STUDY ON STRENGTH AND DURABILITY CHARACTERISTICS OF HYBRID FIBRE REINFORCED CONCRETE

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Abstract—*The combining of fibres, often called hybridization, is investigated in this paper for a M40 grade concrete. The addition of two or more types of fibres in concrete with suitable combination may increase overall properties of the concrete. In this research, concrete is made with addition of different proportions of hybrid (steel & polypropylene fibres). Steel fibres added with percentage of 0.5%, 0.6%, 0.7% & 0.8% by volume of concrete and polypropylene fibres added with percentage of 0.5%, 0.4%, 0.3% & 0.2% by weight of cement. Compressive strength, splitting tensile and flexural strength and acid test were performed and results were analyzed. The test results show when adding these proportions of fibres then the strength will gradually increases than control* **concrete.**

Keywords— compressive strength, hybrid composites, split tensile strength & flexural strength and durability.

1. INTRODUCTION

Concrete is relatively strong in compression but weak in tension and tends to be brittle. A micro crack appears in cement products due to the load and environmental changes. So cement based materials have low tensile strength and cause brittle failure. Once failure is initiated, the nearly complete loss of loading capacity then the concrete is characterized by quasi-brittle failure. It can be overcome by the addition of a small amount of short randomly distributed fibres and practiced among others that remedy the weakness of concrete such as high shrinkage cracking, low durability and low growth resistance etc. Incorporation of steel and polypropylene materials in concrete significantly increase its bleeding, plastic settlement, thermal and shrinkage strains and stress concentrations imposed by external restraints. The fibres are able to prevent the surface cracking through bridging action leading to an increased impact resistance of concrete.

2. MATERIAL USED

A. Cement: OPC 53 grade was used in this investigation conforming to IS 12269:2013. The properties of this cement are under,

- Specific gravity :3.16
- Fineness :8%
- Normal consistency :26%

B. Fine aggregate: River sand was used. The properties of fine aggregate are,

- Specific gravity : 2.4
- Fineness modulus : 2.56
- Water absorption : 0.8%

C. Coarse aggregate: Locally available, maximum size 20mm

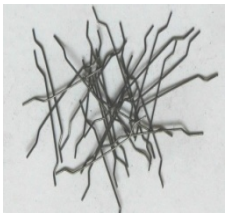
- Specific gravity : 2.6
- Crushing value : 12.42%
- Impact value : 11.2%

D. Water: Portable water was used in this investigation.

E. Chemical Admixture type: Super plasticizer (con plast) 1% weight of cement was used.

F. Steel fibres: In this experimentation, Hooked end steel fibres (L=30mm, dia=0.5mm) were used.

G. Polypropylene fibres: Fibrillated 20mm cut length fibres were used.



Hooked end Steel fibres

polypropylene fibres

3. MIX PROPORTION:

As per IS 10262:2009 designed by M40 grade of concrete and conplast used as a superplasticizer and water cement ratio 0.40.

Table 1: Concrete mix proportions

Materials	Quantity	Proportion
Cement	410	1
Fine aggregate	604	1.5
Coarse aggregate	1170	2.9
Water	164	0.4
Super plasticizer	4.1	0.01

4. EXPERIMENTAL PROGRAMME AND DISCUSSION OF RESULT

A. Compressive strength test result:

The compression test is carried out on specimen like cube. The cube specimen is of the size 15 ×15×15 cm. If the largest nominal size of the aggregate does not exceed 20mm, 10 cm cubes may be used as an alternative. The specimens were tested for compressive strength as per IS 516-1959 using a calibrated compression testing machine of 2000 KN capacity. After placing the specimen the compression load is applied due to compression fails this failure is noted. The compressive strength of the specimen was calculated by using the formula

$$f_c = \frac{P}{A} \text{ N/mm}^2$$

Where,
P = Load at which the specimen fails in Newton (N)
A = Area over which the load is applied in mm^2
f_c = Compressive stress in N/mm^2

Table 2: Results of compressive strength

Type of concrete	7 days N/mm^2	28days N/mm^2	60days N/mm^2
Control concrete	35.55	45.33	53.77
S0.5P0.5	37.33	47.11	58.66
S0.6P0.4	39.11	49.33	61.22
S0.7P0.3	41.34	53.78	64.00
S0.8P0.2	44.44	56.44	67.55

The comparative results for tensile strength of concrete cube between conventional concrete and hybrid fibre reinforced concrete are shown in fig 1.

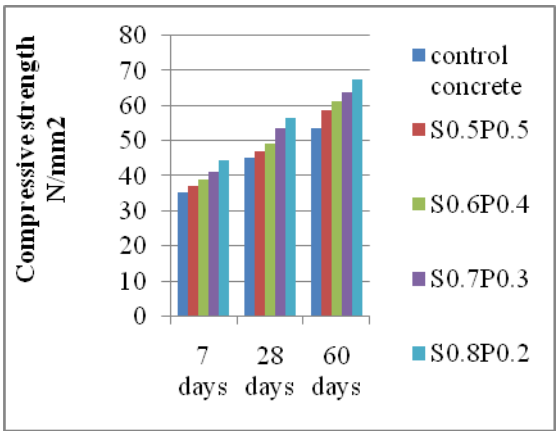


Fig.1 comparisons of compressive strength

B. Flexural strength test

It is measured by loading un-reinforced beam or prism of size 100 × 100 × 500 mm. The prism is casted and after 24 hours it was de-molded and kept in a curing tank for 7,28,60 days and then it was taken out dried in atmosphere for few hours after that the specimens were tested for its flexural strength as per IS: 516-1959 using a calibrated flexural testing machine. The bed of testing machine should be supported, and these rollers should be mounded that the distance from center is 50 mm for 100 mm specimen. The Flexural Strength is expressed as Modulus of Rupture in N/mm2. The Flexural Strength of the specimen was calculated by using the formula

$$f_b = \frac{pl}{bd^2} \text{ N/mm}^2$$

Where,
P = Load at which specimen fails in N
l = Effective span in mm
b = Breadth of the specimen in mm
d = Depth of specimen in mm

Table 2: Results of flexural strength

Type of concrete	7 days N/mm^2	28days N/mm^2	60days N/mm^2
Control concrete	5.39	6.13	6.8
S0.5P0.5	5.89	6.47	7.13
S0.6P0.4	6.13	6.72	7.35
S0.7P0.3	6.37	6.86	7.60
S0.8P0.2	6.62	7.11	7.84

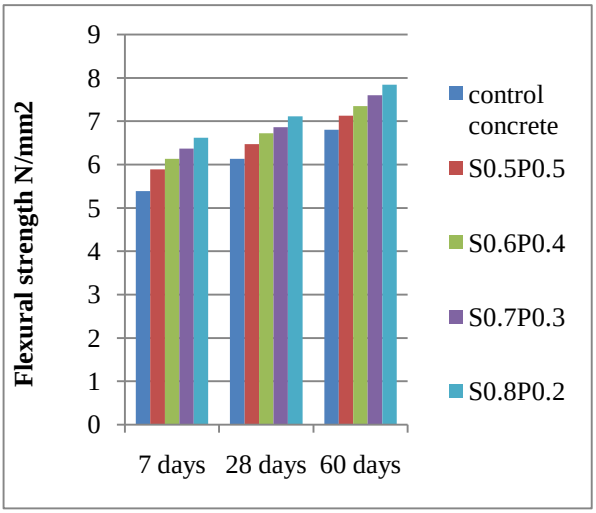


Fig.2 comparisons of flexural strength

C. Split tensile strength

Split tensile strength of concrete is usually found by testing concrete cylinder of size 100 mm × 200 mm. The specimens were tested for its strength as per IS: 516-1959 using a calibrated compression testing machine of 2000 KN capacity. Two packing strips of plywood 3mm thick were provided between the specimen one at top and another at bottom. The specimen was placed on the plywood strip and aligned so that, the central horizontal axis of the specimen is exactly perpendicular to the load applying axis. The tensile strength of the specimen was calculated by using the formula

$$f_t = \frac{2p}{\pi dl} \text{ N/mm}^2$$

Where,

p = Maximum load in N applied to the specimen

d = Measured length in cm of the specimen

l = Measured diameter in cm of the specimen

ft = Tensile strength N/mm2

Table 2: Results of tensile strength

Type of concrete	7 days N/mm^2	28days N/mm^2	60days N/mm^2
Control concrete	4.77	4.93	6.36
S0.5P0.5	5.09	5.57	8.28
S0.6P0.4	5.25	6.21	8.91
S0.7P0.3	5.41	6.68	9.23
S0.8P0.2	5.73	7.48	9.68

The comparative results for tensile strength of concrete cube between conventional concrete and hybrid fibre reinforced concrete are shown in fig 3.

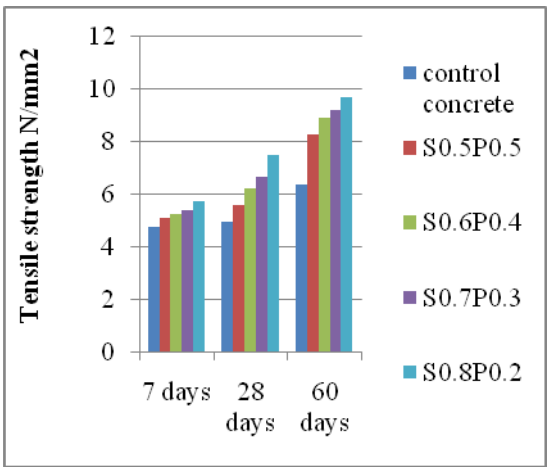


Fig.3 comparisons of tensile strength

D. Acid test:

In order to assess the weight loss, concrete cubes is exposed to chemical media. For acid test, hydrochloric acid (HCL) solution was prepared by mixing 5% of Conc. Hcl with one litre of distilled water as per ASTM G20-8 or make an Acidic solution with 1N (Normality) as per laboratory standards.

After normal curing (60 days) cubes were taken out and weight of cube was noted. Than weighted cubes was immersed in the prepared hydrochloric acid for 7 and 28 days. After curing the cubes were taken out from acid and weight of cubes was noted. From this weight loss of cubes is calculated.

Weight loss = Weight of cube after Normal Curing –Weight of cube after taking from acid solution

Table 4: Results of acid test

SI.No	Type of concrete	Percentage loss in weight (kg)	
		28days	*60 days*
1	Control concrete	0.32	0.38
2	S0.5%P0.5%	0.41	0.45
3	S0.6%P0.4%	0.54	0.60
4	S0.7%P0.3%	0.71	0.78
5	S0.8%P0.2%	0.79	0.86

The comparative results for acid test of concrete cube between conventional concrete and hybrid fibre reinforced concrete are shown in fig 4.

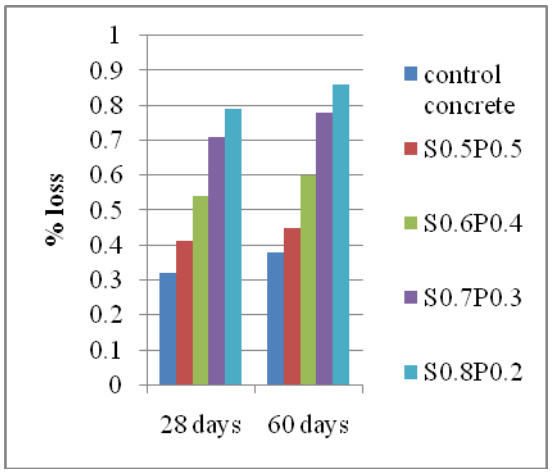


Fig 4: comparisons of acid attack test

5. CONCLUSION

The study on the effect of hybrid fibres with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete.

Based on the experimental results the following conclusions are drawn

1.Compressive strength

- The compressive strength between S0.6P0.4 and S0.7P0.3 is increase high as compare to other interval.
  - S0.8P0.2 gives high strength as compare to other combination.
  - The addition of hybrid fibres will gradually increase the strength compared to other control concrete.

2. Split tensile and flexural strength
   - S0.8P0.2 gives high tensile and flexural strength as compare to other combination.
   - The strength increases at 28 & 60 days with all proportions of hybrid fibres as compare to conventional concrete.

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