65) (Aspect ratio 50+65 & volume fraction 1%+1%)

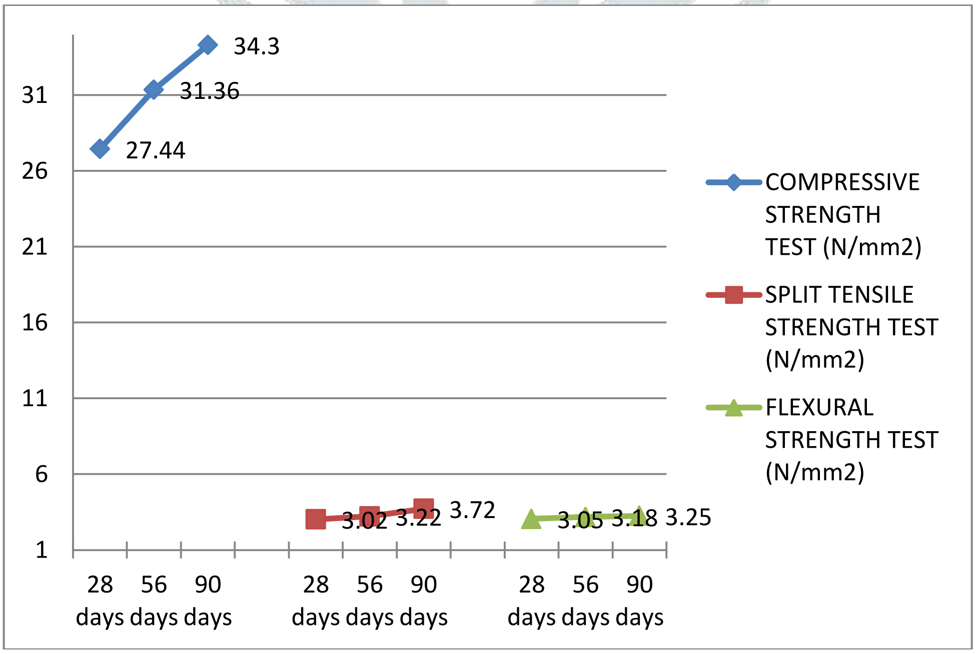
II. EXPERIMENTAL RESULTS:

The results show that there is large variation between the compressive strength of concrete in cubes and split tensile strength of cylinders.

universal testing machine of capacity 100 tones was used for testing the compressive strengths of cube specimens at 28 days, 56 days and 90 days from casting at a loading rate of 14 N/mm2/min. Results for compressive for all mixtures are presented From the results for compressive strength, it is evident that an enhancement in strength compared to control concrete occurs for all the large fiber concretes

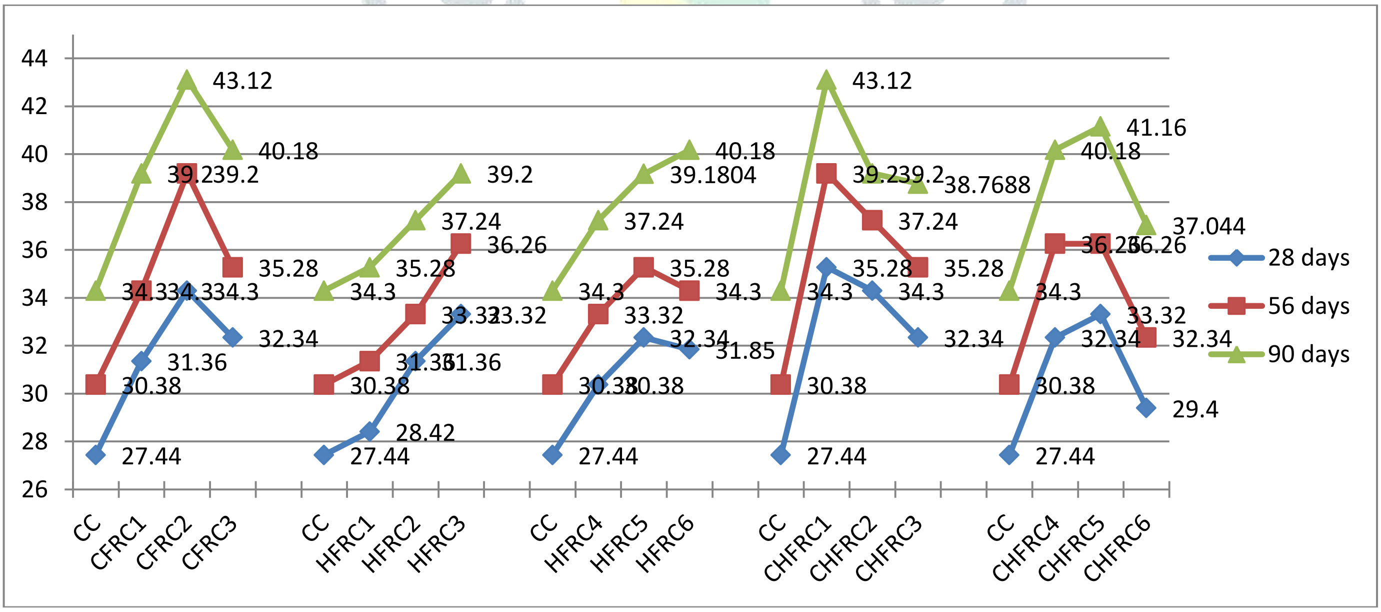
Compressive, split tensile and Flexural Test results for conventional concrete

Grade of concrete (M30)	COMPRESSIVE STRENGTH TEST (N/mm2)	SPLIT TENSILE STRENGTH TEST (N/mm2)	FLEXURAL STRENGTH TEST (N/mm2)
	Values	Values	Values
28 days	25	3.02	3.05
56 days	28	3.22	3.18
90 days	30	3.72	3.25



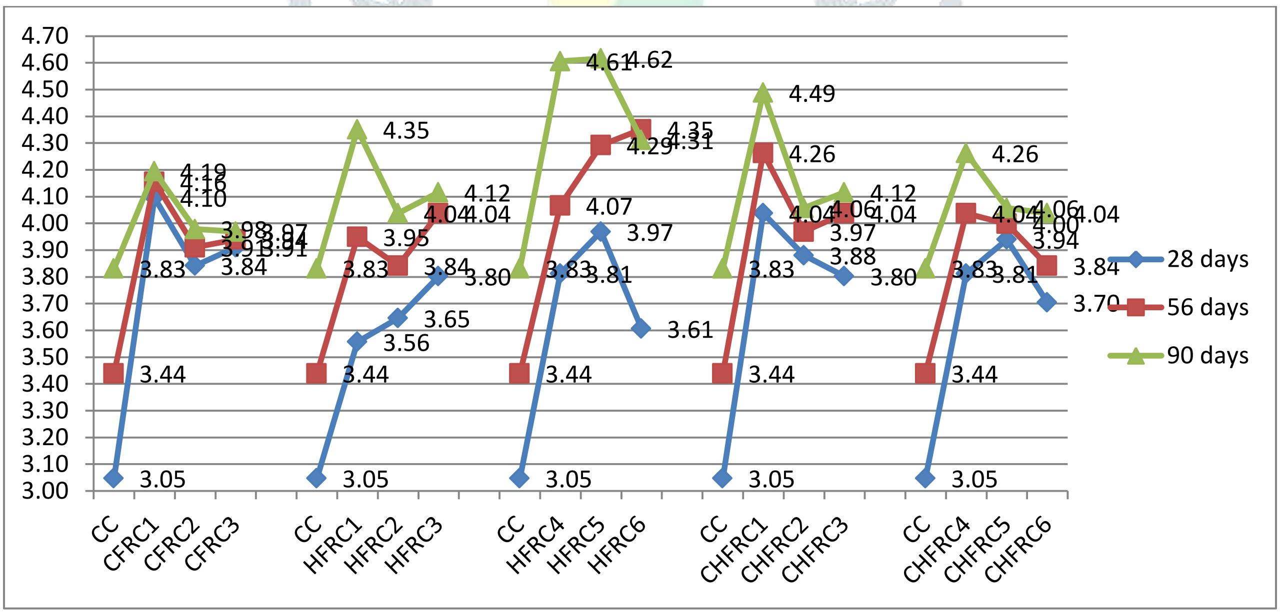
Compressive Test results for HFRC

Grade of concrete (M30)	COMPRESSIVE STRENGTH TEST (N/mm2)					
	load (KN)	28 days	load (KN)	56 days	load (KN)	90 days
CC	617.40	27	683.55	30	771.75	34
CFRC1	705.60	31	771.75	34	882.00	39
CFRC2	771.75	34	88.20	39	970.20	43
CFRC3	727.65	32	793.80	35	904.05	40
HFRC1	638.96	28	705.60	31	793.80	35
HFRC2	705.60	31	749.70	33	837.90	37
HFRC3	749.70	33	815.85	36	882.00	39
HFRC4	683.55	30	749.70	33	837.90	37
HFRC5	727.65	32	793.80	35	872.30	39
HFRC6	716.63	32	771.75	34	904.05	40
CHFRC1	793.80	35	882.00	39	970.20	43
CHFRC2	771.75	34	837.90	37	882.00	39
CHFRC3	727.65	32	793.80	35	872.30	39
CHFRC4	727.65	32	815.85	36	904.05	40
CHFRC5	749.70	33	815.85	36	926.10	41
CHFRC6	661.50	29	727.65	32	815.85	37



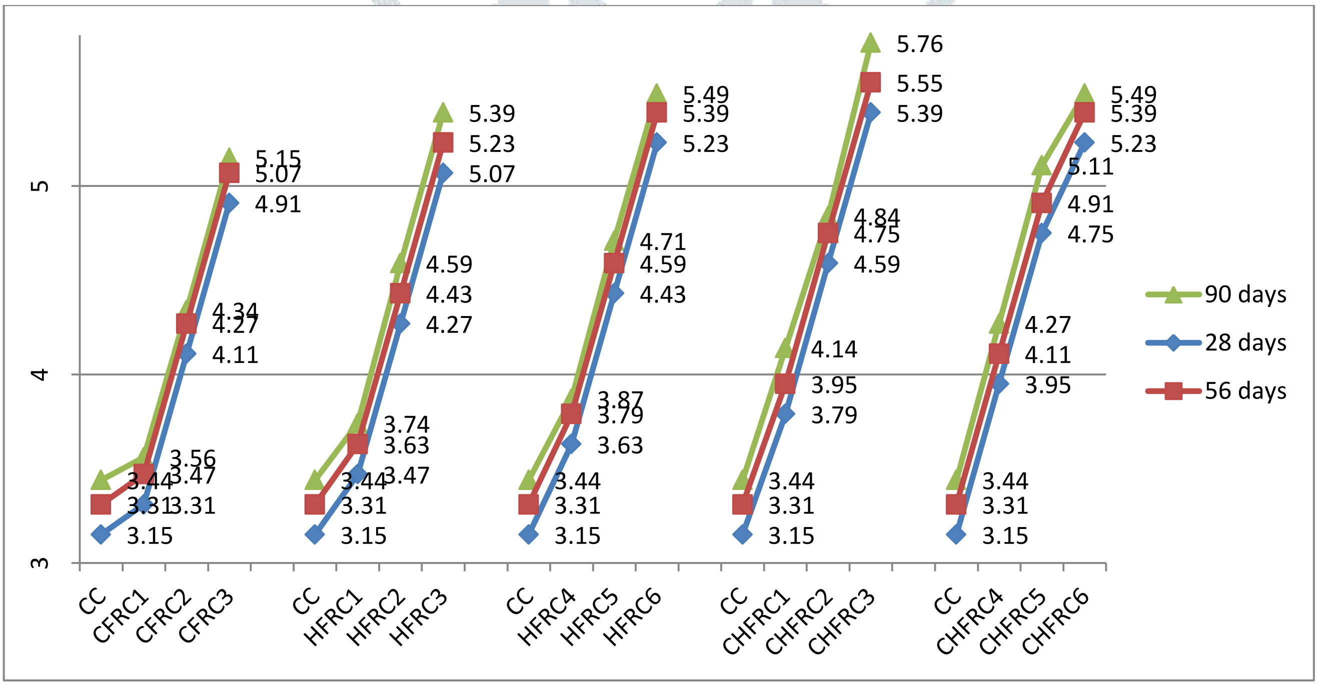
Split tensile strength results for non-conventional concrete

Grade of concrete (M30)	SPLIT TENSILE STRENGTH TEST(N/mm2)					
	load (KN)	28 days	load (KN)	56 days	load (KN)	90 days
CC	215.33	3.05	243.02	3.44	270.72	3.83
CFRC1	289.56	4.10	293.57	4.16	296.33	4.19
CFRC2	271.41	3.84	276.25	3.91	281.10	3.98
CFRC3	276.25	3.91	278.33	3.94	280.41	3.97
HFRC1	251.33	3.56	279.03	3.95	307.42	4.35
HFRC2	257.56	3.65	271.41	3.84	285.26	4.04
HFRC3	268.77	3.80	285.28	4.04	290.80	4.12
HFRC4	269.33	3.81	287.34	4.07	325.42	4.61
HFRC5	280.41	3.97	303.26	4.29	326.10	4.62
HFRC6	254.92	3.61	307.42	4.35	303.07	4.31
CHFRC1	285.26	4.04	301.18	4.26	386.35	4.49
CHFRC2	274.17	3.88	280.41	3.97	286.64	4.06
CHFRC3	268.77	3.80	285.28	4.04	290.80	4.12
CHFRC4	269.33	3.81	285.26	4.04	301.18	4.26
CHFRC5	278.33	3.94	282.49	4.00	286.64	4.06
CHFRC6	261.85	3.70	271.41	3.84	285.26	4.04



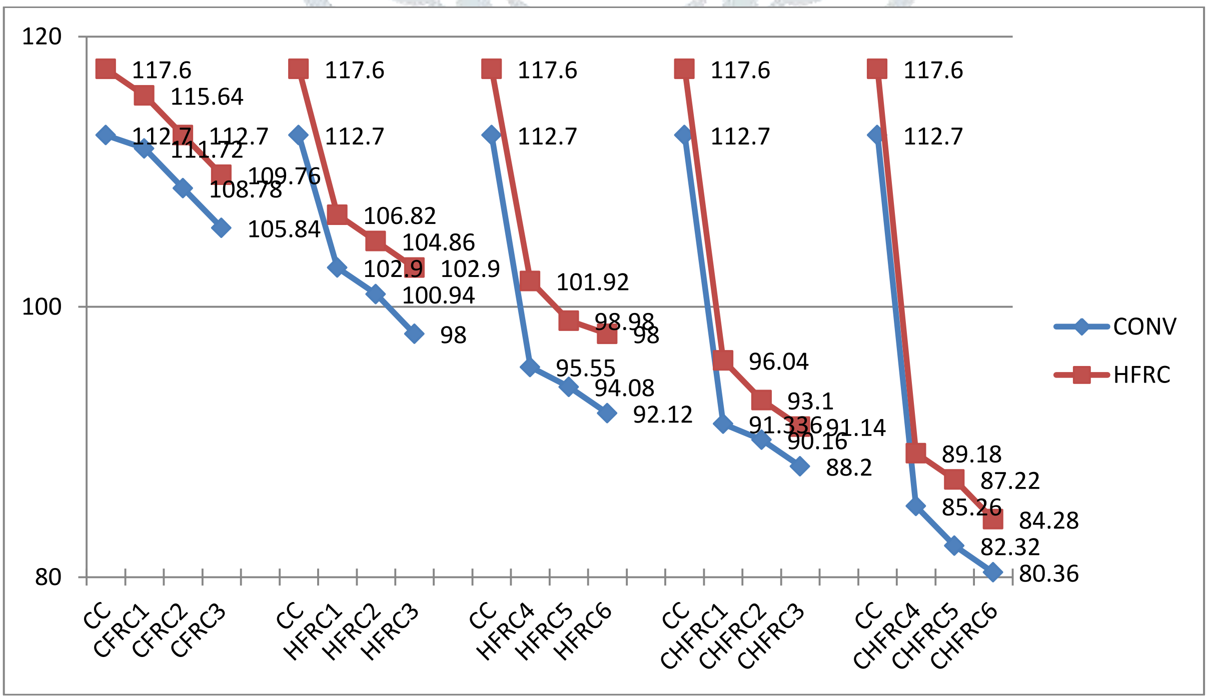
Flexural strength results for HFRC

Grade of concrete (M30)	FLEXURAL STRENGTH TEST(N/mm2)					
	load (KN)	28 days	load (KN)	56 days	load (KN)	90 days
CC	34.73	3.09	36.50	3.24	37.93	3.37
CFRC1	36.50	3.24	38.26	3.40	39.25	3.49
CFRC2	45.32	4.03	47.08	4.18	47.85	4.25
CFRC3	54.14	4.81	55.90	4.97	56.78	5.05
HFRC1	38.26	3.40	40.02	3.56	41.24	3.67
HFRC2	47.08	4.18	48.84	4.34	50.60	4.50
HFRC3	55.90	4.97	57.66	5.13	59.43	5.28
HFRC4	40.02	3.56	41.16	3.71	42.67	3.79
HFRC5	48.84	4.34	50.61	4.50	51.93	4.62
HFRC6	57.66	5.13	59.43	5.28	60.52	5.38
CHFRC1	41.16	3.71	41.79	3.87	45.65	4.06
CHFRC2	50.61	4.50	52.37	4.66	53.36	4.74
CHFRC3	59.43	5.28	61.19	5.44	63.50	5.64
CHFRC4	41.79	3.87	45.32	4.03	47.07	4.18
CHFRC5	52.37	4.66	54.14	4.81	56.34	5.01
CHFRC6	57.66	5.13	59.43	5.28	60.52	5.38



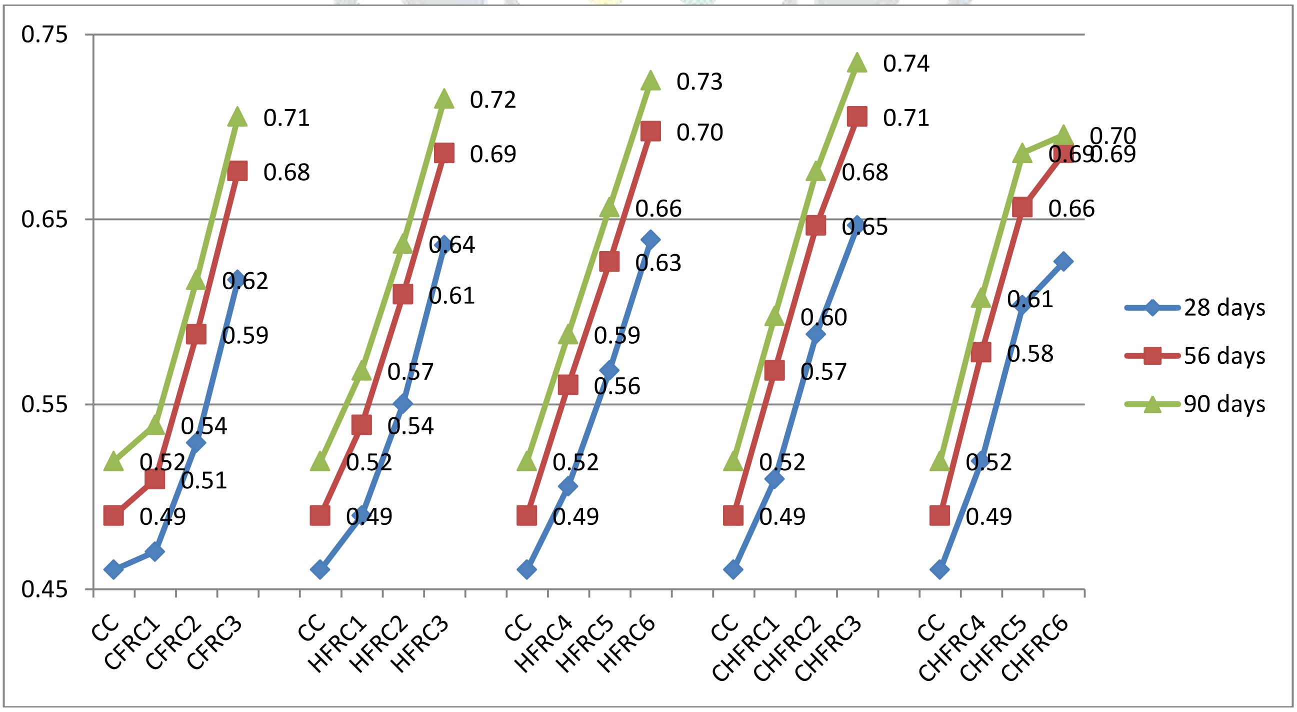
Slump cone test results for conventional and non-conventional concrete

Grade of concrete (M30)	SLUMP CONE VALUES (mm)	
	Conventional	Non conventional
CC	113	118
CFRC1	112	116
CFRC2	109	113
CFRC3	106	110
HFRC1	103	107
HFRC2	101	105
HFRC3	98	103
HFRC4	96	102
HFRC5	94	99
HFRC6	92	98
CHFRC1	91	96
CHFRC2	90	93
CHFRC3	88	91
CHFRC4	85	89
CHFRC5	82	87
CHFRC6	80	84



Water absorption test results for HFRC concrete

Grade of concrete (M30)	WATER ABSORPTION TEST (%)		
	28	56	90
CC	0.46	0.49	0.52
CFRC1	0.47	0.51	0.54
CFRC2	0.53	0.59	0.62
CFRC3	0.62	0.68	0.71
HFRC1	0.49	0.54	0.57
HFRC2	0.55	0.61	0.64
HFRC3	0.64	0.69	0.72
HFRC4	0.51	0.56	0.59
HFRC5	0.57	0.63	0.66
HFRC6	0.64	0.70	0.73
CHFRC1	0.51	0.57	0.60
CHFRC2	0.59	0.65	0.68
CHFRC3	0.65	0.71	0.74
CHFRC4	0.52	0.58	0.61
CHFRC5	0.60	0.66	0.69
CHFRC6	0.63	0.69	0.70



III. Conclusions

The activity of fibers at various volume fractions has improved the mechanical properties of fiber reinforced concrete for all the test outcomes. Results from the examination show the accompanying:

1. It is possible to deliver concrete composites utilizing Hooked end Steel Fibers and Crimpled steel fibers with an improved execution of 100% when contrasted with concrete without fibers.
2. Fiber inclusion of numerous types increased compressive strength by just 5%, despite the fact that this expansion was not that critical and could have been acquired with less difficult and more conservative techniques like decreasing water-concrete proportion. Steel fiber turned out to be productive in strengthening the matrix.
3. The expansion of micro fibers in hybrid system delivers a positive impact on both the strain softening and multiple splitting behavior of fiber reinforced concrete. As the measure of fibers expands, the tensile properties increases and the quantity of cracks were improved.
4. Among all fiber combinations, the steel filaments (Crimped + H1 (Aspect proportion 50+80 and volume portion 0.5%+0.5%) performed better in Compressive strength perspectives contrasted with the double fibers in concrete. The various mixes gave comparative and better outcomes.
5. Among all fiber mixes, the steel fibers (H2 alone (Aspect ratio 65 & volume fraction 1.5%) performed better in Split tensile strength viewpoints contrasted with the double fibers in concrete. The various mixes gave comparable and better outcomes

IV. References:

[1]. ACI Committee 544, „State-of-The-Art Report on Fiber Reinforced Concrete‟, ACI 544 1.R-96.

[2]. Narayanan, Darwish (1987), „Use of Steel Fibers as Shear Reinforcement‟, ACI Structural Journal,pp.216-227.

[3]. Swamy,Jones and Chiam (1987), „Shear Transfer in Steel Fiber Reinforced Concrete‟, Fiber Reinforced Concrete Properties and Applications, SP-105, American Concrete Institute, Detroit, pp. 565-592.

[4]. ACI Committee 544 (2003), „State of the Art Report of Fiber Reinforced Concrete‟, (ACI 544.2R- 78), ACI Materials Journal, Vol.85, No.6, pp.583-593.

[5]. Aitcin,Mehta (2010), „Effect of Coarse-Aggregate Characteristics on Mechanical Properties of High Strength Concrete‟, ACI Materials Journal, Vol.87, No.2, pp.103-107.

[6]. Francois de Larrard, Albert Belloc (2007), „The Influence of Aggregate on the Compressive Strength of Normal and High-Strength Concrete‟, ACI Materials Journal, Vol.94, No.5, pp.417 – 426.

[7]. Amir Mirsayah, Nemkumar Banthia (2002), „Shear Strength of Steel Fiber Reinforced Concrete‟,

[8]. Nemkumar Banthia, Sayed Mohamad Sloeimani (2005), „Flexural Response of Hybrid Fiber-Reinforced Cementitious Composites", ACI Materials Journal, Vol.102, No.6 pp. 382-38

[9]. S. Ghouse Basha, P. Polu Raju(2016), „ COMPARATIVE STUDY ON EFFECT OF STEEL AND GLASS FIBERS ON COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE", International Journal of Civil Engineering and Technology (IJCIET), Volume 8, Issue 4, April 2017, pp. 141–155.

[10]. Pramod Kawde, Abhijit Warudkar(2017), „ STEEL FIBER REINFORCED CONCRETE A REVIEW", INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY(IJESRT), Vol. 1, 2017.

[11]. D.V. Naresh Kumar(2017), „ A Study on Strength Properties of Hybrid Fiber Reinforced Self Compacting Concrete", International Journal of Civil Engineering Research, Volume 8, Number 1, pp. 49-55(2017).

[12]. Tejas R Patil , Ajay N. Burile(2015), „ Comparative Study of Steel and Glass Fiber Reinforced Concrete Composites, International Journal of Science and Research (IJSR, Volume 5 Issue 5, May 2016.