HYBRID FIBRE REINFORCED CONCRETE

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***Abstract* — A study on the mechanical performance of Hybrid fibre Reinforced Concrete (HFRC). The addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack resistor and would substantially improve its properties. This type of concrete is known as Fiber Reinforced Concrete. The addition more than one type of fiber in concrete is known as Hybrid Fibre Reinforced Concrete. In this study we use steel fibers and polypropylene fibers. Fibers have been used to reinforce materials that are weaker in tension than in compression. Steel fiber and polypropylene fiber are used as Hybrid fibers. They are used in different proportions as 0.25%, 0.5%, 0.75%, and 1% in this study. Experiments were conducted to study the effect of steel fibre and polypropylene fibre in different proportions in hardened concrete. Compressive strength tests on cube and Flexural strength test on beam were carried out to study the properties of hardened concrete.**

***Index Terms*—Hibrid, fibre.**

I. INTRODUCTION

Hybrid Fibre Reinforced Concrete

A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that drives benefits from each of the individual’s fibres and exhibits a synergetic response.

Addition of short discontinuous fibres plays an important role in the improvement of mechanical properties of Concrete. It increases elastic modulus; decreases brittleness controls cracks initiation and its subsequent growth and propagation. Deboning and pull out of the fibre require more energy absorption, resulting in a substantial increase in the toughness and fracture resistance of the materials to the cyclic and dynamic loads.

Advantages of Hybrid Fibre Reinforced Concrete

1) To provide a system in which one type of fibre, this is stronger and stiffer, improves the first cracks stress and ultimate strength, and the second types of fibre, which is more flexible, and ductile leads to improved toughness and stain in the past cracking zone.

2) To provide hybrid reinforcement in which one type of fibre is smaller, so that it bridges the micro cracks of which growth can be controlled. This leads to a higher tensile strength of the composite. The second type of fibre is larger, so that it arrests the propagating micro cracks and can substantially improve the toughness of the composite.

3) To provide a hybrid reinforcement, in which the durability of fibre type is different. The presence of the durable fibre can increase the strength and toughness relation after age while the other type is to guarantee the short term performance during transportation and installation of the composite elements.

History of HFRC

The concept of using fibres as reinforcement is not new. Fibres have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibres were used in concrete, there was a need to find a replacement for the asbestos used in the concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass, and synthetic fibres such as polypropylene fibres were used in concrete, and research in to new fibre reinforced concretes continues today.

Types of Fibre Reinforced Concrete

1) Steel Fibre Reinforced Concrete
2) Polypropylene Fibre Reinforced Concrete
3) Glass Fibre Reinforced Concrete
4) Carbon Fibre Reinforced Concrete
5) Nylon Fibre Reinforced Concrete

Application of Hybrid Fibre Reinforced Concrete

HFRC can be used in any kind of construction because of its unique Properties and also as it very easy to obtain high range of strength values.

Some of the pioneering applications are as follows

- Bridges.
- Tunnel linings.

Building components like column.

- Sandwich structure like steel concrete structure.
- Industrial flooring,
- machine foundation

II. REASERCH METHODOLOGY

Various test on cement, aggregate and concrete was done as per is standards

A. Standard consistency

S. N.	Weight of sample	Trail No.	Percentage of Water (%)	Penetration (mm)
1	400 gm	1	25	0
			25	0
			25	0
2	400 gm	2	27	8
			27	9
			27	9

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3	400 gm	3	29	19
			29	17
			29	18
4	400 gm	4	31	29
			31	32
			31	33

Cement Used is PPC
Standard consistency of given sample (P) = 31%

B. Initial setting time of cement

Weight of cement sample taken (W1) =400 gm

Amount of water added $=0.85\text{x}\frac{P}{100}\text{x}W1$

$=0.85\text{x}\frac{31}{100}\text{x}400$

=105.4 ml

Initial setting time = 32min

C. Soundness of cement

Weight of sample taken (W1) =400gm
Amount of water added = 105.4ml
Initial reading between pointer =14mm
Final reading between the pointers =15mm
Soundness =final reading – initial reading
=15 - 14
=1 mm

D. Bulking of sand

Volume of sample taken (V1) =800 ml
After adding of water volume of sample (V2) = 785 ml

Bulking = $\frac{V1-V2}{V2}$ x100 = $\frac{800-785}{785}$ x100
= 1.91%

E. Specific gravity

a. For fine aggregate

Weight of empty pychnometer (W1) = 570 gm
Weight of pychnometer and sand (W2) = 1050 gm
Weight of pychnometer, sand and water (W3)= 1775 gm
Weight of pychnometer and water (W4) = 1505 gm

Specific gravity = $\frac{W2-W1}{(W2-W1)-(W3-W4)}$

$= \frac{(1055-570)}{(1055-570)-(1775-1505)}$

= 2.28

b. For coarse aggregate

Weight of empty pychnometer (W1) = 570 gm
Weight of pychnometer and aggregate (W2)= 1225 gm
Wt. of pychnometer, aggregate & water (W3) =1925 gm
Wt. of pychnometer and water (W4) = 1505 gm

Specific gravity = $\frac{W2-W1}{(W2-W1)-(W3-W4)}$

$= \frac{(1225-570)}{(1225-570)-(1925-1505)}$

= 2.79

III. MIX DESIGN AS PER IS 10262:2009

M20 Concrete Mix Design

A. Stipulation for proportioning

Grade Designation : M20
Type of cement : PPC 53 Grade
Maximum Size of aggregate : 20 mm
Minimum cement content : 300 Kg/m3
Maximum water cement ratio : 0.55
Workability : 100mm
Exposure condition : Mild
Degree of supervision : Good
Type of aggregate : Crushed angular
Maximum cement content : 450 Kg/m3
Chemical used : None

B. Test data for materials

Cement used : PPC 53 Grade
Specific gravity of cement : 3.15
Specific gravity of coarse aggregate : 2.79
Specific gravity of fine aggregate : 2.28
Water absorption of coarse aggregate : 0.418%
Sieve analysis of coarse aggregate
: Confirming to grading zone I of Table 4 IS 383:2002
Sieve analysis of fine aggregate :
Confirming to grading zone I of Table 4 IS 383:2002

C. Target Strength for Mix Proportioning

Target Mean Strength for specified characteristic strength of cube is
f'ck = fck +1.65S
fck = 20 N/mm2
S = 4 N/mm2 … (from table 1, IS 10262:2009)
f'ck = 20 + 1.65(4) =26.6 N/mm^2
Target mean strength = 26.6 N/mm^2
Characteristic strength @ 28 days = 20 N/mm^2

D. Selection of water cement ratio

Maximum water cement ratio for plain cement concrete from table 5, IS 456:2000 is 0.55.
Based on Experience, water cement ratio of 0.5 is adopts.
0.5<0.55 Hence O.K

E. Selection of water content

From Table 2, IS 10262:2009
Minimum water content = 186 lit/m^3… (for 50 mm slump)
For every 25 mm slump 3% additional water is required
Estimate of water content for 75 mm slump

$= 186 + (\frac{3}{100}\text{x } 186)$

= 191.58 lit/m^3

F. Calculation of cement content

Water cement ratio = 0.5

Cement content = $\frac{191.58}{0.5}$

=383.16 Kg/m^3 >300 Kg/m^3 … (from IS 456:2000)
Hence O.K

G. Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate = 0.62 … (from Table 3, IS 10262:2009)
Volume of fine aggregate = (1- 0.62)
= 0.38

H. Mix Calculation

- Volume of concrete (a) = 1m3
- Volume of cement (b) = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{384}{3.15} \times \frac{1}{1000}$
= 0.121 m3

- Volume of water (c) = $\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$ $= \frac{191.58}{1} \times \frac{1}{1000}$ = 0.191 m3
- Volume of all aggregate (d) = [a- (b + c)]
= [1- (0.121+0.191)]
= 0.688 m3
- Mass of coarse aggregate = d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000
= 0.688 x 0.62 x 2.79 x 1000
= 1138.91 Kg
- Mass of fine aggregate = d x volume of fine aggregate x specific gravity of fine aggregate x 1000
= 0.688 x 0.32 x 2.28 x 1000
= 627.5 Kg
- Mix proportion

Cement = 383 Kg
Fine aggregate = 627.5 Kg
Coarse aggregate = 1138.91 Kg
Water = 191.58 Liter
W/C Ratio = 0.5

S. N.	Items	For 1 m3 concrete	Mix Ratio
1	Cement	383 Kg	1
2	Fine agg.	627.5 Kg	1.63
3	Coarse agg.	1138.91 Kg	2.97
4	Water	191.58 Liter	0.5

IV. RESULTS OF FRESH AND HARDEN CONCRETE

Test on fresh concrete

A. Slump cone test

Table No.1 Slump cone test result

Sr. No.	Concrete	Slump in mm
1	Nominal Concrete	100
2	HFRC 0.25%	97
3	HFRC 0.5%	94
4	HFRC 0.75%	89
5	HFRC 1%	84

Result: - With increase in fibre, there is low slump value.

B. Compaction factor test

Table No.2 Compaction factor test result

Sr. No.	Concrete	Compaction Factor
1	Nominal Concrete	0.87
2	HFRC 0.25%	0.85
3	HFRC 0.5%	0.83
4	HFRC 0.75%	0.79
5	HFRC 1%	0.77

Result: -With increase in fibre, the compaction factor reduces.

C. VEE-BEE test

Table No.3 VEE-BEE test results

Sr. No.	Concrete	V-B Slump (mm)	V-B Time (sec)
1	Nominal Concrete	95	5
2	HFRC 0.25%	92	6
3	HFRC 0.5%	87	10
4	HFRC 0.75%	84	11
5	HFRC 1%	82	14

Result: -With increase in fibre, V-B slump decrease with increase in V-B time.

Tests on Harden Concrete

A Compression test on cubes

Table no 4. Compression test results

S N	Days	Avg. Compressive Strength of Concrete without fibre and with fibre (N/mm^2)				
		Plain Concrete	0.25% (S0.4P 0.6)	0.5% (S0.4P 0.6)	0.75% (S0.4P 0.6)	1.0% (S0.4P 0.6)
1	7	14.43	16.46	17.56	19.3	23.57
2	14	18.66	22.41	24.11	28.52	31.31
3	28	23.33	29.62	33.17	36.56	43.75

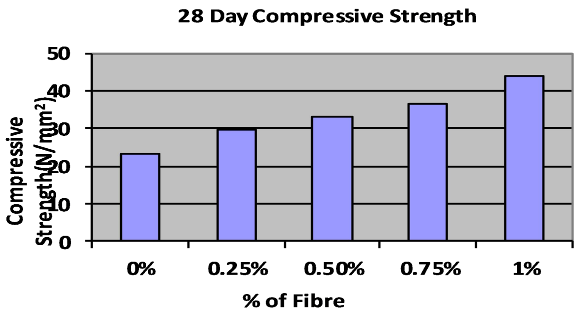

Fig. 1 Showing 28 day increase in Compressive strength

B. Flexural test on beam

Table.No.6 Flexural test results

SN	Days	Avg. flexural Strength of Concrete without fibre and with fibre (N/mm^2)				
		Plain Concrete	0.25% (S0.4P0.6)	0.5% (S0.4P 0.6)	0.75% (S0.4P 0.6)	1.0% (S0.4P0.6)
1	28	1.91	2.56	2.97	3.15	3.74

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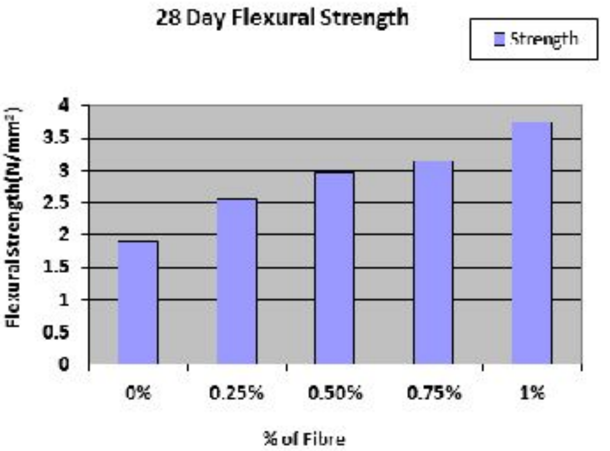

Fig. 2 Showing 28 day increase in flexural strength

V. Percentage Increase in Strength

A. Compressive Strength

Table No. 7 Percentage Increase in Compression Strength

SN	Type of Concrete	Percentage Increase		
		7 Day	14 Day	28 Day
1	HFRC 0.25% (S0.4P0.6)	14.07	21.14	26.12
2	HFRC 0.5%(S0.4 P0.6)	21.7	30.38	42.03
3	HFRC 0.75%(S0.4 P0.6)	33.75	52.3	58.41
4	HFRC 1%(S0.4 P0.6)	63.34	69.73	78.23

B. Flexural Strength

Table No. 8 Percentage Increase in Flexural Strength

Sr. No.	Type of Concrete	Percentage Increase
		28 Day
1	HFRC 0.25%(S0.4 P0.6)	34.03
2	HFRC 0.5%(S0.4 P0.6)	55.49
3	HFRC 0.75%(S0.4 P0.6)	64.92
4	HFRC 1%(S0.4 P0.6)	95.81

VI. CONCLUSION

1. This will result in reduction of secondary reinforcement at some level and make structure economical.
2. It prevents spalling of concrete which result in better protection of reinforcement cover.
3. HFRC can be used to resist seismic effects in structure, the floors additionally act as foundation slab that is bracing and carrying the entire building load.

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