IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 10, Oct 2014, 17-24

BEHAVIOURAL STUDY OF STEEL FIBER AND POLYPROPYLENE FIBER REINFORCED CONCRETE

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ABSTRACT

This paper presents the results of an experimental study investigating the effects of steel fibres and polypropylene fibres on the mechanical properties of concrete. Experimental program consisted of compressive strength test, split tensile strength test and flexural strength tests on steel fibre reinforced concrete and polypropylene fibre reinforced concrete. Three types of fibres used are hooked end steel fibre of length 30mm, crimped steel fibre of length 25mm and enduro-600 polypropylene of length 50mm with aspect ratio 50. The main aim of this experiment is to study the strength properties of steel fibre and polypropylene fibre reinforced concrete of M30 grade with 0%, 0.25%, 0.5%, and 0.75% by volume of concrete. This study consisted of compressive strength test and split tensile strength test on hybrid fibre reinforced concrete with 0.5% polypropylene fibres and 0.75% steel fibres.

KEYWORDS: Aspect Ratio, Enduro-600 Polypropylene Fibre, Hybrid Fibre Reinforced Concrete, Polypropylene Fibre Reinforced Concrete, Steel Fibre Reinforced Concrete

INTRODUCTION

Concrete is by far the most widely used construction material today. It is versatile, has desirable engineering properties, can be moulded into any shapes and more importantly is produced with cost-effective materials. There is an old saying that broken stone, sand, and cement make good concrete. But the same proportion of broken stone, sand and cement also make bad concrete. To make good concrete now variety of innovative materials such as fibres, admixtures and construction chemicals, pozzolanas and different concrete making techniques are adopted in present day construction. In recent years, intensive research has resulted in advances and innovation in the technology of fibres such as glass, polypropylene, carbon etc., and more basic knowledge has been gained on the behaviour of cement concrete containing these fibres. Concrete containing hydraulic cement, water, aggregate, and discontinuous discrete fibres is called fibre-reinforced concrete. The incorporation of short discrete fibres (steel, polypropylene, glass, carbon) can lead to useful improvements in the mechanical behaviour of tension weak concrete.

OBJECTIVE

The main aim of this experiment is to study the strength properties of steel fibre and polypropylene fibre reinforced concrete with 0%, 0.25%, 0.5%, and 0.75% by volume of concrete and also hybrid fibre reinforced concrete with 0.5% of polypropylene fibre and 0.75% of steel fibre by volume of concrete. The strength properties of fibre

reinforced concrete are compared with normal concrete (reference mix) without any fibres. Three types of fibres used are hooked end steel fibre with aspect ratio 50, crimped steel fibre with aspect ratio 50 and polypropylene with aspect ratio 50.

MATERIALS AND METHODOLOGY

Constituent Materials Used

Cement

In this experiment 53 grade ordinary Portland cement (OPC) with brand name Dalmia was used for all concrete mixes. The physical properties of cement used are as given in table.1.

Table 1: Physical Properties of Cement

Sl. No	Properties	Value	IS Specification and Test Procedure
1	Specific gravity	3.14	IS:4031
2	Standard consistency	35%	IS:4031 & IS269
3	Initial Setting time in minutes	129	>30, IS:4031 & IS269
4	Final Setting time in minutes	320	<600, IS:4031 & IS269

Fine Aggregate

The fine aggregate used for the study was manufactured sand which was free from deleterious materials like clay, silt content and chloride contamination. The physical properties of fine aggregate used are as given in table.2.

Table 2: Physical Properties of Fine Aggregate

Sl No.	Properties	Value
1	Specific gravity	2.50
2	Fineness modulus	3.015
3	Grading of sand	zone II

Coarse Aggregate

The coarse aggregates used for the work is of 20mm and 12mm size which is free from deleterious materials like clay, silt content and chloride contamination.

Table 3: Physical Properties of Coarse Aggregate

Sl No.	Properties	Value
1	Specific gravity	2.67
2	Fineness modulus	2.24

Water

Clean potable tap water available in the laboratory, which satisfies drinking standards, was used for the preparation of specimens and for the curing of specimens.

Super Plasticizer

Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. In my study Master Rebuild was used as super plasticizer. This was obtained from BASF Construction Chemicals (India) Pvt. Ltd

Steel Fibres and Polypropylene Fibres

Steel fibres and Polypropylene fibres were obtained from Jeethmull Jaichandlall (Madras) pvt. ltd,195, Rasappa Chetty Street, Chennai. The length of crimped steel fibres used are 25mm of equivalent diameter 0.5mm leading to an aspect ratio of 50 and The length of hooked end steel fibres used are 30mm of equivalent diameter 0.6mm leading to an aspect ratio of 50. The young's modulus of steel fibres was found to be 2×10^5 MPa. The density of steel fibre was found to be 78500 N/m^3. The ENDURO-600 macro synthetic polypropylene fibres were having a length of 50mm and their average thickness was found to be 1mm leading to an aspect ratio of 50. The density of polypropylene fibres was found to be 9460 N/m^3

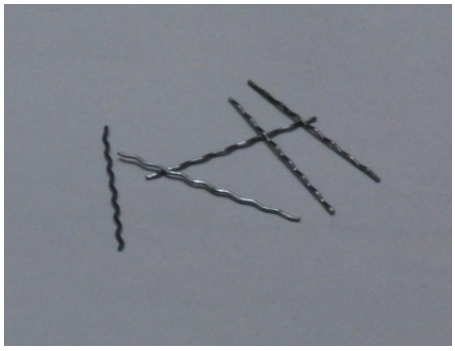

Figure 1: Crimped Steel Fibres

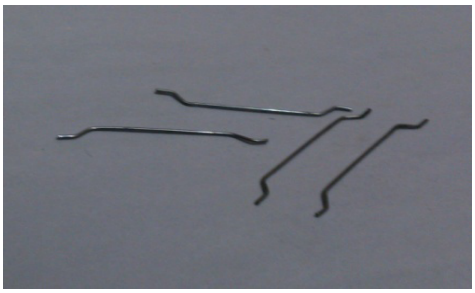

Figure 2: Hooked End Steel Fibres

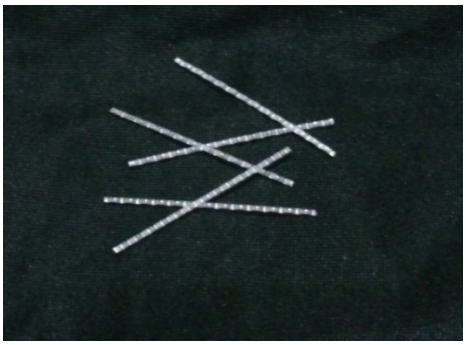

Figure 3: Enduro-600 Polypropylene Fibres

Concrete Mix Design

Mix design was done as per IS 10262. The super plasticizer dosage was adopted as 1 % of cement.

Table 4: Mix Proportion for M30

Material	Calculated Quantity
Cement	360 kg
Coarse aggregate : 20 mm (60%)	733.8 kg
Coarse aggregate : 12 mm (40%)	489.2 kg
Fine aggregate	629 kg
Water	144 liters

Testing Procedure

Concrete test specimen consist of 150x150x150mm cubes, Cylinders of 150mm diameter and 300mm height and 100x100x500 beams. Concrete cube specimen were tested at 7 and 28 days to obtain the compressive strength of concrete. Cylindrical specimen were tested at 7 and 28 days to obtain the split tensile strength of concrete. Beam specimen were tested at 7 and 28 days to obtain the flexural strength of concrete.

EXPERIMENTAL RESULTS

Compressive Strength Test Results

The following table gives the overall results of compressive strength for reinforced concrete with steel and polypropylene fibres reinforced concrete. The table also gives the percentage increase of compressive strength with respect to plain reinforced concrete (reference mix).

Table 5: Overall Test Results of Compressive Strength

Description of Concrete	Percentage of Fibres	Compressive Strength (MPa)	Percentage Increase of Compressive Strength w.r.t Reference Mix
Plain reinforced concrete (without any fibers) (Reference mix)	0	38.9	------
Fiber reinforced concrete with hooked end steel fiber of length 30mm	0.25%	40.83	4.96%
	0.50%	46.73	20.12%
	0.75%	50.63	30.15%
Fiber reinforced concrete with crimped steel fiber of length 25 mm	0.25%	43.14	10.899%
	0.50%	51.13	31.44%
	0.75%	53.73	38.12%
Fiber reinforced concrete with ENDURO-600 polypropylene fiber of length 50 mm	0.25%	40.03	2.91%
	0.50%	44.83	15.24%
	0.75%	41.77	7.37%

Table 6: Compressive Strength Test Results of Hybrid Fibre Reinforced Concrete with 0.5% of ENDURO-600 Polypropylene Fibre and 0.75% of Crimped Steel Fibre

Specimen Identification	Percentage of Fibre Content		Average Compressive Strength (MPa)	
	Steel	Polypropylene	7^{th} Day	28^{th} Day
AFC100P0	100	0	35.9	53.73
AFC75P25	75	25	34.26	52.6
AFC50P50	50	50	32.6	47.3
AFC25P75	25	75	30.5	45.2
AFC0P100	0	100	29.76	44.83

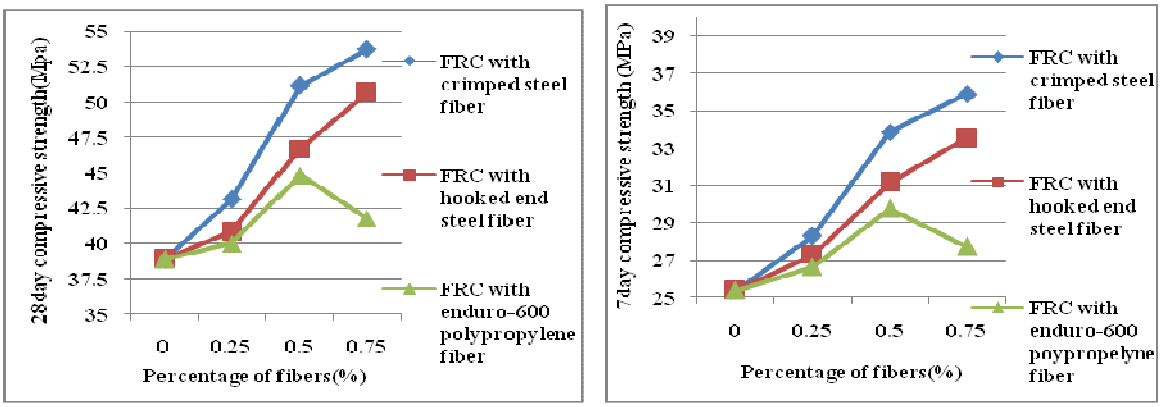

Figure 4: Variation of 28 and 7 day Compressive Strength with Different Percentage of Steel Fibres and Polypropylene Fibres

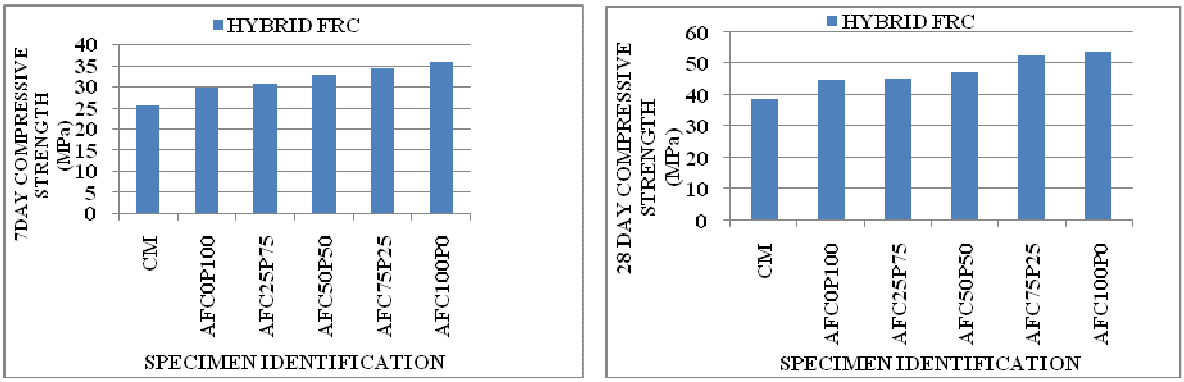

Figure 5: Variation of 7 and 28 day Compressive Strength of Hybrid Fibre Reinforced Concrete

Splitting Tensile Strength Test Results

Table 7: Overall Test Results of Splitting Tensile Strength

Description of Concrete	Percentage of Fibres	Splitting Tensile Strength (MPa)	Percentage Increase of Splitting Tensile Strength w.r.t Reference Mix
Plain reinforced concrete (without any fibres) (Reference mix)	0	3.233	------
Fibre reinforced concrete with hooked end steel fibre of length 30mm	0.25%	3.55	9.81%
	0.5%	3.96	22.48%
	0.75%	4.31	33.32%
Fibre reinforced concrete with crimped steel fibre of length 25 mm	0.25%	3.82	18.15%
	0.5%	4.45	37.64%
	0.75%	4.62	42.9%
Fibre reinforced concrete with ENDURO-600 polypropylene fibre of length 50 mm	0.25%	3.39	4.86%
	0.5%	3.9	20.63%
	0.75%	3.53	9.19%

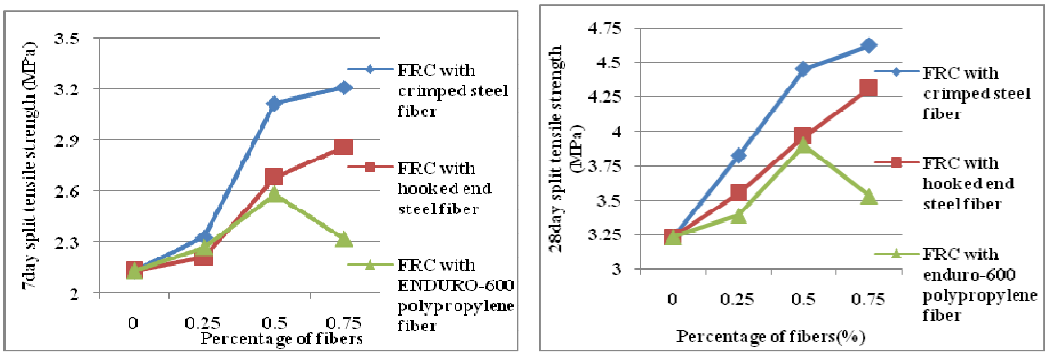

Figure 6: Variation of 7 and 28 day Split Tensile Strength with Different Percentage of Steel and Polypropylene Fibre

Table 8: Splitting Tensile Strength Test Results of Hybrid Fibre Reinforced Concrete with 0.5% of ENDURO-600 Polypropylene Fibre and 0.75% of Crimped Steel Fibre

Specimen Identification	Percentage of Fibre Content		Average Splitting Tensile Strength (MPa)	
	Steel	Polypropylene	7^{th} Day	28^{th} Day
AFC75P25	75	25	3.13	4.54
AFC50P50	50	50	3.03	4.39
AFC25P75	25	75	2.90	4.33

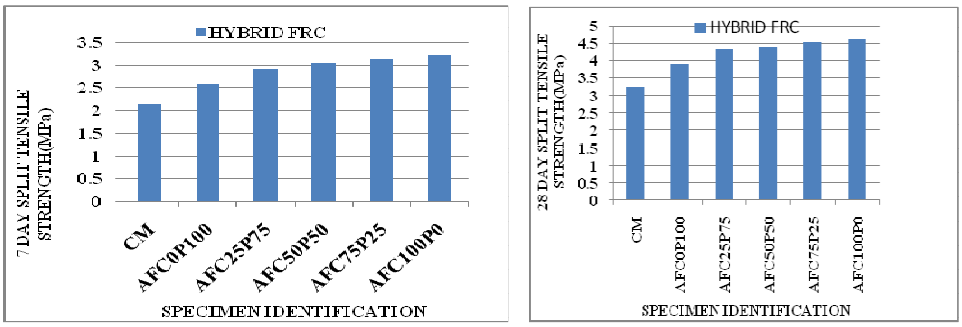

Figure 7: Variation of 7 and 28 day Split Tensile Strength of Hybrid Fibre Reinforced Concrete

Flexural Strength Test Results

Table 9: Overall Test Results of Flexural Strength

Description of Concrete	Percentage of Fibres	Flexural Strength (MPa)	Percentage Increase of Flexural strength w.r.t Reference Mix
Plain reinforced concrete (without any fibres)	0	4.08	------
Fibre reinforced concrete with hooked end steel fibre of length 30mm	0.25%	4.32	5.88%
	0.5%	5.20	27.45%
	0.75%	5.68	39.22%
Fibre reinforced concrete with crimped steel fibre of length 25 mm	0.25%	4.72	15.69%
	0.5%	5.60	37.25%
	0.75%	5.92	45.09%
Fibre reinforced concrete with ENDURO-600 polypropylene fibre of length 50 mm	0.25%	4.16	1.96%
	0.5%	4.48	9.80%
	0.75%	4.12	0.98%

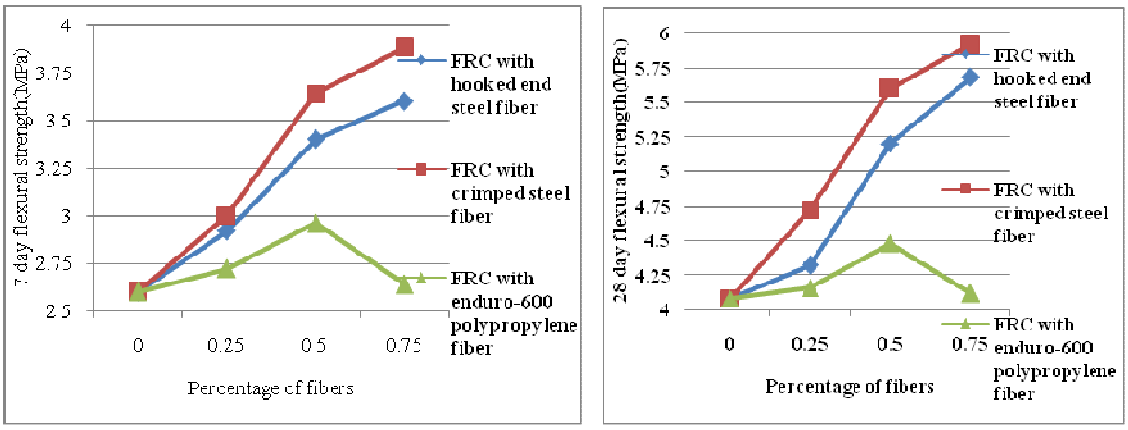

Figure 8: Variation of 7 and 28 Day Flexural Strength with Different Percentage of Steel and Polypropylene Fibre

CONCLUSIONS

The steel fibre reinforced concrete yield higher compressive strength with addition of 0.75% steel fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better compressive strength than hooked end steel fibre of 30mm length with aspect ratio 50. The steel fibre reinforced concrete yield higher splitting tensile strength with addition of 0.75% steel fibre by volume of concrete. The polypropylene fibre reinforced concrete yield higher splitting tensile strength with addition of 0.5% polypropylene fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better splitting tensile strength than hooked end steel fibre of 30mm length with aspect ratio 50. The steel fibre reinforced concrete yield higher flexural strength with addition of 0.75% steel fibre by volume of concrete. The polypropylene fibre reinforced concrete yield higher flexural strength with addition of 0.5% polypropylene fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better flexural strength than hooked end steel fibre of 30mm length with aspect ratio 50.

REFERENCES

1. MR. Mehul J Patel, MRS. S. M Kulkarni, *"Effect of polypropylene fiber on the High Strength Concrete", Journal of Information, Knowledge and Reserch in Civil Engineering,* Volume 2, Issue 3, Nov-12-Oct-13.
2. Roohollah Bagherzadeh Ph.D, Hamid Reza Pakravan, Adol-Hossein Sadeghi, Mazoud Latifi, Ali Akbar Merati, *"An Investigation on Adding Polypropylene Fibers to Reinforce Lightweight Cement Composites", Journal of Engineered Fibers and Fabrics,* Volume7. Issue 4, 2012
3. Eray Baran, Tolga Akis, Seda Yesimen, *"Pull-out behavior of Prestressing strands in steel fiber reinforced concrete", Construction and Building Materials* 28(2012) 362-371
4. Budia Aulia. (2002), *"Effects of polypropylene fibers on the properties of high strength concrete", Lacer journal no*. 7, pp. 21-26.
5. Shetty M. S., *"Concrete Technology",* Chand S. and Company Limited, New Delhi, 6th Edition, 2005.
6. IS: 456- 2000, *"Plain and reinforced concrete- code of practice (fourth revision)"*, Bureau of Indian Standards, New Delhi, India.

7. Marco Orgrass and Yvette Klug. (2004), *"Steel Fiber Reinforced Ultra High Strength Concretes", Lacer journal no* -9, pp. 31-36.

8. Balasubramanian. K, Bharatkumar. B. H, and Gopalkrishnan S. (1996), *"Impact resistance of steel fiber reinforced concrete using drop weight impact method"*, The Indian Concrete Journal, mar, pp. 257-262.

9. Amir A. Mirsayah and Nemkumar Banthia. (2002), *"Shear Strength of Steel Fiber Reinforced Concrete"*, ACI Materials Journal, Vol. 99, No. 5, pp. 473-479.

10. Talukdar S. and Baruah P. (2007), *"A Comparative Study of Compressive, Flexural, Tensile and Shear Strength of Concrete with Fibers of Different Origins",* Indian Concrete Journal, Oct, pp 17-24.