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COMPARATIVE STUDY OF CONVENTIONAL CONCRETE AND PFRC

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ABSTRACT

Investigations to overcome the brittle response and limiting post yield energy absorption of concrete lead to the development of fiber reinforced concrete using discrete fibers within the concrete mass. In this paper, polypropylene fiber was used to increase the compressive strength of concrete.
Totally 63 cubes were cast and tested. Based on the experimental results of workability and mechanical strength studies, a two length of 06 mm and 20 mm and three volume fractions such as 1.0%, 1.5% and 2.0% are chosen for further studies. From these results, it is concluded that even though addition of fibers reduces the workability of fresh concrete, improvements in the mechanical strength properties are observed which ranges from 10% to 20%.

Keywords: *polypropylene fiber; Workability; compressive strength*

1. INTRODUCTION

In nominal lengths of 6, 12 or 20 mm, polypropylene fiber is the ideal additive for concrete mixtures in order to reduce plastic shrinkage, cracking and crazing and improve the surface properties of the concrete. The fibers do not replace the usual steel structural reinforcement or the customary procedures for correct setting of the concrete. When fibers are used, it is very often possible to replace meshes by the fibers.
A concrete mix has been designed to achieve the minimum grade of M25. The investigation contains two phases. In the first phase, to identify the effects on workability and mechanical strength properties due to the addition of fibers, workability tests such slump cone test, and the second phase, to mechanical strength tests on standard specimens such as compressive strength were conducted on the fibrous concrete specimens to obtain the optimum volume fraction and length of fibers.

2. NOMENCLATURE

F_0 – Plain cement concrete
F_{A1} – Concrete with 1.0% Polypropylene fiber of 6 mm cut length
F_{A2} – Concrete with 1.5% Polypropylene fiber of 6 mm cut length
F_{A3} – Concrete with 2.0% Polypropylene fiber of 6 mm cut length
F_{B1} – Concrete with 1.0% Polypropylene fiber of 20 mm cut length
F_{B2} – Concrete with 1.5% Polypropylene fiber of 20 mm cut length
F_{B3} – Concrete with 2.0% Polypropylene fiber of 20 mm cut length
f’ck -Target Average Compressive Strength at 28 days
fck - Characteristic Compressive Strength at 28 day
S - Standard Deviation=4 N/mm2 From Table 1, IS 10262: 2009

3. MATERIAL TESTING FOR MIX DESIGN

It includes materials and fibers used detailed methodology of experimental programmed, mix proportions, specimen details, reinforcement detailing and test set up. Initially two different cut length (6 mm, 20 mm) of polypropylene fiber and three volume fractions (1.0%, 1.5% & 2.0%) have been taken.
The slump cone test is used to assess the workability of conventional concrete. The influence of fibers on workability of concrete are studied.

3.1 Materials and mix

The materials used in this investigation were: ordinary Portland cement, coarse aggregate of with a maximum size of 20 mm, fine aggregate of river sand and portable water, polypropylene fiber. The detailed properties are given in subsequent contents.

3.2 Cement

Ordinary Portland cement of 53 grades conforming to IS 12269:1987 was used. Tests were carried out on various physical properties of cement and the results are shown in Table 1

Table 1. Physical Properties of 53 Grade Ordinary Portland cement

Physical Properties	Requirements as per IS 12269:1987	For OPC used
Standard Consistency	-	35%
Initial Setting Time	>= 30 min	37 min
Specific gravity	-	3.15

3.3 *Fine Aggregate*

Natural river sand was used as fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part- I). The results are shown in Table 3.2. The results obtained from sieve analysis are furnished in Table 3.3. The results indicate that the sand conforms to Zone I of IS: 383 – 2002 (Table no. 2)

Table 2 Sieve Analysis of Fine Aggregate

I.S. Sieve Size	Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative Percentage Weight Retained	Cumulative Percentage Weight Passing

4.75 mm	42	42	2.1	97.9
2.36 mm	64	106	5.3	94.7
1.18 mm	170	276	13.8	86.2
600 µ	1130	1406	70.3	29.70
300 µ	312	1718	85.9	14.1
150 µ	278	1996	99.8	0.2
<150µ	4	2000	100	0.0

3.4 Coarse Aggregate

Crushed granite stones obtained from local quarries were used as coarse aggregate. The maximum size of coarse aggregate used was 20 mm. The properties of coarse aggregate were determined by conducting tests as per IS: 2386 (Part – III). The results are tabulated in Table 3

Table 3 Physical Properties of Fine Aggregate
(Tests as per IS: 2386 – 1968: Part II and III)

Physical properties	Fine Aggregate	Coarse Aggregate
Specific gravity	2.28	2.79
Fineness Modulus	2.77	3.5
Bulk density (kg/m3)	1712.6	1644.4

3.5 Water

Portable water free from salts was used for casting and curing of concrete as per IS: 456 – 2000 recommendations.

3.6 Super plasticizer

BV – 40 type of super plasticizer is used.

3.7 Fibers

Table 4 Typical Properties of Fiber

Material	Polypropylene
Specific gravity	0.91
Tensile strength	0.67 KN/mm^2
Young Modulus	4.0 KN/mm^2
Melting point	>165°C
Absorption	NIL
Bulk Density	910 Kg/m^3
Fiber cut length	6mm, 20mm

4. MIX DESIGN (As per 10262:2009)

Target Strength for Mix Proportioning is calculated by using equation

f'ck = fck + 1.65 S

f'ck = 25 + 1.65 x 4

= 31.6 N/mm

Water cement ratio is selected according to Indian Standard Specification (IS 456:2000, page no-5)

Water cement ratio for M_{25} is 0.4.

According to Indian Standard Specification (IS 10262:2009 From table 2)

minimum water content for 20 mm aggregate = 186 liter (for 25mm to 50 mm slump range)

Estimated water Content for 100 mm Slump

= 186 + (6/100) x 186

= 197.16 Lit/m^3

= 197 Lit/m^3

calculation of Cement Content is given as follows

Water-Cement Ratio = 0.40

Water Content = 197 kg/m^3

Cement content = (197/0.4) = 490 Kg/m^3

According to Indian Standard Specification (IS 456:2000 from table 5) for M_{25} Grade of Concrete minimum cement Content = 280 Kg/m^3.

As our cement content 490 kg/m^3 which is greater than 280 Kg/m3 hence it is ok

From sieve analyses Zone I of Table 4 of IS : 383-2002

According to Indian Standard Specification (IS 10262:2009 from table 3)

Volume of Coarse aggregate is taken to be 0.6

Volume of Fine Aggregate = 1 – 0.6

= 0.4

And then quantities of all ingredients are calculated for 1 m^3 of concrete. The mix proportion is found to be 1: 1.47: 2.22. The quantities of 1 m^3 of concrete are shown in the following table5

Table 5 Quantity of 1 m^3 concrete

Item		Quantity
Water		196 Kg
Cement		490 Kg
Fine Aggregate		722 Kg
Coarse Aggregate		1087 Kg
Super plasticizer		3 lit.
Weight of Polypropylene to be added	1%	1.41 kg
	1.5%	2.11 kg
	2%	2.82Kg

5. TEST SET UP AND RESULT

5.1 Workability Studies (Slump cone Test)

The slump cone test was conducted as per IS: 7320 – 1974 The slump was measured in mm.

Fresh mix characteristics are more to the plain concrete. In this study, different volume fractions like 1.0% 1.5% of fibers of two different lengths like 6 mm different mixes were prepared and tested.

emphasized in fiber concrete compared polypropylene fibers & their three and 2.0% were taken. Regarding length and 20 mm were chosen. Totally 7

The decrease in the height of slumped cone is called 'slump of concrete'. Table 6 shows the test results of slump cone test.

Table 6 Slump Test Results

Mix type	F_0	F_{A1}	F_{A2}	F_{A3}	F_{B1}	F_{B2}	F_{B3}
Slump height in mm	110	105	98	87	102	96	85

It is obvious in all the figures that fresh concrete mix workability is damaged by increasing the fiber reinforcing index. The rate of drop in workability with increase of fiber reinforcing index seems to be comparable. Following Bar chart shows workability of different mix

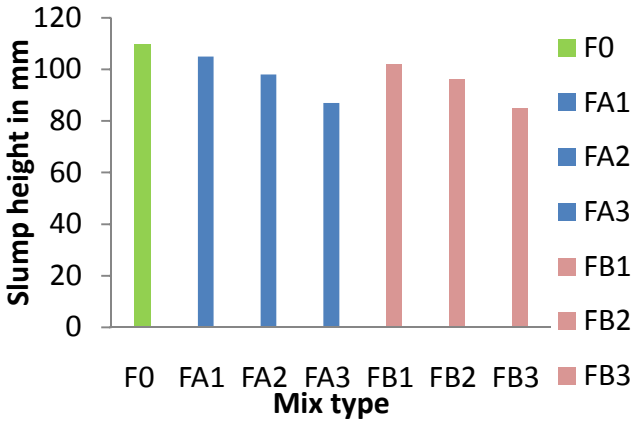

Figure 1 workability of different mix

5.2 Mechanical Strength Studies

(Compressive Strength test)

According to Indian Standard specifications (IS: 516 – 1959), the compression test on cubes was conducted.
To evaluate the mechanical strength characteristics of concrete reinforced with polypropylene fiber, detailed experimental investigation was carried out and the results are discussed.
Totally 63 cube specimens of size 150×150×150 mm with 7 mixes were casted and tested. Three volume fractions were considered for of two different lengths. Results for compressive strength based on the average values of three test data. Mixes has been compared with the experimental results in Table 7.

Table 7 Compressive strength test result

Mix type	*Compressive Strength after 7 Days in N/mm²*	*Compressive Strength after 14 Days in N/mm²*	*Compressive Strength after 28 Days in N/mm²*
F_0	19.18	22.60	26.20
F_{A1}	23.4	32.41	35.65
F_{A2}	29.59	37.69	41.46
F_{A3}	24.27	34.32	37.75
F_{B1}	25.08	31.53	34.68
F_{B2}	28.45	36.67	40.34
F_{B3}	26.40	33.58	36.94

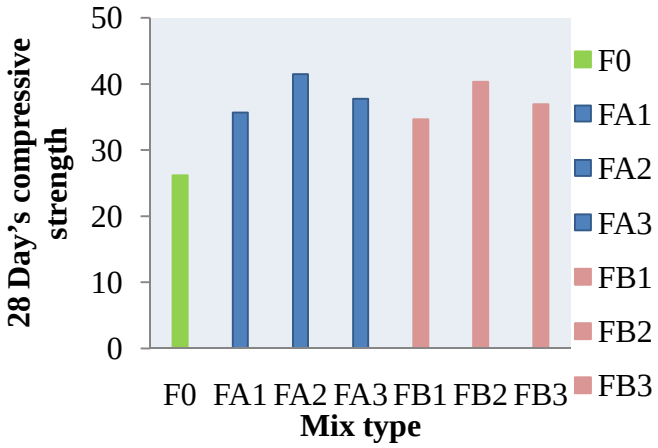

Figure 2 - 28 day's Compressive Strength of different mix

6. ADVANTAGES OF FIBER CONCRETE

- Homogeneous reinforcing, reducing the possibility of spalling at concrete edges

- Simplifies construction process. Precise placement of steel mesh is not required
- Reduces labour required to place and handle mesh
- Easier construction method and only one concrete application saving time
- Improves the wet mix by reducing the potential of concrete segregation
- Reduces the overall bleed and consequential settlement cracking
- Inhibits early plastic shrinkage cracking
- Increases the cohesiveness of the concrete
- Removes the potential risk of corrosion of steel crack control mesh
- Cost effective versus steel mesh

7. DISADVANTAGES OF FIBER CONCRETE

Fiber Concrete does not replace any structural steel reinforcing

8. APPLICATION

Fiber reinforced concrete can be used in all types of concrete applications to achieve enhanced quality concrete with any finish. Main uses are:

- Driveways
- Pathways
- Floors (industrial, commercial or domestic)
- Precast elements
- Cold Room floors
- Very thin sections with large surface to thickness ratios
- Any other concrete application where enhanced properties are required

9. CONCLUSION

A series of tests carried out to examine the effect of polypropylene fiber on the compressive of concrete. The following conclusions have been drawn from this work

1. Polypropylene fiber of 6 mm cut length inclusions in amount of 1.0%, and 1.5% increased the compressive strength up to 36% and 58% respectively.
2. Our result shows that 2.0% inclusion of polypropylene fiber give less strength than 1.5% of polypropylene fiber.
3. Polypropylene fiber inclusions in amount of 1.0%, 1.5% and 2.0% decreases the workability.

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