Influence of Polypropylene fibres on mechanical properies of low volume fly ash concrete

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***Abstract*- This paper represents the compressive experimental study of influence of fibre volume fractions of polypropylene fibres on mechanical properties of normal-strength-fibre-reinforced-concrete. For the mechanical properties of polypropylene fibre reinforced concrete (PFRC), the study has been conducted as follows: compressive strength, splitting tensile strength all of which were measured after the sample being cured for 28 days. Fly ash is used in constant rate of 10% by weight of cement while monofilament polypropylene fibre of 12mm length is used in volume fraction of 0% to 3% with the increasing rate at 0.5%. Polypropylene fibers influenced the compressive strength of PFRC, however applying these fibers at their maximum percentage volume determined through this study, increased the tensile strength by 8.88% in the splitting tensile strength test, and 9.90% in the compressive strength. The optimum dosage in both the cases obtained 1.5%.**

***Index Terms*- Polypropylene Fibre-Reinforced, Concrete, Compressive Strength, Split Tensile Strength, Cube and Cylinder**

I. INTRODUCTION

Polypropylene fibre reinforced concrete is embryonic construction material and a new generation chemical fibre and can be used as secondary reinforecement but cannot replace primary one [1]. The term fibre reinforced concrete (FRC) is defined by ACI Committee 544 as a concrete made of hydraulic cements containing fine and coarse aggregates and discontinuous discrete fibres [8]. The workability of concrete decreases with the increase of fibre volume fractions [2] but it can be overcome by high range of water reducing admixtures [3]. The mechanical properties of concrete enhances by using polypropylene fibres [5]. Normal-strength-fibre-reinforced fly ash concrete affects by fibre volume fractions upto 1% after further increase in polypropylene fibre results in retarding. However compressive strength decreases with increase of flyash content while improves the workability of PFRC [7]. It is found that the split tensile strength increased with increasing fiber content Fibers tend to bridge the micro cracks and hamper the propagation of cracks. When tensile stress is transferred to fibers, the micro cracks are arrested and thus improve the split tensile strength of concrete [6]. Polypropylene when used as composite with steel fibres also improves the mechanical properties of concrete [4].

II. EXPERIMENTAL OUTLINE

2.1 MATERIALS

2.1.1 Cement

The cement used was Ordinary Portland cement 53 grade [12], with a specific gravity of 3.13. Initial and final setting times of the cement were 110 min and 270 min respectively and chemical composition is given in Table 1.

2.1.2 Fly ash

Low lime fly ash is used confirming to IS 3812 [18] in fixed rate of 10% by mass of cement. With specific gravity of 2.2 . Chemical oxide composition of cement and fly ash were given in table-1

2.1.3 Aggregate

Dry and clean natural, river aggregate was used in concrete mixture [13]. The gravel was 20 mm maximum nominal size with 1% absorption value and its relative density at saturated surface dry (SSD) condition was 2.71. The absorption value of the sand used was 1.2% and its relative density at saturated surface dry (SSD) condition was 2.51. The specific gravity of sand and aggregate is 2.72 and the silt

content of sand is 2%. The grading of the mixed aggregate was presented in Table 2.

2.1.4 Fibers

Polypropylene fiber, which was named Recron 3s, monofilament polypropylene fibers of length 12mm with a density 0.91, and a tensile strength ranging between 400 and 600 MPa.

2.2 Mixture composition and preparation

For each cubic metre of concrete, approximate concrete composition is given in Table 3. Mixture design is made with according to Mix Design method of Indian standard [11]. At the beginning of the mixture design, cement content 516 kg/m3 and water–cement ratio 0.40 were chosen as constant.

Fresh concretes containing 10% constant fly ash as cement replacement in mass basis were prepared by modifying the control Portland cement concrete. Fresh fiber-reinforced concretes containing 0.5%, 1%, and 1.5%, 2%, 2.5% and 3% polypropylene fiber in volume basis were prepared while 0% represents standard concrete

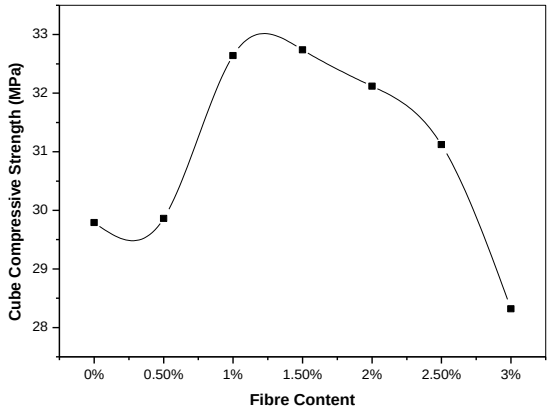
The mixing procedure of fibre reinforced concrete involved the following steps. First, the sand and gravel were place in tilting drum mixer and mixed dry for 1 min. Second, the binder and fibre were spread and mixed dry for 1min. Third, the mixing water was slowly added and mixed for 3 min. Last, the freshly mixed polypropylene-fibre-reinforced-concrete (PFRC) was fed into specimen moulds and vibrated on vibrating table simultaneously. After casting, each specimen was demoulded after 24 hours. Demoulded specimens are then cured in water tank at 27° ± 2°C until age of testing [14] [15].

2.3 Testing Methods

Compressive strength of each specimen was determined using IS: 516-1959 [16] and split tensile strength was determined using IS 5816-1999 [17]. The compressive strength and split tensile strength were measured at 28 days. Specimen dimensions were 150x150x150 mm for compressive strength and 150x300 mm for split tensile strength.

III. RESULTS AND DISCUSSION

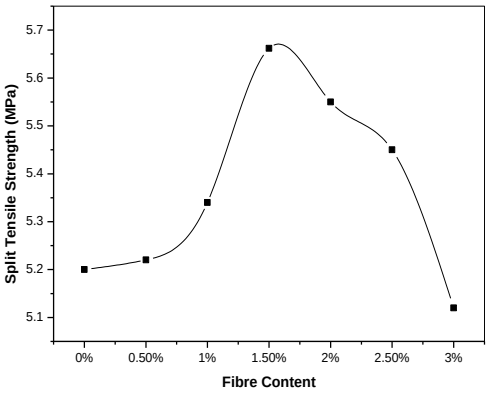
a) Compressive strength of cube vs polypropylene fibres



Compressive strength vs percentage of fibre for M 25 Design mix (fig 1)

The graph represents the compressive strength of concrete cube with 0-3% of Fibre to weight of cement with 0% as standard concrete. With the addition of fibre the compressive strength of concrete cube increased by 0.23 % at 0.5 % fibre content, 9.57% at 1 % fibre content, 9.90% at 1.5 % fibre content, 7.82% at 2 % fibre content, 4.46% at 2.5 % fibre content and decreased by 4.93 % at 3% fibre content. The optimum dosage for maximum fibre content was 1.5 % giving compressive strength of 32.74 with 9.90% increase from control specimen. The minimum compressive strength was 28.32 with 4.93% decrease from control specimen.

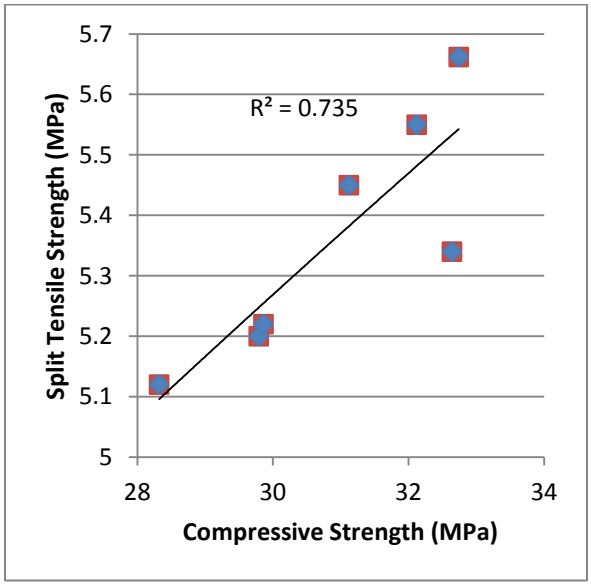
b) Tensile Strength of Cylinder vs percentage of Polypropylene Fibres



Split Tensile Strength vs % Fibre for M 25 Design mix (fig 2)

The graph represents the split tensile strength of concrete cylinder with 0-3% of Fibre to weight of cement with 0% as standard concrete. With the addition of fibre the compressive strength of concrete cube increased by 0.38 % at 0.5 % fibre content, 2.69% at 1 % fibre content, 8.88% at 1.5 % fibre content, 6.73% at 2 % fibre content, 4.80% at 2.5 % fibre content and decreased by 1.54% at 3% fibre content. The optimum dosage for maximum fibre content was 1.5 % giving tensile strength of 5.662 with 8.88% increase. The minimum tensile strength was 5.12 with 1.54% decrease from control specimen.

C) Comprison of compressive and tensile strength vs percentage fibre(with fly ash)



Relation between compressive and tensile strength (fig 3)

The Relationship between Compressive Strength – Split Tensile Strength for M25 is given by
$ft = 0.733fck^{0.579}$ with coefficient of variation $R^2=0.735$

IV. CONCLUSION

From this laboratory work the following conclusions were made:

1. Use of fly ash in PFRC makes concrete to set earlier and also involves in improvement of the compressive and tensile properties.
2. The optimum dosage of fibre content is 1.5%.
3. With the increase in fibre dosage the compressive and tensile properties improves.
4. Beyond 1.5% increase in fibre dosage decreases the compressive and tensile strength.
5. The maximum increase in compressive strength is 9.90% having compressive strength 32.74 Mpa.
6. The maximum increase in split tensile strength is 8.88% with tensile strength 5.662 Mpa.
7. So we can say that the increased compressive strength due to fibre percentage is due to fibre and aggregate bonding and not due to cement paste bonding. The fibres are acting as anchors between the cement paste and the fine and coarse aggregates which results in increased durability of concrete before failure.
8. By regression analysis the relation established between compressive and tensile strength of PFRC and it is $ft = 0.733fck^{0.579}$ with coefficient of variation $R^2=0.735$.

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APPENDIX

Table-1

Chemical composition of cement and fly ash (%):

Oxide	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O_3**	**Na_2O_3**	**LOI**
Cement	19.6	5.1	3.63	60.91	2.52	2.62	0.9	0.25	0.95
Fly Ash	50.5	21.82	5.31	7.11	2.51	0.2	0.98	0.45	3.32

Table-2

Mixed aggregate gradations:

Particle size(mm)								
	0-0.25	0.25-0.5	0.5-1	1-2	2-4	4-8	8-16	16-20
Cement Content (%)	3.33	11.21	5.1	7	18.6	31.2	23.5	20.2

Table-3
Concrete composition for M^3:

Mix No.	Fibre Volume Fraction (%)	Fibre Length mm	Cement (Kg/m^3)	Fine Agg. (Kg/m^3)	Coarse Agg. (Kg/m^3)	w/c Ratio
Mix I	0	-	465	745	958	0.4
Mix II	0.5	12				
Mix III	1					
Mix IV	1.5					
Mix V	2					
Mix VI	2.5					
Mix VII	3					