Effect of Basalt, Polypropylene and Hybrid Fibres on Mechanical Properties of Concrete

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Abstract- *To study the strength properties and workability of concrete containing basalt, polypropylene and hybrid fibres reinforced concrete. The investigation was carried out using basalt fibre, polypropylene fibre and hybrid fibres as additional material of concrete. For this research work M30 grade of concrete was used and tests were conducted for various proportion of basalt fibre (BF) and polypropylene fibre (PPF) i.e.(0.3%,0.6%,0.9%,1.2% and 1.5%by weight of cement) with locally available materials and also hybrid fibres (BF+PPF),basalt fibre 0.3% by weight of cement is constant and polypropylene fibre varies i.e.(0.3%,0.6%and 0.9%by weight of cement).The concrete specimen were tested for compressive and split tensile strength for 7 days and 28 days. The workability is not much affected with the addition of fibres. The results shows increment in compressive strength at 16.31% when basalt fibre used at 1.2%by weight of cement and 10.27% increase when 1.50%of Polypropylene fibre used for test 28 days. The split tensile strength increases at 32.30% at 28 days when Hybrid fibre used at 0.9%by weight of cement. The compressive strength of basalt fibre is greater as compare to polypropylene fibre.*

Keywords- Compressive strength, Split tensile strength, Basalt fibre, Polypropylene fibre, M30 grade of concrete.

I. INTRODUCTION

Concrete is widely used in structural engineering with its high compressive strength, low cost and abundant raw material. But common concrete has some shortcomings, for examples, shrin-kage and cracking, low tensile and flexural strength, poor toughness, high brittleness, low shock resistance and so on, that restrict its applications. To overcome these deficiencies, additional materials are added to improve the performance of concrete. Fibre reinforced concrete is a cement-based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength. resistance to splitting, impact resistance and excellent permeability, and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of mortar.

Basalt fibre (BF) is an inorganic fibre material. It is an all-natural material and originates from volcanic rock. Basalt rock is melted at high temprature (1450 0C) and rapidly drawn into a continuous fibre. It can be chopped into various lengths. It color can vary between brown, gold and gray [1].The basic characteristics of basat fibre materials are high temperature resistance, high corrosion resistance, resistance to acid and alkalis, high strength and thermal stability. Basalt and polypropylene materials can be used as a reinforcing composite material for the construction industry, specially as a less expensive to carbon fibre. The basalt fibre reinforced concrete serves the function of reinforcement ,and can extend the life of construction in the fields of housing, highways, rail-ways urban elevated roads, runways, ports and subway tunnels etc. It is good for bridge and shoreline concrete structures.

II. LITERATURE REVIEW

Several experimental investigation have been done in the past study the behaviour and mechanical properties of basalt & polypropylene fibre reinforced concrete. The inclusion of basalt and polypropylene fibre in the concrete have shown better results of compressive, split tensile and flexural strength of concrete. The slump of concrete decreases with increasing the fraction volume of fibre a slightly increase in the splitting tensile strength with increase the basalt fibre till 0.3% and then its decreases with 0.5% basalt fibre added [2].The workability of concrete decreases with the addition of basalt fibres, but these difficulty can be overcome by plasticizers or superplasticizers. The compressive strength and flexural strength increases with the addition of basalt fibre. The ductility charactrictics have improved with the addition of basalt fibre [3].The addition of polypropylene fibre improve the performance charactristics of the light weight cement composite. The use of fibre makes the concrete light weight and low composite material [4].The effects of addition of various proportion of polypropylene fibre on the high strength concrete. Increase in flexural, tensile and shear strength was found with the addition of fibre [5].

III. EXPERIMENTAL WORK

The main objective of the experimental program were

a) To control the slump of concrete with the addition of basalt, polypropylene and hybrid fibre reinforced concrete.
b) To compare the effects on compressive strength, split tensile strength with and without addition of basalt, polypropylene and hybrid fibres reinforced concrete. The investigation was carried out on concrete cubes (150m 150mm 150mm) for finding compressive strength and cylinders (150mm 300mm) for finding the split tensile strength tests. Each specimen was casted as per IS

procedure. After casting M30 grade of concrete ,specimen were demoulded after 24 hours and specimen were kept for a period of 7 days and 28 days in the curing tank until the time of test. The detailed mix proportion of M30 grade of concrete is given in table:1

Table:1 Quantity of materials per cubic meter of concrete

Material	Proportion by weight	Weight in kg/m^3
Cement	1	424
Fine aggregate	1.83	778.65
Coarse aggregate	2.54	1077.75
w/c ratio	0.40	169.56
Admixture	0.6%	2.54

3.1 Material Used

3.1.1 Cement-In the present research work 43 grade OPC (PRISM) is used for casting all cubes and cylinders.The cement is uniform in color i.e.grey with light greenish shade and it is free from lump.Physical properties of cement given in table:2

3.1.2 Fine Aggregate-The fine aggregate used for the experimental work conform to grading zone-2 by sieve analysis.The fine aggregate is sieved through 4.75 mm sieve to remove any particle greater than 4.75 mm size.Physical properties of fine aggregate given below table:3

3.1.3 Coarse Aggregate-The broken stone is generally used as a coarse aggregate.Locally available coarse aggregate having the maximum size 20 mm and 12.5 mm used in the present work. Physical properties of fine aggregate given below table:3

3.1.4 Basalt Fibre-Basalt chopped fibre golden brown color was used in the concrete mixes.The density of fibre is 2.75 kg/m^3 and available in the length of 6 to 12 mm.The physical properties of basalt fibre are given below in table:5

Fig-1 Chopped Basalt Fibre

Table: 5 Physical properties of chopped basalt fibre

Sr.No.	Properties	Values
1	Diameter	13 um
2	Length of fibre	6-12mm
3	Appearance	Golden brown
4	Tensile strength	4840MPa
5	Modulus of elasticity	89000MPa
6	Specific gravity	2.75kg/m^3

Table:2 Physical properties of ordinary portland cement

Physical properties	Experimental values	Recommended values
Finenesss of cement	4%	<10%
Specific gravity of cement	3.14	3.15
Normal consistency (% by weight of cement)	30%	30-35%
Setting times(minutes) i. Initial ii. final	 94 188	 30 600
Compressive strength (MPa) i. 7-days ii. 28-days	 33.5 43.5	 33 43

Table:3 Physical properties of fine aggregate

S.NO.	Properties	Values
1	Specific gravity	2.65
2	Fineness modulus	2.92
3	Grading zone	2
4	Silt content	3.62%
5	Water absorption	1.2%

Table:4 Physical properties of coarse aggregate

Physical properties	Observed values		Recommended values
	12.5 mm aggregate	20 mm aggregate	
Fineness modulus	6.74	7.03	6.5-8
Aggregate crushing value(%)	18.5	24.63	Not more than 45%
Aggregate impact value(%)	26.38	22.18	Not more than 45%
Specific gravity	2.7	2.7	2.6-2.8
Water absorption(%)	0.55	0.5	<0.5

3.1.5 Polypropylene Fibre-Fibermesh150,formerly Stealth® e3®, micro-reinforcement system for concrete-100 percent virgin homopolymer polypropylene multifilament fibers containing no reprocessed olefin materials. Specifically engineered and manufactured in an ISO 9001:2000 certified facility for use as concrete reinforcement at an application rate of 1.0 to 1.5 lbs per cubic yard (.60 to .90 kg per cubic meter).The chemical physical properties of polypropylene fibre are given below in table:6 and fig-2

Fig-2 Polypropylene fibre

Table:6 Chemical And Physical Properties of polypropylene fibre

Absorption	Nil	Melt Point	324°F (162°C)
Specific Gravity	0.91	Ignition Point	1100°F (593°C)
Fiber Length	Graded	Thermal Conductivity	Low
Electrical Conductivity	Low	Alkali Resistance	Alkali Proof
Acid & Salt Resistance	High		

3.1.6 Admixture- In order to make the concrete mixes workable MasterRheobuild® 817 RL admixture was used. The addition of fibres reduces the workability, therefore in order to make it use for practical purposes admixtures in 0.6% by weight of cementious materials was added to the mix.

3.1.7 Water-Water is an important ingredient of concrete as it actively participate in the chemical reaction with cement. In the present investigation, tap water is used for both mixing and curing purposes.

3.2 Test Procedure

3.2.1 Compressive Strength Test-compressive strength test of concrete with and without basalt, polypropylene and hybrid fibres were conducted for 7 days and 28 days. The load was applied and increase continiously until the resistance of the specimen to the increasing load breaks down. The maximum load applied to the specimen was then recorded. Average of three value was the taken ass the representatives of compressive strength of the sample as noted. The experimental set up for compressive strength test as per IS 516:1959 shown in fig-3.The compressive strength test specimen can be determine by the following formula

$$F_t = \frac{P}{A}$$

Where

f_c = Compressive Strength, MPa
P = load applied at failure, KN
A = loaded area of cube, mm^2

Fig-3 Testing Of Cube

3.2.2 Split Tensile Strength Test-The split tensile strength test were conducted as per IS 5816:1999.The size of cylinder is 300 mm length with 150 mm diameter. The test is carried out by a placing a cylindrical specimen horizontly between the loading surface of a universal testing machine and load is applied until the failure of cylinder along the vertical diameter. The maximum load is applied to the specimen was recorded. Average of three values was taken as the representative of batch fig-4 shows the testing of split tensile strength test.

The split tensile strength of cylinder is calculated by the following formula

$$F_t = \frac{2P}{\pi LD}$$

Where,

Ft = split tensile strength, Mpa
P = load at failure, KN
L = length of cylinder, mm
D = diameter of cylinder, mm

Fig-4 Testing of cylinder

IV. RESULT AND DISCUSIONS

4.1 Compressive Strength –The results of compressive strength are obtained and are, presented Table:7, for basalt fibre and Table:8 for polypropylene fibre. The variation of compressive strength with respect to adding of basalt fibre and Polypropylene fibre contents for various % by weight of cement given below in table:7&8.

Table: 7 Compressive strength test values of basalt fibre

Sr.No.	Mix designation	Fibre contents (%) by weight of cement	Compressive strength (MPa)	
			7 days	28 days
1	M0	0.0	22.46	38.37
2	M1	0.30	24.18	39.55
3	M2	0.60	25.58	41.13
4	M3	0.90	26.69	42.96
5	M4	1.20	27.78	44.63
6	M5	1.50	21.76	41.52

Table: 8 Compressive strength test values of Polypropylene fibre

Sr.No.	Mix designation	Fibre contents (%) by weight of cement	Compressive strength (MPa)	
			7 days	28 days
1	M0	0.0	22.46	38.37
2	M1	0.30	22.59	39.11
3	M2	0.60	23.11	39.75
4	M3	0.90	24.18	40.53
5	M4	1.20	25.93	41.40
6	M5	1.50	26.33	42.31

4.1.1 Effect of % of Basalt , Polypropylene and Hybrid fibres on workability of concrete

The addition of basalt fibre does not much affected the workability of concrete. The addition of basalt fibre the slump value range between 95-80mm.Therefore a minor decreasing the slump value with the addition of basalt fibre in different variation by weight of cement. But in case of polypropylene fibre the slump value decreases greater as compare basalt fibre as shown in fig-5

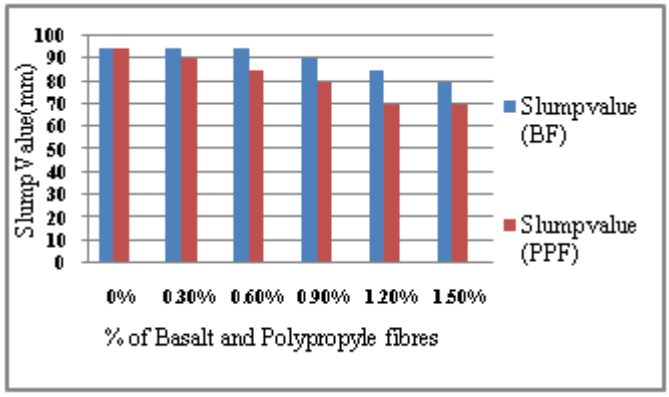

Fig-5 Effect of % age of fibre on slump values of concrete mixes

4.1.2 Effect of % of Basalt fibre on compressive strength of concrete

The results shows that the compressive strength of concrete increases with the addition of basalt fibre in various % by weight of cement. The addition of 1.2% basalt fibre by weight of cement gives the optimum compressive strength as compare to plain concrete. The compressive strength increases by 16.31% as compare to without addition of basalt fibre for 28 days.Fig:6 clearly shows the increase in strength for different percentage of basalt fibre in concrete.

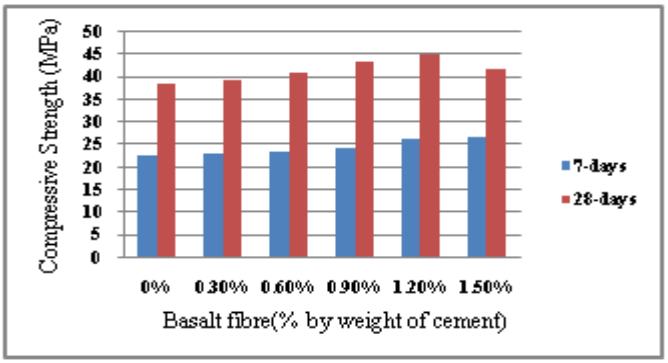

Fig-6 Effect of % of basalt fibre on compressive strength of concrete

4.1.3 Effects of % of Polypropyle fibre on compressive strength of concrete

The results shows that the compressive strength of concrete increases with the addition of Polypropylene fibre in various % by weight of cement. The addition of 1.5% polypropylene fibre by weight of cement gives the optimum compressive strength as compare to plain concrete. The compressive strength increases by 10.27% as compare to without addition of polypropylene fibre for 28 days.Fig:7 clearly shows the increase in strength for different percentage of polypropylene fibre in concrete.

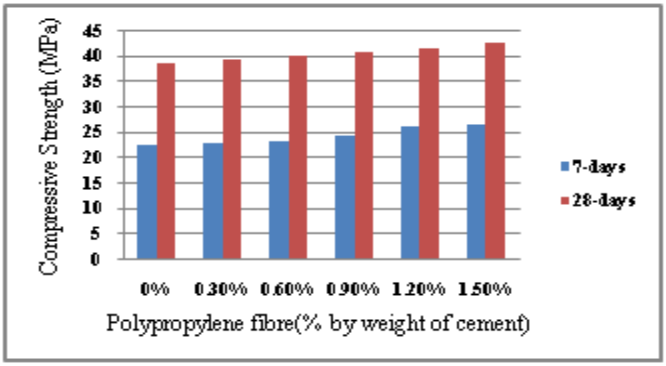

Fig-7 Effect of % of Polypropylene fibre on compressive strength of concrete

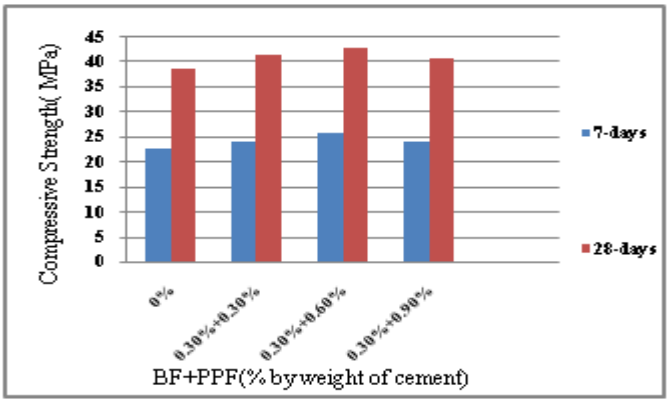

Fig-8 Effects of % of hybrid fibres on compressive strength of concrete

4.1.5 Compressive strength and percentage of fibres relationship for basalt and polypropylene fibres

Fig:9 shows the correlation between compressive strength and percentage of fibre at 28 days.In these plot it is clear that the compressive strength is very much dependent of percentage of fibres for a particular grade of concrete.The Empirical equations for 28 days compressive strength for basalt and polypropylene fibre are obtained M30 grade of concrete mix.The correlation cofficient for these two equation was 0.99 for basalt fibre & 0.93 for polypropylene fibre.It is indicate a high degree of correlation between compressive strength and percentage of fibres.

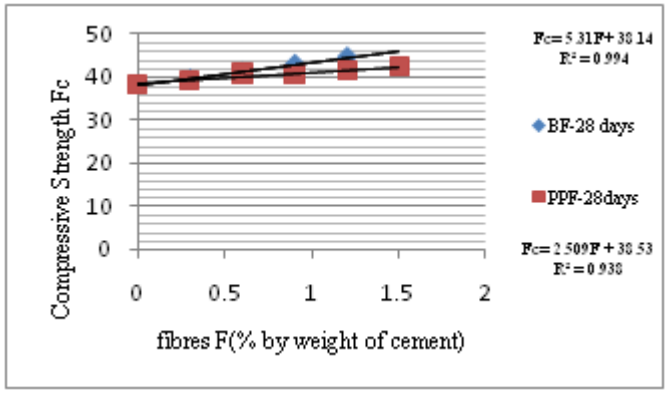

Fig-9 Relation between compressive strength and %age of fibres

4.1.6 Compare the compressive strength of Basalt fibre (BF) and Polypropylene fibre(PPF)

The compressive strength of basalt fibre is high as compare to polyporpylene fibre as shown in fig-10.The compressive strength of basalt fibre for addition of 1.20%of basalt fibre by weight of cement compressive strength increases as 7.80% as compare to polypropylene fibre for 28 days.

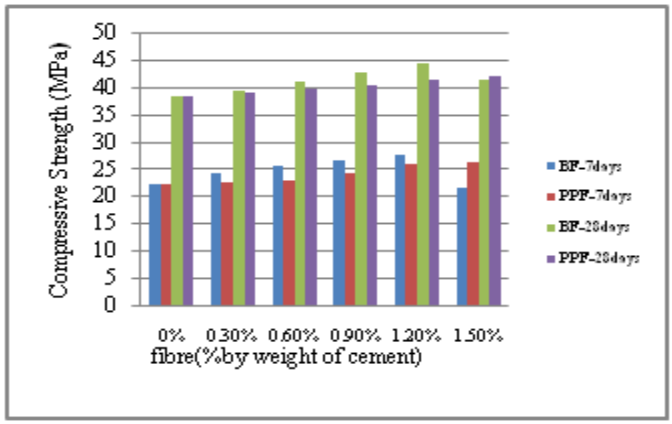

Fig-10 Compare the compressive strength of BF and PPF various % of fibre by weight of cement

4.2 Split tensile strength –The results of split tensile strength are obtained and are represented in table:9.The variation of split tensile strength with respect to variation of hybrid fibre as shown in fig-11

Table:9 Compressive strength and split tensile strength test values of hybrid fibre(BF+PPF)

Sr .No	Mix designation	Fibre contents (PP+PPF %) by weight of cement	Compressive strength MPa		Split-tensile strength MPa	
			7 days	28 days	7 days	28 days
1	M0	0.0	22.46	38.37	2.10	3.53
2	M1	0.30+0.30	23.86	41.11	2.33	3.83
3	M2	0.30+0.60	25.47	42.56	2.87	4.67
4	M3	0.30+0.90	23.98	40.50	1.96	3.11

4.2.1 Effects of hybrid fibres on split tensile strength concrete

The results shows that the Split tensile strength of concrete increases with the addition of hybrid fibres in various % by weight of cement. The addition of 0.30% basalt fibre and 0.60% of polypropylene fibre by weight of cement gives the optimum split tensile strength as compare to plain concrete. The split tensile strength increases by36.66% & 32.29% as compare to without addition of fibre for 7&28 days and .Fig:11 clearly shows the increase in strength for different percentage of hybrid fibre in concrete.

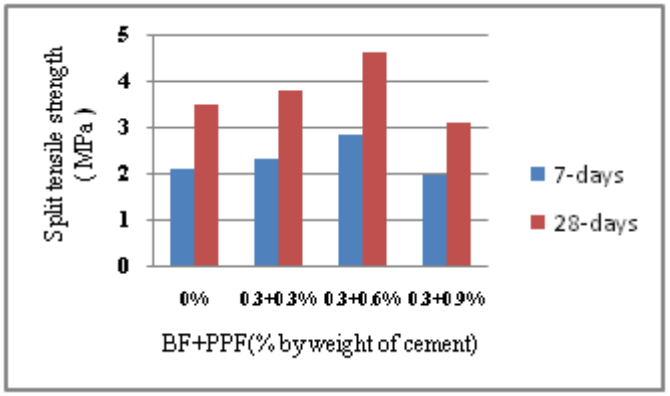

Fig-11 Effect of % of hybrid fibres on split tensile strength of concrete

4.2.2 Compressive strength and percentage of fibres relationship for hybrid fibres

Fig:12 shows the correlation between Split tensile strength and percentage of fibre at7& 28 days.In these plot it is clear that the split tensile strength is very much dependent of percentage of fibres for a particular grade of concrete.The Empirical equations for 7&28 days split tensile strength for hybrid fibre are obtained M30 grade of concrete mix.The correlation cofficient for these two equation was 0.83 for 7-days & 0.80 for 28-days hybrid fibre.It is indicate a high degree of correlation between compressive strength and percentage of fibres.

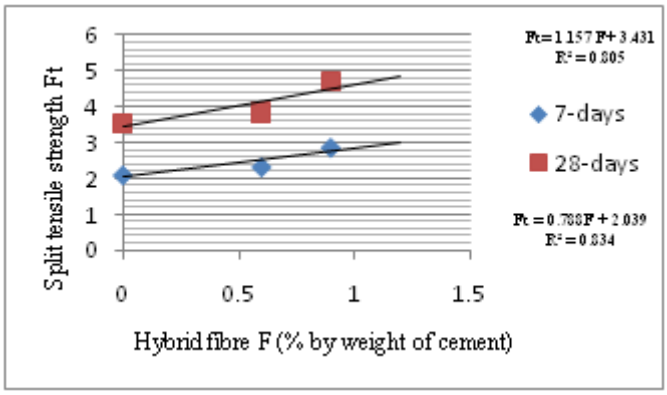

Fig-12 Relation between split tensile strength and %age of fibres

V. CONCLUSIONS

1) The use of basalt chopped fibres advantageously improve the compressive as well as split tensile strength without the affecting the workability of concrete

2) The inclusion of basalt fibres does not affect the slump value significantly as compare to polypropylene fibre. The slump value ranges between 95 to 80 mm respectively.

3) The increase in the content of percentage of basalt fibres increase the compressive strength marginally. Addition of 1.2% basalt fibres increases the compressive strength upto 23.68% &16.31% for 7 days and 28 days .

4) **4)**The increase in the content of percentage of polypropylene fibres increase the compressive strength. Addition of 1.5% polypropylene fibre increase the compressive strength upto 17.23% &10.23% for 7days and 28 days respectively.

5) The compressive strength of hybrid fibres increases to 10.91% for 28 days for the addition of hybrid fibres 0.9% by weight of cement.

6) The hybrid fibres also increase the split tensile strength of concrete. The addition of hybrid fibre 0.9% by weight of cement gives the maximum split tensile strength 32.30% for 28 days.

7) An emperical equation has been formulated for calculating 28 days compressive and split tensile strength for basalt, polypropylene and hybrid fibres which is as follows:

Fc =5.31F+38.14
Fc =2.50 F+38.53
Ft = 1.15 F +3.43

Where Fc = 28 days of compressive strength in MPa
Ft = 28 days split tensile strength in Mpa
P = Percentage of fibres

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