Experimental Study on Normal to High Strength of Hybrid Fibre Reinforced Concrete

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Abstract - The presence of fibers in the body of the concrete or the provision of a tensile skin of fibre concrete can be expected to improve the resistance of conventionally reinforced structural members to cracking, deflection and other serviceability conditions. This project focuses on the experimental investigation on mechanical properties of steel fibre and polypropylene fibre on different strength of concrete. For this study, Bundled Hooked-End Steel Fibers with aspect ratio of 60mm were used. The fibers were added in concrete at different fibre volume fractions of 0.5% on different strength of concrete of M25 grade as low strength and M40 grade as High strength. The effects of fibers on the different strength were studied in terms of compressive strength and splitting tensile strength properties. The test results shows that a significant improvement in compressive strength and Split tensile strength of concrete for a volume fraction of 0.5% for low strength of concrete was found to be 38.44% and 146.71% .The test results has never shown much improvement in strength in case of high strength concrete. The test results also indicate that the compressive strength and splitting tensile strength showed a considerable enhancement with decrease in the volume fraction of polypropylene fibers.

I. INTRODUCTION

Steel Fibre

Steel fibers for use in concrete are available in a variety of shapes, sizes and metal types. Many fibres with round, rectangular and crescent shaped cross-sections, are commercially available. They range in ultimate strength from 345 to 2070 MPa. Fibre sizes range from 13 x 0.25 mm to 64 x 0.76 mm. Fibres with hooked or deformed ends could be used in smaller quantities because they develop higher pullout resistance. Fibre contents in construction projects have typically ranged from 0.5% to 2.0% by volume.

Polypropylene Fibre

Polypropylene fibres are available both in single-filament and fibrillated form in lengths ranging from 0.25 to 2 in. (6 to 50 mm). Short fibres in form of pulp are also available. Monofilament polypropylene fibres have inherent weak bond with the cement matrix because of their relatively small specific surface area. Fibrillated polypropylene fibres are slit and expanded into an open network thus offering a larger specific surface area with improved bond characteristics. Polypropylene fibre contents of up to 12% by volume have been used successfully with hand-packing fabrication techniques. But volumes of 0.1% of 50-mm fibre in concrete have been reported to have caused a slump loss of 75 mm. Polypropylene fibres have been reported to reduce unrestrained plastic and drying shrinkage of concrete at fibre contents of 0.1 to 0.3% by volume.

The objectives of the study are to assess the mechanical properties in terms of compressive, splitting tensile strength tests of hybrid fibre reinforced concrete with different strengths of concrete. To study the effects of concrete strength in improving the different mechanical properties of hybrid fibre reinforced concrete.

II. MATERIALS

A. Ordinary Portland Cement (Opc)

Cement is the most important ingredient in concrete. Generally use of high grade cements offer many advantages for making stronger concrete. Although they are little costlier than low grade cement, they offer 10-20% savings in cement consumption and also they offer many other hidden benefits.. In the modern construction activities, higher grade cements have become so popular that 33 grade cement is almost out of the market. The manufacture of OPC is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution, economic and other technical reasons. The properties of cement like Consistency, initial setting time, final setting time and specific gravity were studied and the obtained results were as shown in Table1.

Table 1 Properties of Ordinary Portland cement

Test	**Result**	**As per IS 4031-1998**
Consistency	53	_
Initial setting time	90 min	Not less than 30 min.
Final setting time	5 hours	Not more than 600 min.
Specific gravity	3.14	_

B.Aggregates

The aggregates suitable for plain concrete are suitable for FRC. The aggregate are normally divided into two categories, namely, fine and coarse. The grading requirements for fine aggregates used in concrete are listed in ASTM specification C-33. At least 80 percent of the particles should be smaller than 3mm. Fiber-reinforced concretes containing normal-weight or lightweight aggregates have been successfully used in a number of field applications. The properties of Fine aggregate and Coarse aggregate are given in Table 2 and 3 respectively.

Table 2 Properties of Fine aggregate

Test	**Result**	**As per IS 383-1970**
Fineness modulus	5	5 to 7
Specific gravity	2	2.6

Table 3 Properties of Fine aggregate

Test	**Result**	**As per IS 383-1970**
Fineness modulus	2.80	Medium sand
Specific gravity	2.70	2.55

C.Fibres

Two different types of fibres were used for the study are Bundled hook steel fibres and Polypropyleneand their properties are shown in Table 4 and 5.

Table 4 Properties of the Steel Fibres

Property	**Bundled Hooked End Steel Fibres**
Length (mm)	**60**
Diameter (mm)	**0.75**
Aspect ratio (l/d)	**80**
Tensile strength (N/mm^2)	**1225**
Elastic modulus (N/mm^2)	**210000**

Table 5 Properties of the Polypropylene Fibres

Material	Polypropylene
Specific gravity	0.92
Fibre length (mm)	30
Strength (N/mm^2)	550
Elastic modulus(N/mm^2)	3500

III.EXPERIMENTAL STUDY

TEST PROCEDURE

The specimens were subjected for the following tests

- Compressive Strength Test (Cubes 150x150x150mm)
- Splitting Tensile Strength Test (Cylinder 150x300mm)

Table 6 Compressive Strength of M25 Grade Concrete With 0.5% Of Hybrid Fibre

Specimen Designation	Volume of Fraction (%)			Compressive Strength Attained From 7days Curing in (N/mm^2)	Compressive Strength Attained From 28days Curing in (N/mm^2)
	Steel	Poly propylene	Total		
CC	-	-	-	20.265	28.95
A11	0.5	-	0.5	25.914	37.02
A12	-	0.5	0.5	21.742	31.06
A13	0.3	0.2	0.5	28.056	40.08
A14	0.2	0.3	0.5	26.719	38.17

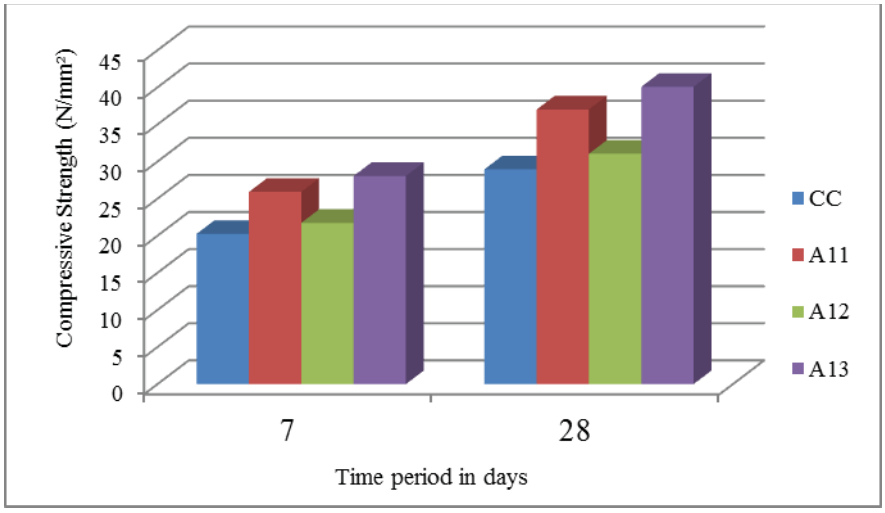

Figure 1 Compressive Strength of Concrete with 0.5% of HYFRC on M25 grade

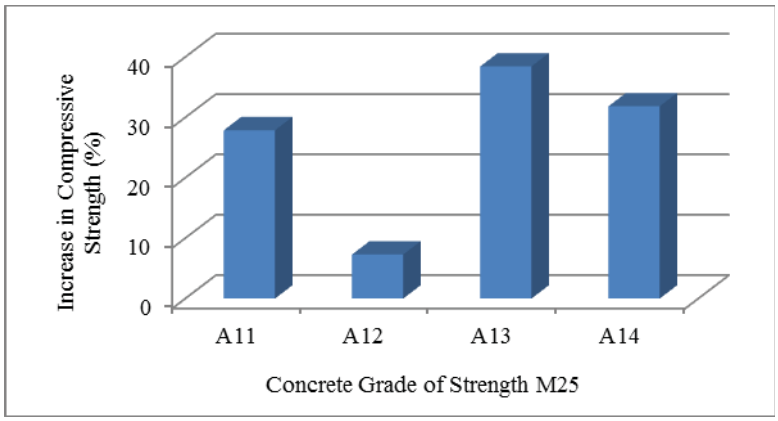

Figure 2 Effect of Hybrid Fibre on M25 Grade Concrete for Compressive Strength

The effect of fibre on compressive strength of concrete compared with the control specimens on M25 are shown in Fig.2. The compressive strength of HYFRC was reduced with increase in the percentage of polypropylene fibre. The compressive strength of HYFRC showed an improvement in the range of 7.28% to 38.44% when compared with CC.

Table 7 Compressive Strength Of M40 Grade Concrete With 0.5% Of Hybrid fibre

Specimen Designation	Volume of Fraction (%)			Compressive Strength Attained From 7days Curing in (N/mm^2)	Compressive Strength Attained From 28days Curing in (N/mm^2)
	Steel	Poly propylene	Total		
CC	-	-	-	30.1	43
A11	0.5	-	0.5	31.696	45.28
A12	-	0.5	0.5	30.47	43.53
A13	0.3	0.2	0.5	33.32	47.6
A14	0.2	0.3	0.5	31.059	44.37

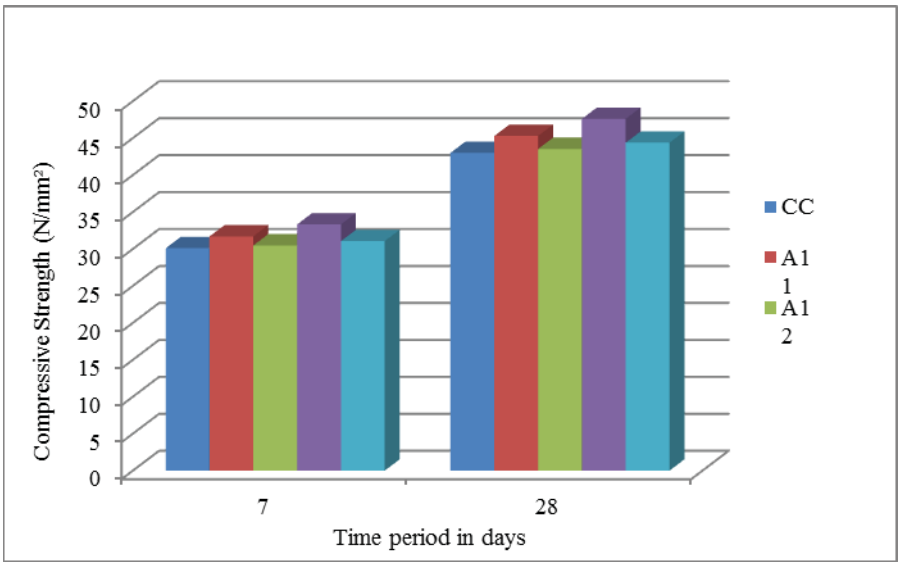

Figure 3 Compressive Strength of Concrete with 0.5% of HYFRC on M40 grade

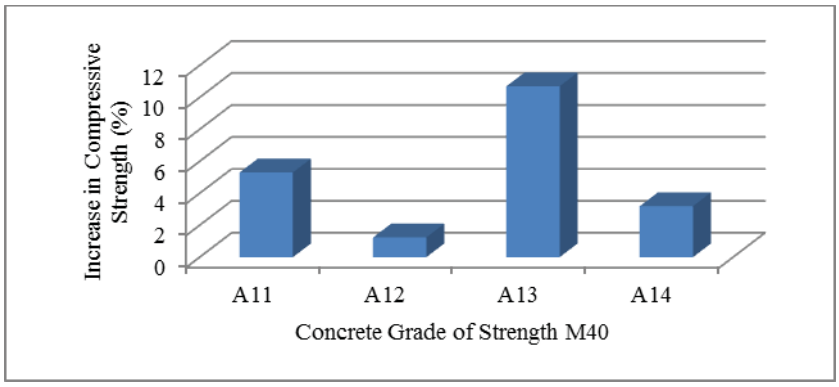

Figure 4 Effect of Hybrid Fibre on M25 Grade Concrete for Compressive Strength

Figure 4 shows the effect on compressive strength of concrete is compared with the control specimen for the effect of HYFRC on M40. It has been observed that the HYFRC shows an improvement in increasing the fibre volume fraction. The compressive strength of HYFRC shows an increase in the range of 1.23% to 10.69% at a volume fraction of 0.5% of HYFRC when compared with control concrete. The compressive strength of HYFRC was increased up to 10.69%

Table 8 Split tensile Strength of Concrete with 0.5% of HYFRC on M25 grade

Specimen Designation	Volume of Fraction (%)			Split Tensile Strength Attained From 7days Curing in (N/mm^2)	Split Tensile Strength Attained From 28days Curing in (N/mm^2)
	Steel	Poly propylene	Total		
CC	-	-	-	1.225	1.96
A11	0.5	-	0.5	3.325	4.83
A12	-	0.5	0.5	2.1	3
A13	0.3	0.2	0.5	2.625	3.75
A14	0.2	0.3	0.5	2.45	3.5

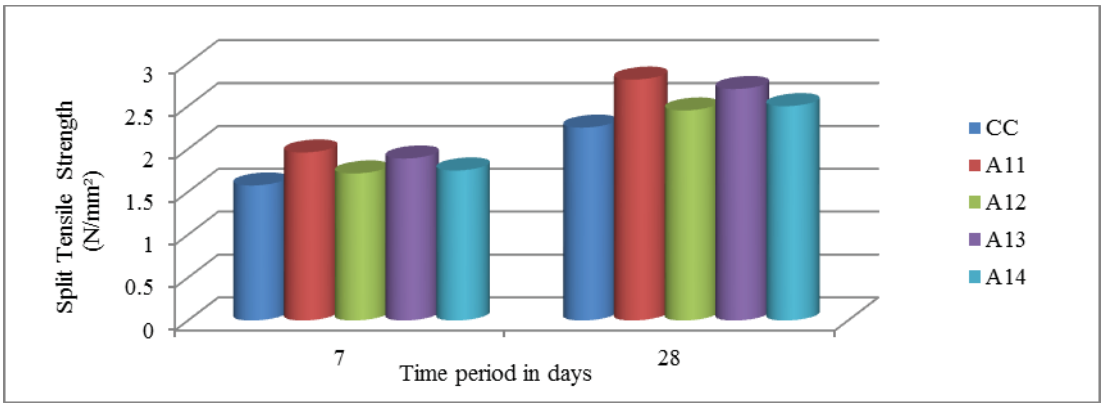

Figure 5 Split Tensile Strength of Concrete with 0.5% Of HYFRC on M25 Grade

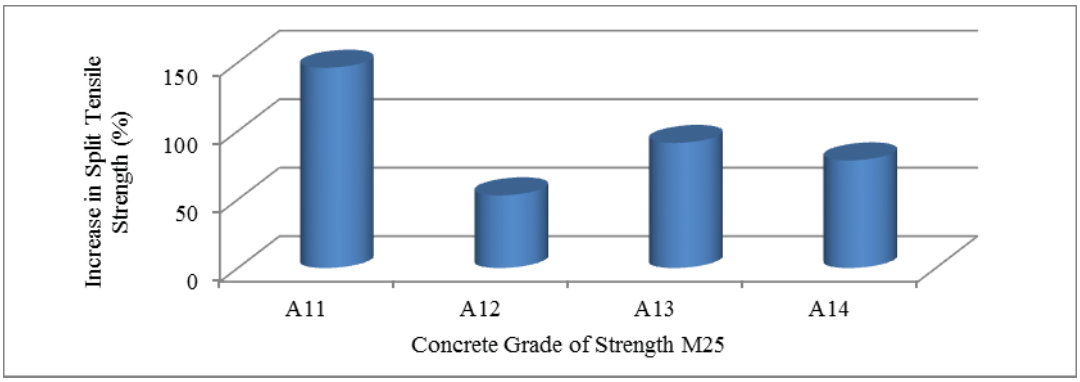

Figure 6 Effect of Hybrid Fibre on M25 Grade Concrete for Split Tensile strength

The effect of fibre on splitting tensile strength of concrete compared with the control specimens as shown in Figure.6. The Splitting Tensile strength of HYFRC is reduced when addition of percentage of polypropylene fibre is increased. The Splitting Tensile strength of HYFRC improvement ranges from 56.36% to 146.7% when compared with control concrete.

Table 9 Split tensile Strength of Concrete with 0.5% of HYFRC on M40 grade

Specimen Designation	Volume of Fraction (%)			Split Tensile Strength Attained From 7days Curing in (N/mm^2)	Split Tensile Strength Attained From 28days Curing in (N/mm^2)
	Steel	Poly propylene	Total		
CC	-	-	-	1.575	2.25
A11	0.5	-	0.5	1.96	2.81
A12	-	0.5	0.5	1.715	2.45
A13	0.3	0.2	0.5	1.89	2.7
A14	0.2	0.3	0.5	1.75	2.5

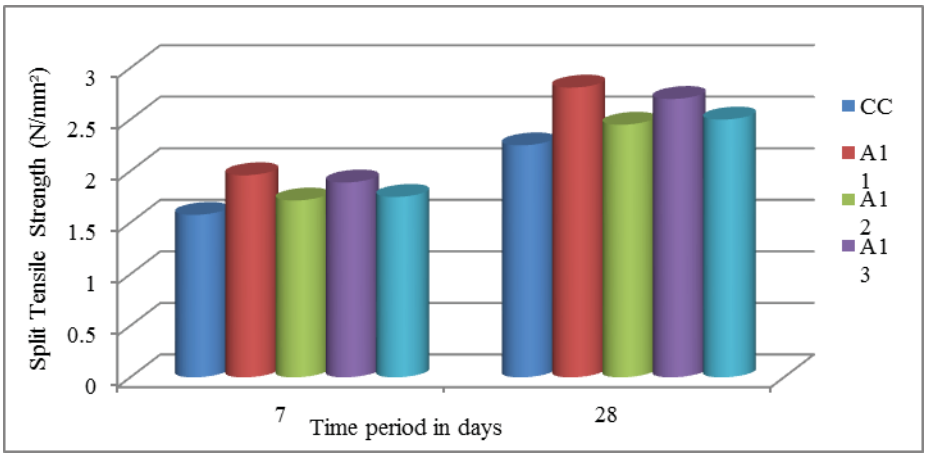

Figure 7 Split Tensile Strength of Concrete with 0.5% of HYFRC on M40 grade

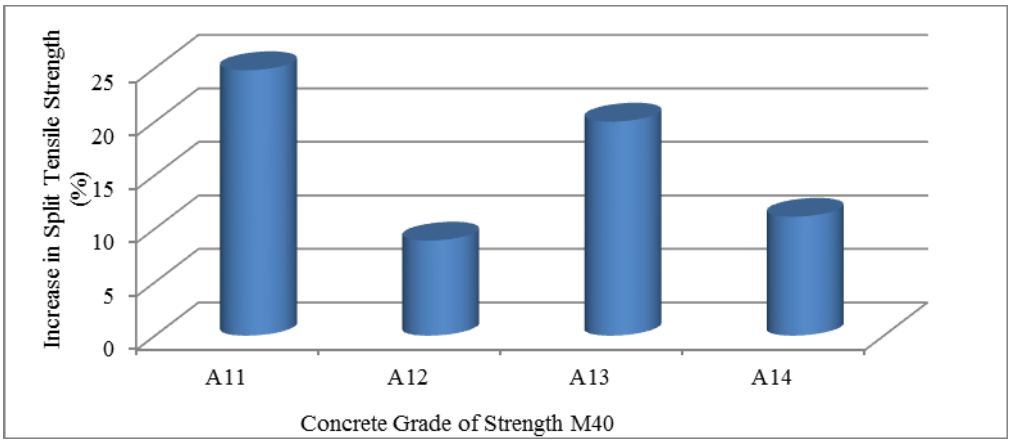

Figure 8 Effect Of Hybrid Fibre On M40 Grade Concrete For Split Tensile Strength

The effect of 0.5% of hybrid fibre on M40 for cylinder specimens is compared with the control specimen is shown in Figure 8. It has been observed that the HYFRC shows an improvement in increasing the fibre volume fraction. The split tensile strength of HYFRC shows an increase in the range of 8.88% to 17.23% at a volume fraction of 0.5% of HYFRC when compared with control concrete. The maximum split tensile strength of HYFRC was increased up to 22.43%.

IV.CONCLUSION

The following conclusions were drawn based on the test results arrived from the compressive strength of cube and split tensile strength of cylinder:

1. The volume fraction of 0.5% on M25 grade concrete shows a considerable enhancement in compressive strength and volume fraction of 0.5% 0n M25 grade of strength shows a significant improvement in splitting tensile strength than the control concrete.
2. The compressive strength of hybrid fibre reinforced concrete was reduced with the addition of percentage of polypropylene fibre.
3. The maximum compressive strength attained for 0.5% of volume fraction with 0.3 % of steel fibre and 0.2% of polypropylene on M25 grade of strength was 38.44% when compared with control concrete.
4. Volume fraction of 0.5% 0n M25 grade of strength shows a significant improvement of 146.71% in splitting tensile strength of concrete when compared to control concrete.

REFERENCES

[1] Binsbergen F. (1970), ‘ Heterogeneous nucleation in the crystallization of poly olefins’: part 1. Chemical and physical nature of nucleating agents, pp 11-253.
[2] Lankard D. R. and Newell J. K (1984), ‘Preparation of highly reinforced steel fibre reinforced concrete composites in Fiber Reinforced Concrete’, Proceedings of an International Conference (American Concrete Institute, Detroit), 286-306.
[3] M. Grzybowski and S.P. Shah (1990), ‘Shrinkage cracking of fiber reinforced concrete’, ACI Mater. J. 87 (2), 138– 148.
[4] Qian CX, Stroeven P. (2000). ‘Development of hybrid polypropylene–steel fibre-reinforced concrete’, Cem Concr Res, p. 30-63.
[5] Song P.S. and Hwang S.(2004), ‘Mechanical properties of high-strength steel fibre-reinforced concrete’, Construction and Building Materials 18, pp 669–673.
[6] Swamy R N. and Barr B. (1989), ‘Reinforcement of Normal and High Strength Concretes with Fibrillated Polypropylene Fibres’ , Elsevier Applied Science, London, pp 229-239.
[7] Swamy RN. (1987), ‘High-strength concrete-material properties and structural behaviors’, ACI SP-87, Detroit: American Concrete Institute, p.110–146.
[8] Swamy RN.and Barr B. (1989), ‘Fracture Characteristics of High Strength Concrete and FRC Materials’, Elsevier Applied Science, London, pp 411-419.
[9] V M Malhortra, G G Carette and A Bilodeau (1994).’ Mechanical Properties and Durability of Polypropylene Fiber Reinforced High-volume Fly Ash Concrete for Shotcrete Applications’. ACI Materials Jour, p. 478-486.