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Experimental Study on Concrete Reinforced with Basalt Fiber and Polypropylene

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In this paper, an attempt has been made to study the strength properties of concrete with different percentages of Basalt fiber and Polypropylene. The concrete mixture design is done for M20 grade of concrete with water cement ratio 0.45. The Basalt fiber reinforced concrete containing fibers of 0.05%, 0.2% and 0.5% and Polypropylene containing 0.2%, 0.3% and 0.5%. The cube size is 100mm x100mm x100 mm for testing the compressive strength and Tensile strength of concrete. Flexural strength is checked by testing beams of size 500 mm x 100 mm x 100 mm beneath two points loading. From experiment, it was concluded that the Basalt fiber and polypropylene content that gives maximum compressive strength, Tensile strength and flexural strength was 0.2% and 0.2% respectively.

Keywords: Basalt Fiber, Polypropylene, Compressive Strength, Flexural Strength, Tensile Strength.

Concrete is mostly wide construction material in the world due to its ability it can be mould and shape. However concrete has some deficiencies as listed below, Low tensile strength, Low post cracking capacity, Brittleness and low ductility, Low impact strength. These properties can be improved by the use of Basalt fiber reinforced concrete. The addition of fibers improves the post cracking response of the concrete, i.e., it improves its energy absorption capacity and apparent ductility, and also provides crack resistance and crack control.

Recent report aimed at energy conversation in the cement and concrete industry has in part, focused on the use of less energy intensive materials such as Fly ash, Slag and Silica Fume, polypropylene. Polypropylene is a byproduct obtained from thermal industry which is used as mineral admixtures in concrete. The addition of Polypropylene improves the latter strength and durability of the concrete.

I. RESEARCH SIGNIFICANCE

This research is aimed at studying the improvement in properties of concrete like compressive strength, tensile strength and flexural strength which increases with adding basalt fibers and polypropylene with different percentages in concrete. The optimum percentage of volume fraction of basalt fiber and polypropylene by weight of cement is determined at which it gives more compressive, tensile and flexural strength. The study also aims at determining the flexural strength of the concrete beams based on the cross sectional dimensions, span and amount of basalt fibers + polypropylene used and compared with actual strength obtained based on experimental results. The research findings will help engineers to understand the overall performance of concrete for compressive strength, tensile strength and flexural strength.

II. EXPERIMENTAL PROGRAM AND SETUP

In this Chapter, the test results are presented and discussed. The test results cover the compressive strength, tensile strength flexural strength, workability of concrete and compaction factor. The main aim of this experimentation is to study the effect of adding volume fraction of basalt fibers and polypropylene on the properties of concrete.

The experimental program is divided in four phases.

A. Concrete mix design as per IS 10262-2009 for M20 grade of concrete. Volume fraction of basalt fibers and polypropylene with varying percentages.
B. Casting of cubes and beams.
C. Curing of cubes and beams for 7 days and,14 Days and 28 days.
D. Testing of all beam specimens with single point loading for all cubes. Each test result plotted in the Figures or given in the Tables is the mean value of results obtained from at least three specimens.

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III.MATERIAL AND METHODS

A. *Cement*

The cement used in this experimental work is 43 grades Ordinary Portland Cement. All properties of cement are tested by referring IS 12269 - 1987 Specification for 43 Grade Ordinary Portland cement.

B. *Water*

Potable water used for the experimentation.

C. *Fine Aggregate*

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.63.

D. *Coarse Aggregate*

Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20mm having the specific gravity value of 2.68.

Table 1 Property of FA and CA

Properties	Fine Aggregate (River Sand)	Coarse Aggregate (Crushed Stone)
Specific Gravity	2.63	2.68
Fineness Modulus	3.75	7.13
Loose Bulk Density (Kg/m^3)	1450	1350
Compacted Bulk Density (Kg/m^3)	1700	1610

E. *Basalt Fibers*

Basalt fibers are the most commonly used type of fibers. Basalt has high modulus of elasticity. Use of Basalt fibers provides significant improvements in flexure, impact and fatigue strength of the concrete. Concrete containing hydraulic cement, water, aggregate, and discontinuous discrete fibers is called fiber reinforced concrete.. The length of fiber is 18mm and the diameter of fiber is 22mm.

Table 2 Properties of Basalt Fiber

Mechanical Properties of Basalt Fiber	
Length	18mm
Diameter	22mm
Specific gravity	0.996
Tensile Strength	2.9 to 3.1 Gpa
Elastic modulus	85 to 87 Gpa

F. *Polypropylene*

The usage of cement blended with mineral admixtures such as Polypropylene is growing rapidly in construction industry due to the considerations of cost saving and sustainability. The addition of polypropylene in concrete results in improvement of properties such as workability, later age strength development and durability characteristics

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Length (mm)	Diameter(micron)	Elastic modulus (MPa)	Tensile strength (MPa)	Density (g/cm3)
19	30	Not more than 5	160 to 170	0.91

Table: Physical properties of polypropylene.

Specific gravity in gm/cm3	0.90
Elongation (%)	40 to 100
Abrasion resistance	Good
Moisture absorption (%)	0 to 0.05
Softening point (ºC)	140
Melting point (ºC)	165
Chemical resistance	Generally excellent
Relative density	0.91
Thermal conductivity	6.0 (with air as 1.0)
Electric insulation	Excellent
Resistance to mildew, moth	Excellent

G. Concrete

A control concrete mix of M20 grade was mix proportioned. The mix design procedure was according to the guidelines of IS 10262-2009. The fine aggregate confirming to zone II of IS 383:1970 and coarse aggregate of nominal size 20mm was used in the study. The cement used was 43 grade OPC with w/c ratio 0.45. Specific gravity of fine aggregate and coarse aggregate are 2.63 and 2.68 respectively.

Mix Proportion.

water	cement	Fine Aggregate	Coarse Aggregate
185	412	612	1158
0.45	01	1.48	2.81

IV. RESULTS AND DISCUSSION

A. Compressive Strength Test

Standard cube specimens of 100mm x 100mm x 100mm size were casted. The cube compressive strength for different mixes at period of 7 days, 14 days and 28 days curing was calculated by following formula:

Compressive strength (N/mm^2) = P/A

Where,

P: Failure load

A: cross sectional area of cube

Table: Compressive Strength at 7 days, 14 days and 28 days

Mix No.	Basalt Fiber%	polypropylene%	Compressive Strength (N/mm^2)		
			7 Days	14 Days	28 Days
S0	00%	00%	24.39	31.71	34.18
S1	0.05%	0.2%	27.69	34.80	42.63
S2	0.05%	0.3%	26.77	32.93	40.80
S3	0.05%	0.5%	26.02	31.75	35.71

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S4	0.2%	0.2%	37.81	41.88	42.89
S5	0.2%	0.3%	34.65	37.59	39.12
S6	0.2%	0.5%	30.58	31.93	32.04
S7	0.5%	0.2%	30.54	38.42	41.04
S8	0.5%	0.3%	27.62	33.34	40.92
S9	0.5%	0.5%	23.60	28.87	31.43

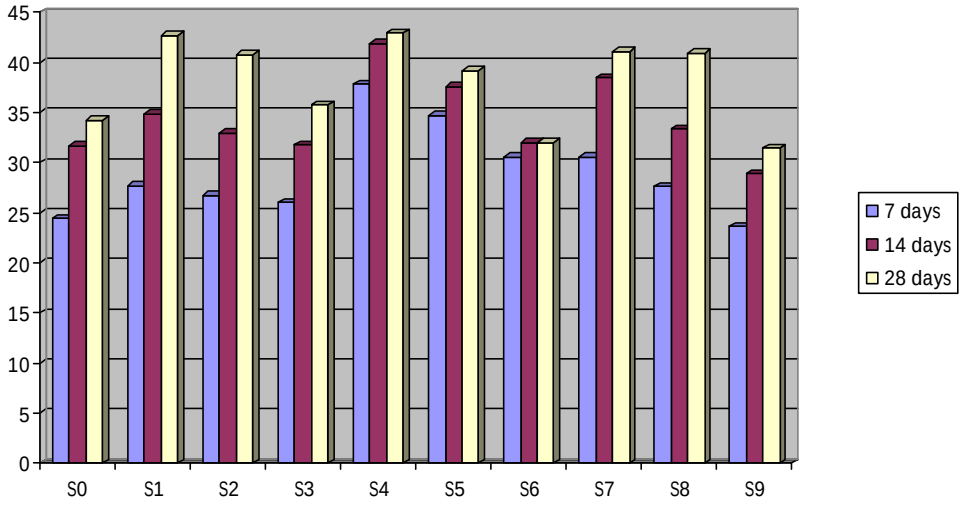

Fig: Compressive Strength at 7 days, 14 days and 28 days

B. Flexural Strength Test

Standard cube specimens of 100mm x 100mm x500mm size were casted. The cube compressive strength for different mixes at period of 7, 14 and 28 days curing was calculated by following formula:

Flexural strength (N/mm^2) = PL/bd^2

Where,

P: Failure load,

L: centre to centre distance between the supports,

b: width of specimen,

d: depth of specimen

Table: Flexural Strength at 7 days, 14 days and 28 days

Mix No.	Basalt Fiber%	polypropylene%	Flexural Strength(N/mm^2)		
			7 Days	14 Days	28 Days
S0	00%	00%	3.55	4.05	4.38
S1	0.05%	0.2%	3.97	4.92	5.66
S2	0.05%	0.3%	3.71	4.91	5.20
S3	0.05%	0.5%	3.13	3.83	4.46
S4	0.2%	0.2%	5.19	6.59	7.34
S5	0.2%	0.3%	4.80	5.33	6.27
S6	0.2%	0.5%	4.17	4.91	5.50
S7	0.5%	0.2%	4.71	5.18	5.86
S8	0.5%	0.3%	4.03	4.84	5.60
S9	0.5%	0.5%	3.69	4.16	4.94

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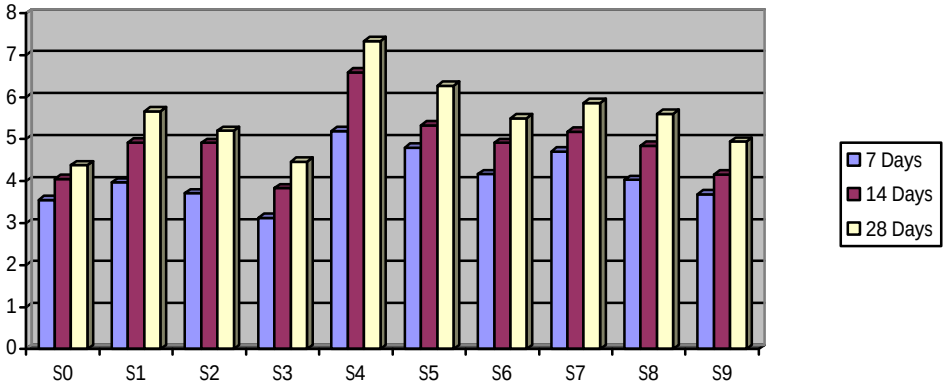

Fig. Flexural Strength at 7 days, 14 days and 28 days

C. Tensile Strength Test

The 100mm x 100mm x 100mm size cubes are casted and curing is done for 7 days, 14 Days and 28 days. They were tested for tensile strength in compression testing machine.

Tensile strength = 0.642 P/ S^2

Table: Tensile strength at 7days, 14 days and 28 days

Mix No.	Basalt Fiber%	polypropylene%	Compressive Strength (N/mm^2)		
			7 Days	14 Days	28 Days
S0	00%	00%	2.43	2.97	3.46
S1	0.05%	0.2%	2.97	3.69	4.89
S2	0.05%	0.3%	2.70	3.08	4.00
S3	0.05%	0.5%	2.61	2.94	3.78
S4	0.2%	0.2%	3.43	4.29	5.02
S5	0.2%	0.3%	3.30	4.03	4.65
S6	0.2%	0.5%	3.18	3.73	4.28
S7	0.5%	0.2%	3.04	3.74	4.31
S8	0.5%	0.3%	2.92	3.55	3.80
S9	0.5%	0.5%	2.76	3.08	3.43

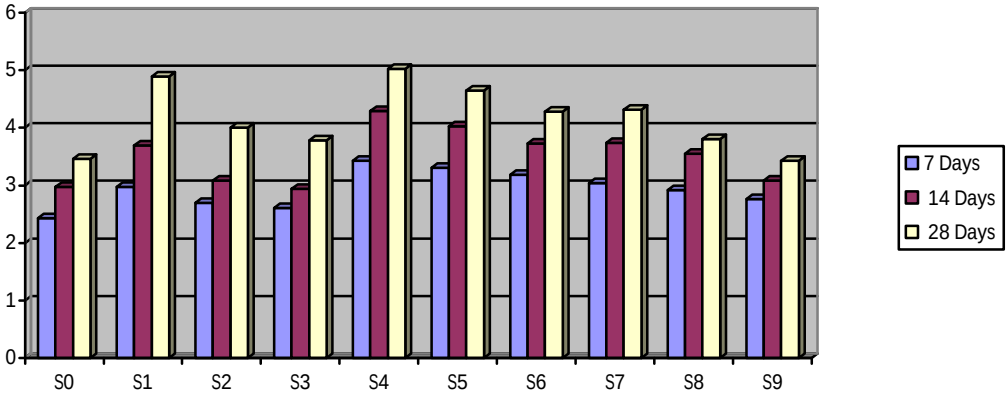

Fig. Tensile Strength at 7 days, 14 days and 28 days

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V. CONCLUSION

Based on the result and observation made in this experimental research study. The following conclusions are drawn.

A. As the percentage of Basalt fiber content by total volume of the concrete increases it gives high compressive strength, tensile strength and flexural strength compare to plain concrete.
B. Workability of concrete is improves when fly ash percentage increases.
C. Early age 7 days compressive strength and tensile strength is increased 40 to 45% by addition of 0.2 % Basalt fiber and 0.2% Polypropylene.
D. However the compressive strength, tensile strength and flexural strength increased at 28 days of age in compression of controlled concrete are 32 to 35% and 28 to 30% respectively by addition of 0.2 % Basalt fiber and 0.2% polypropylene.
E. The compressive strength, tensile strength and flexural strength of concrete increases with Basalt fiber & Polypropylene content. Therefore it is always preferable to use 0.2% volume fraction of Basalt fiber & 0.2% of Polypropylene and it gives us better result.

VI. ACKNOWLEDGMENT

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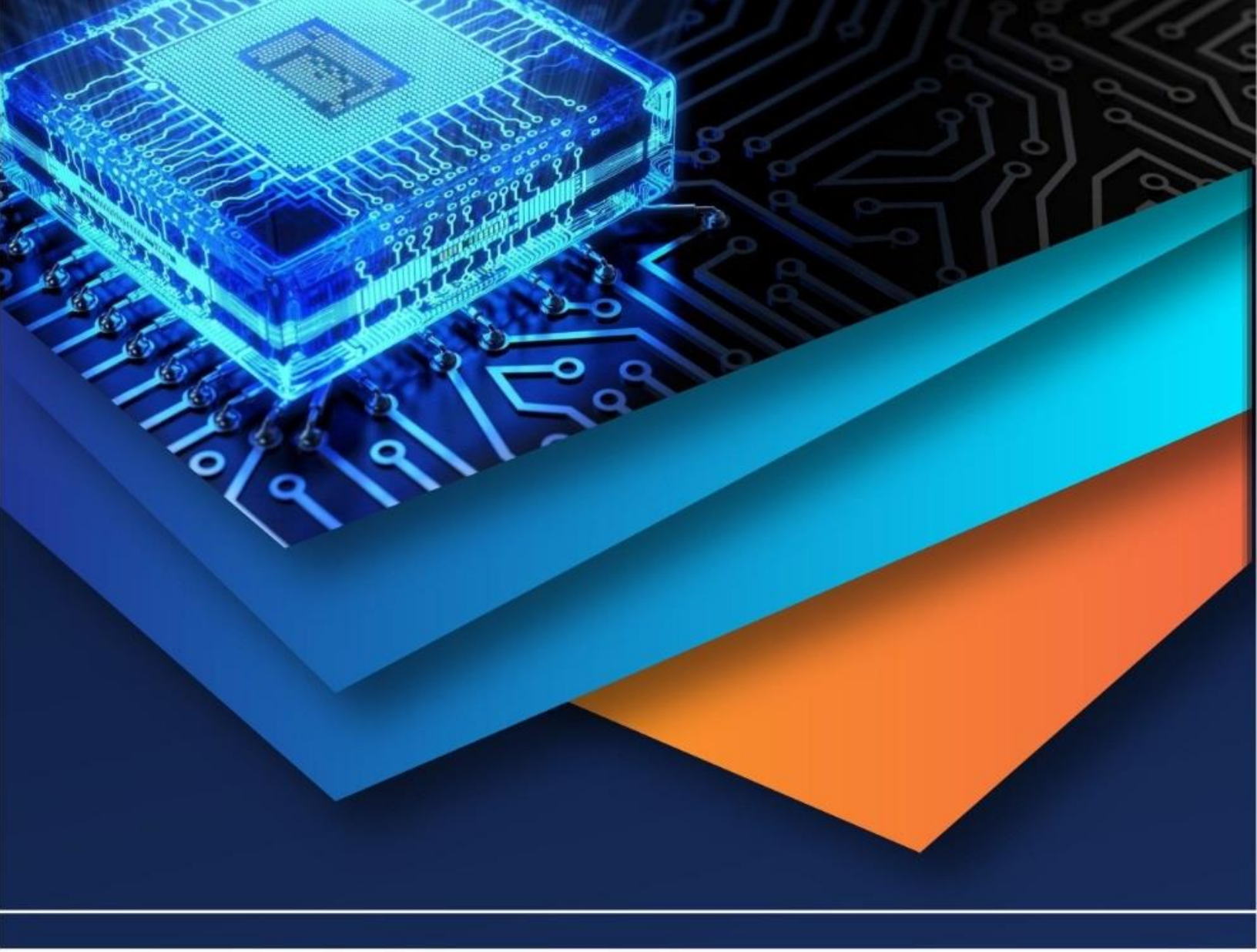

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