International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.6, No.7, July 2017 DOI:10.15693/ijaist/2017.v6i7.7-11

Strength Properties of Concrete Using Bottom ash with addition of Polypropylene Fiber

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Abstract: The present research work has been carried out to evaluate the feasibility of utilization of coal bottom ash as fine aggregate in concrete and Polypropylene fibre is additionally used to enhance the strength characteristics of concrete. The concrete mix is prepared for various combinations of 0%, 10%, 20% and 30% by bottom ash to the fine aggregate and polypropylene fibre with 0.5%, 1.0%, and 1.5% by total weight of the Cube. The grade of concrete to be designed is M25. Compressive strength, Split Tensile Strength and Flexural Strength are performed and these are compared with controlled concrete. With age, compressive strength of bottom ash concrete mixtures increased at faster rate than that of control concrete. The pozzolanic activity of coal bottom ash which started after 28 days of curing age contributed significantly in improving the compressive strength of bottom ash concrete mixtures. Bottom ash 20% and polypropylene 1% is found the highest of all combinations.

***Index terms*:** Bottom ash, Polypropylene fibre, Compressive strength, Split tensile Strength.

I. INTRODUCTION

At present-day, the structural industry is afflicted with the paucity of this crucial constituent material of concrete especially river sand. To overcome this problem, it is essential to us to find its substitute material. Coal bottom ash is a coarse rough and fire-resistant by-product from coal burning furnaces. It is composed of mainly silica, alumina and iron with small amounts of calcium, magnesium sulphate, etc. It has similar properties to that of natural river sand like appearance and partical size distribution. These properties of bottom ash inspired researchers to use as substitute for sand.

II. OBJECTIVE

- Effect of Bottom Ash on Compressive Strength, Tensile Strength and Flexural Strength of concrete.
- Effect of combined application of Bottom Ash and Polypropylene on Durability of concrete.
- Comparison of the test results of Conventional Concrete and Bottom Ash concrete.
- Comparison of the test results of Conventional Concrete with combined use of Bottom Ash and Polypropylene concrete preparation.

III. LITERATURE REVIEW

Yuksel and Genc (2007) found that 28-day compressive quality of base Ash solid blends diminished with increment in base fiery remains content. Compressive quality of base fiery remains solid blend containing half coal base Ash as sand substitution was lower by31.8% than that of control cement. With 10% sand supplanting with Coal Bottom Ash debris, 90-day compressive quality of cement diminished by 6.9%. This demonstrates a Coal Bottom Ash remains impede the pickup in compressive quality of Bottom Ash solid blends.

Aramraks (2006) exhibited that the compressive quality of base powder solid blends incorporating50 and 100% Coal Bottom Ash debris as sand substitution was around 20 to 40% lower than that of regular sand solid blends.

Kurama and Kaya (2008) watched that 28-day flexural quality of base fiery remains concrete fusing coal base Ash as bond substitution was practically equivalent to that of control solid example.

IV.MATERIALS AND ITS PROPERTIES

A. Cement

Ultratech Ordinary Portland Cement (OPC) of 53 grade of Cement conforming to IS: 12269 standards has been procured and various tests have been carried out according to IS: 8112-1989 from them it is found that

- Specific Gravity of Cement is 3.15
- Initial and Final setting times of Cement are 50min and 480 min respectively
- Fineness of cement is 6.0%

B. Fine Aggregate

The locally available natural river (Zone I) sand is taken for this research. Various tests have been carried out as per the procedure given in IS 383(1970) from them it is found that,

- Specific Gravity of fine aggregate is 2.52
- Fineness Modulus of Fine Aggregate is 3.19

C. Coarse Aggregate

Machine Crushed granite aggregate confirming to IS 383-1970 consisting 20 mm maximum size of aggregates has been obtained from the local quarry. It has been tested for properties such as Specific Gravity, Sieve Analysis, and the results are as follows.

- Obtained Specific Gravity of coarse aggregate is 2.7
- Fineness Modulus of Coarse Aggregate 3.36

D. Bottom Ash

Bottom ash is part of the non-combustible residue of combustion in a furnace or incinerator. In an industrial context, it usually refers to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation. The portion of ash that escapes through chimney called fly ash and the clincker that are collected from the bottom hooper and cooled called bottom ash. Coal Bottom Ash was procured from Astrra Chemicals, Mumbai. The properties of Bottom Ash are shown in Table 1.

Table 1 Properties of Bottom Ash

Physical Properties	
Specific Gravity	2.19
Water Absorption	28.9
Fineness Modulus	1.83

E. Polypropylene Fibre

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles, stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. The properties of Polypropylene Fibre are shown in Table 4.

Table 2 Polypropylene Fibre Properties

S.No	Properties	Value (As per MTC)
1	Specific gravity of fibre	0.9-0.91
2	Length	6mm to 12mm
3	Water absorption	0.3%after 24 hours

F. Water

Water used for casting and curing of concrete test specimens is free from impurities which when present can adversely influence the various properties of concrete.

V. CONCRETE MIX PROPORTION

Table 3 Quantities of Ingredients per cum of M20 Grade Concrete

Concrete	Cement (kg)	BA (kg)	PPF (kg)	Water (Lit)	FA (kg)	CA (kg)
Control	330	0	0	165	736	1183
BA 10%	330	63.96	0	165	662.4	1183
BA 10%	330	63.96	0	165	662.4	1183
BA 20%	330	127.92	0	165	588.8	1183
BA 30%	330	191.88	0	165	515.2	1183
BA 10% + PF 0.5%	330	63.96	11.24	165	662.4	1183
BA 10% + PF 1.0%	330	63.96	22.48	165	662.4	1183
BA 10% + PF 1.5%	330	63.96	33.72	165	662.4	1183
BA 20% + PF 0.5%	330	127.92	11.24	165	588.8	1183
BA 20% + PF 1.0%	330	127.92	22.48	165	588.8	1183
BA 20% + PF 1.5%	330	127.92	33.72	165	588.8	1183
BA 30% + PF 0.5%	330	191.88	11.24	165	515.2	1183
BA 30% + PF 1.0%	330	191.88	22.48	165	515.2	1183
BA 30% + PF 1.5%	330	191.88	33.72	165	515.2	1183

A. Test Specimen

Concrete test specimens consist of 150 mm × 150 mm × 150 mm cubes, cylinders of 150 mm diameter and 300 mm height and 100 mm × 100 mm × 500 mm prisms. Compressive strength for 3, 7 & 28 days are performed after curing for cube specimens. For Cylindrical and Prism specimens compressive strength and split tensile strength are conducted after 28days of curing. The load on the specimens is taken as per Indian Standard specifications.

VI. RESULTS AND DISCUSSIONS

A. *Cube Compressive Strength of Concrete*

The test results of cube compressive strength of M25 grade concrete with various proportions of Bottom Ash (BA) and Polypropylene Fibre (PF) is shown in Table 4.

Table 4 Proportion of Bottom Ash (BA) and Polypropylene Fibre (PF)

Concrete	BA	PF	Compressive Strength (MPa)		
			3 Days	7 Days	28 Days
Control Concrete	0	0	12.68	21.76	32.97
BA 10%	10	0	11.65	19.68	30.29
BA 20%	20	0	12.2	20.36	31.72
BA 30%	30	0	12.15	19.9	31.59
BA 10% + PF 0.5%	10	0.5	12.30	21.11	31.98
BA 10% + PF 1.0%	10	1.0	12.42	21.31	32.29
BA 10% + PF 1.5%	10	1.5	12.38	21.24	32.19
BA 20% + PF 0.5%	20	0.5	12.58	21.59	32.71
BA 20% + PF 1.0%	20	1.0	13.10	22.48	34.06
BA 20% + PF 1.5%	20	1.5	12.92	22.17	33.59
BA 30% + PF 0.5%	30	0.5	12.27	21.06	31.90
BA 30% + PF 1.0%	30	1.0	12.37	21.23	32.16
BA 30% + PF 1.5%	30	1.5	12.25	21.02	31.85

The cube compressive strength indicates the average of three test results. It can be observed that the compressive strength of concrete prepared by replacing Bottom Ash as replacement of Fine Aggregate and Polypropylene Fibre as admixture exhibits more strength than the control concrete at 20% Bottom Ash and 1.0% Polypropylene Fibre. It is also observed that concrete prepared at 20% Bottom Ash and 1.0% Polypropylene Fibre, the compressive strength get decreased. Finally, Bottom Ash can be effectively replaced with sand up to 20%, also Polypropylene Fibre can also be incorporated up to 2% by weight of cement.

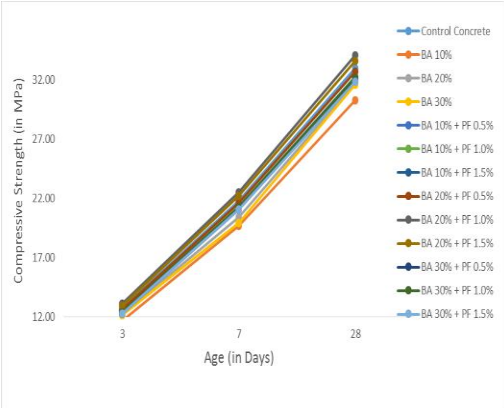

Fig. 1 Comparison Cube compressive strength at 3, 7 & 28 days with (10%, 20% & 30%) Bottom Ash and (0%, 0.5%, 1.0% & 1.5%) Polypropylene Fibre

Figure1. shows the comparison of 3, 7 & 28 Days Cube compressive Strength of Concrete with Fine aggregate replaced with Bottom Ash (10%, 20% & 30%) and (0.5%, 1.0% & 1.5%) of Polypropylene Fibre. It is observed that the combination of 20%BA and 1%PPF get achieved highest strength.

B. Split Tensile Strength

The test results of Split Tensile Strength of M25 grade concrete with various proportions of Bottom Ash and Polypropylene Fibres is shown in Table 5.

2.5Mpa of Split Tensile Strength is achieved for control concrete. The split tensile strength of concrete increased at 20% of Bottom Ash with 1% of Polypropylene Fibre up to 3.55.

Table 5 Split Tensile strength of Concrete at 28 days

Concrete	BA	PF	Compressive Strength (MPa)		
			3 Days	7 Days	28 Days
Control Concrete	0	0	12.68	21.76	32.97
BA 10%	10	0	11.65	19.68	30.29
BA 20%	20	0	12.2	20.36	31.72
BA 30%	30	0	12.15	19.9	31.59
BA 10% +PF 0.5%	10	0.5	12.30	21.11	31.98
BA 10% +PF	10	1.0	12.42	21.31	32.29

1.0%					
BA 10% +PF 1.5%	10	1.5	12.38	21.24	32.19
BA 20% +PF 0.5%	20	0.5	12.58	21.59	32.71
BA 20% +PF 1.0%	20	1.0	13.10	22.48	34.06
BA 20% +PF 1.5%	20	1.5	12.92	22.17	33.59
BA 30% +PF 0.5%	30	0.5	12.27	21.06	31.90
BA 30% +PF 1.0%	30	1.0	12.37	21.23	32.16
BA 30% +PF 1.5%	30	1.5	12.25	21.02	31.85

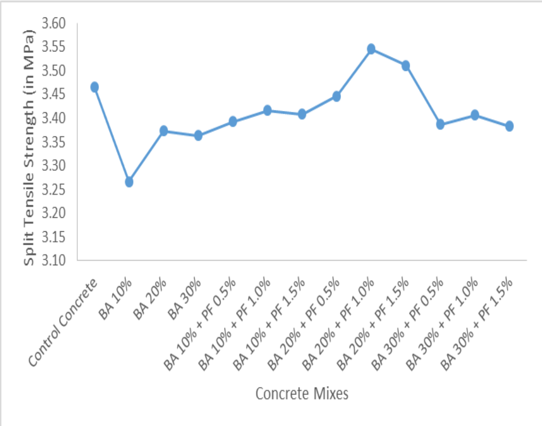

Fig. 2 Comparison of Split Tensile strength with various percentages of Bottom Ash & Polypropylene Fibre and Controlled concrete at 28 days age of concrete

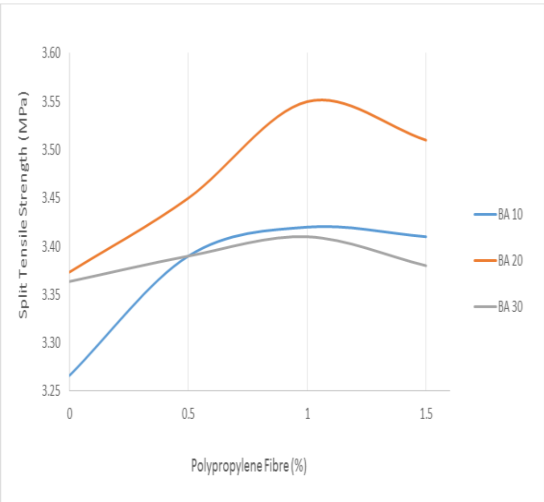

Fig. 3 Comparison of Split Tensile strength with various percentages of Bottom Ash and Polypropylene Fibres at 28 day's age of concrete

Figure 2 & 3 shows the comparison of Split Tensile strength with various percentages of Bottom Ash and Polypropylene Fibre's at 28 days age of concrete. From the graph, the maximum split tensile strength was found at 20% replacement of Bottom Ash with 1% Polypropylene Fibre. 30% Bottom Ash replacement with 1.5% Polypropylene Fibre showed less split tensile strength of concrete at 28 days age of concrete.

C. Flexural Strength of Concrete

Table 6 Flexural strength of Concrete at 28 days

Mix Deignation	**Bottom Ash (%)**	**Polypropylene Fibres (%)**	**Flexural strength (N/mm^2)**
Control Concrete	0	0	5.37
BA 10%	10	0	5.06
BA 20%	20	0	5.23
BA 30%	30	0	5.21
BA 10% + PF 0.5%	10	0.5	5.26
BA 10% + PF 1.0%	10	0.5	5.29
BA 10% + PF 1.5%	10	0.5	5.28
BA 20% + PF 0.5%	20	1.0	5.34
BA 20% + PF 1.0%	20	1.0	5.49
BA 20% + PF 1.5%	20	1.0	5.44
BA 30% + PF 0.5%	30	1.5	5.25
BA 30% + PF 1.0%	30	1.5	5.28
BA 30% + PF 1.5%	30	1.5	5.24

For control concrete, the obtained flexural strength is 5.37 MPa. The variation of flexural strength of concrete increased at 20% Bottom Ash (BA) and 1.0% percentage of Polypropylene Fibres replaced concrete. It is recommended

that Polypropylene Fibres can be used in concrete up to 1.0 % by weight of cement to get the maximum flexural strength of concrete.

The variation of flexural strength of M25 grade concrete with different percentages of Bottom Ash and controlled concrete is shown in Figure 2 and figure 3 shows the variation of flexural strength of M25 grade concrete with different percentages of Bottom Ash with Polypropylene Fibre at 28 days age of concrete.

Fig. 4 Comparison of Flexural strength with various percentages of Bottom Ash & Polypropylene Fibre and Controlled concrete at 28 day's age of concrete.

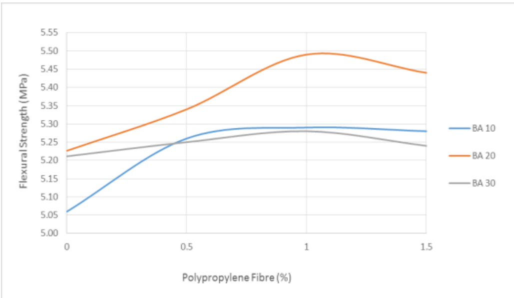

Fig. 5 Comparison of Flexural strength with various percentages of Bottom Ash and Polypropylene Fibres at 28 days age of concrete.

Figure 4 & 5 shows the comparison of Flexural strength with various percentages of Bottom Ash & Polypropylene Fibre and Controlled concrete at 28 days age of concrete. From the graph, the maximum flexural strength was found at 20% replacement of Bottom Ash and 1.0% Polypropylene Fibre compared with the controlled concrete.

VII. CONCLUSIONS

- Compressive strength of bottom ash concrete mixtures developed in a comparable manner to that of control concrete. At 28 days, compressive strength of bottom ash concrete mixtures incorporating up 20% coal bottom ash was found high in all coal bottom ash mixtures.
- The pozzolanic activity of coal bottom ash which started after 28 days of curing age contributed significantly in improving the compressive strength of bottom ash concrete mixtures.
- The combination of bottom ash about 20% and polypropylene fibre about 1% achieved highest strength of all combinations taken.
- Likewise, the highest Split tensile strength and Flexural strength are also achieved at 20% of bottom ash with 1% of polypropylene fibre respectively.

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Authors Profile

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