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Studies on Fibre Reinforced Concrete Using Bottom Ash as Fine Aggregate

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Abstract:
Many researchers have been carried out in the area of bottom ash utilization in the past. In this study fine aggregate in concrete mix has been replaced with lignite bottom ash and Polypropylene fibre is additionally used to enhance the strength characteristics of concrete. A mix design has been done for M25 Grade of concrete. The mix is prepared for different combinations of 0%, 10%, 20% and 30% of replacement of sand by bottom ash with 0.5% and 1% of polypropylene fibre by weight of Cement. The mechanical properties such as compressive strength and flexural strength are performed and these were compared with control mix. It was found that the optimal combination as 20% bottom ash and 0.5% polypropylene fibre.

Keywords: lignite bottom ash, compressive strength, flexural strength, polypropylene fibre.

I. INTRODUCTION

Concrete is one of the most important materials in building construction and other infrastructure works. It is a mixture of cement, water, sand and gravel or crushed aggregates, when placed in forms and allowed to cure becomes hard like stone. The hardening is caused by chemical reaction between water and cement and continues for a long time, and consequently the concrete grows stronger with age. Cement, water and sand combine to form mortar. The mortar fills the voids in coarse aggregates to form concrete. Since the volume of construction industry is growing day by day the requirements of concrete and its constituent materials such as cement, fine aggregate and coarse aggregate are also increasing day by day. Especially the availability of fine aggregates becomes difficult nowadays. Usually River sand is the main raw material used as fine aggregate in the production of concrete. Quantity of river sand availability is limited one. The demand for the protection of the natural environment and the ban on mining in some areas is further aggravating the problem of availability of river sand. The construction industry is plagued due to scarcity and high cost of river sand. To overcome this problem, it is essential to find its substitute material. The thermal power plants, which firing a very high volume of coal and lignite annually to generate electricity. That results in the production of bottom ash at a large scale. The ash content depends upon the non combustible matter present in coal and lignite.

II. MATERIALS AND ITS PROPERTIES

A. Cement

Ordinary Portland cement of 43 grade confirming to IS: 12269-1987 standards have been used in this study and various tests have been carried out. The physical properties of cement are given in Table I.

Table .I. Physical Properties Of Cement

Sl.No	Properties	Value
1	Specific gravity	3.15
2	Initial setting time	36 minutes
3	Final setting time	208 minutes

B. Fine Aggregate

Locally available River sand is taken for this study and various tests have been carried out as per procedure given in IS: 383-1970.The physical properties of fine aggregate are given in Table II.

Table.2. Physical properties of fine aggregate

Sl.No	Properties	Value
1	Specific gravity	2.59
2	Fineness Modulus	2.80
3	Bulk density	1530 kg/m^3
4	Water absorption	1%

C. Coarse Aggregate

Crushed angular aggregate with maximum grain size of 20mm was used and various tests have been carried out as per procedure given in IS 383-1970. The physical properties of fine aggregate are given in Table III.

Table.3. Physical properties of coarse aggregate

Sl.No	Properties	Value
1	Specific gravity	2.75
2	Fineness Modulus	8.75
3	Bulk density	1403 kg/m^3
4	Water absorption	0.8%

D. Bottom Ash

Bottom ash is a by-product of coal and lignite combustion. It is a coarse, angular material of porous surface texture having grain

size similar to or slightly bigger than that of sand. It is mainly composed of silica, alumina, and iron with small amount of calcium, magnesium, sulphate e.t.c. Bottom ash used in this study is from Neyveli Lignite Corporation [NLC].The physical properties of fine aggregate are given in Table IV.

Table.4. Physical properties of Bottom ash

Sl.No	Properties	Value
1	Specific gravity	2.10
2	Fineness Modulus	1.92
3	Bulk density	1408 kg/m^3
4	Water absorption	3.7%

E. Polypropylene Fibre

Polypropylene is a thermoplastic polymer used in a wide variety of applications including packaging and labelling, textiles, stationery, plastic parts and reusable containers, laboratory equipment and automotive components. It is one of the cheapest and abundantly available polymers. Polypropylene short fibres in small volume fractions between 0.5 to 1.0 percent have been commercially used in concrete to achieve considerable improvement in impact strength of the hardened concrete. The properties of Polypropylene Fibre are given in table V.

Table.5. Physical properties of polypropylene fibre

Sl.No	Properties	Value
1	Density	0.9
2	Fibre Length	12mm
3	Water Absorption	0.3%

D. Water

Fresh potable water, which is free from acid and organic substance, was used for mixing the concrete.

III. MIX PROPORTIONS

In this study 10 mix proportions were prepared. First were control mix (without bottom ash) and other mixes contained bottom ash and polypropylene fibre. Quantities of ingredients like cement, fine aggregate, coarse aggregate, bottom ash, polypropylene fibre and water per cum of M25 Grade concrete are shown in table.

TABLE.6. QUANTITIES OF INGREDIENTS PER CUM OF M25 GRADE CONCRETE

Concrete (kg)	Cement (kg)	FA (kg)	BA (kg)	PPF (kg)	CA (kg)	Water (lit)
Control	383	674	0	0	1218	172
BA 10%	383	606.60	67.40	0	1218	172
BA 20%	383	539.20	134.80	0	1218	172
BA 30%	383	471.80	202.20	0	1218	172
BA 10%+ 0.5%PPF	383	606.60	67.40	1.92	1218	172
BA 10%+ 1%PPF	383	606.60	67.40	3.83	1218	172
BA 20%+ 0.5%PPF	383	539.20	134.80	1.92	1218	172
BA 10%+ 1%PPF	383	539.20	134.80	3.83	1218	172
BA 30%+ 0.5%PPF	383	471.80	202.20	1.92	1218	172
BA 10%+ 1%PPF	383	471.80	202.20	3.83	1218	172

IV. EXPERIMENTAL PROGRAM

Ordinary Portland cement of 43 grade conforming to relevant Indian standard specifications has been used for making concrete mixtures. Concrete test specimen consists of 150mmx150 mmx150 mm cubes and100mmx100mx500mm prisms were prepared. After required period of curing, the specimens were taken out of the curing tank and various tests are performed such as compressive strength and flexural strength. In this study compressive strength is performed for 7days and 28 days and Flexural strength for 28 days are performed.

V. RESULTS AND DISCUSSION

A. Compressive strength of concrete

The Compressive strength test results for M25 grade of concrete are shown in table VII.

Table.7.Compressive Strength Test Results

Mix Designation	BA (%)	PPF (%)	Compressive Strength (Mpa)	
			7 Days	28 Days
BA 1	0	0	22.50	33.08
BA 2	10	0	20.29	32.61
BA 3	20	0	22.09	32.99
BA 4	30	0	21.82	32.18
BA 5	10	0.5	22.42	34.20
BA 6	10	1	22.19	34.12
BA 7	20	0.5	25.46	39.35
BA 8	20	1	24.53	37.62
BA 9	30	0.5	24.14	37.42
BA 10	30	1	23.89	36.97

The test result indicates that the compressive strength of concrete containing bottom ash and polypropylene fibre exhibits more strength than that of control concrete .It is observed that the mix designation BA 7 (20% bottom ash and 0.5% polypropylene fibre) achieve more compressive strength when compared to other mixes.

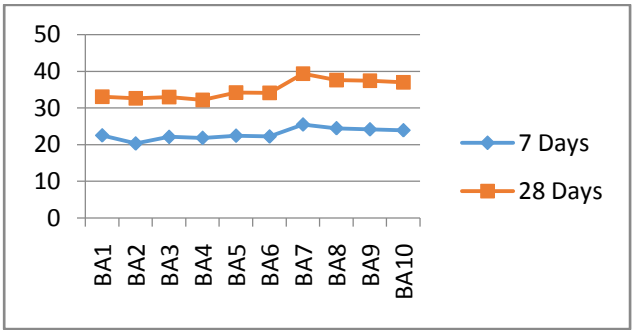

Figure.1. Compressive Strength Test Results

Figure.2.Testing of Cubes in Compression Testing Machine

B. Flexural strength of concrete

The flexural strength results obtained for prism at 28 days are shown in table VIII.

Table.8. Flexural strength test results

Mix Designation	BA (%)	PPF (%)	Flexural strength Mpa
BA 1	0	0	4.98
BA 2	10	0	4.76
BA 3	20	0	4.95
BA 4	30	0	4.84
BA 5	10	0.5	5.07
BA 6	10	1	5.01
BA 7	20	0.5	5.81
BA 8	20	1	5.41
BA 9	30	0.5	5.25
BA 10	30	1	5.16

The test result indicates that the Flexural strength of concrete containing bottom ash and polypropylene fibre exhibits more strength than that of control concrete .It is observed that the mix designation BA 7 (20% bottom ash and 0.5% polypropylene fibre) achieve higher Flexural strength when compared to other mixes. It is also observed that the strength was decreased at 1 % mix of polypropylene fibre when compared to 0.5% of PPF.

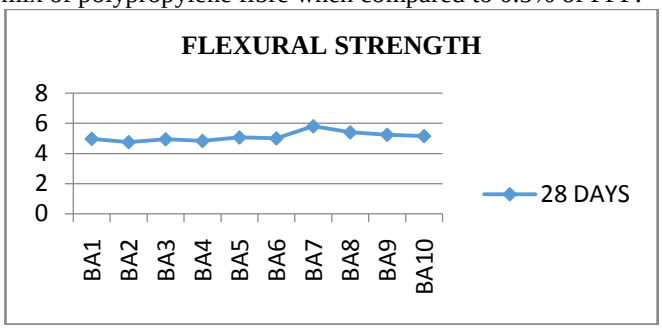

Figure.3. Flexural Strength Test Results

Figure.4.Flexure Strength Testing Of Prism

VI. CONCLUSION

From the test results it was observed that the compressive and flexural strength was higher with the incorporation of polypropylene fibres. It is also observed that the strength was decreased with increase of fibre percentage strength. Hence the optimal combination was found as 20 % bottom ash and 0.5% PPF. This optimum percentage can be used for casting of beams in order to determine the flexural behaviour of FRC beam with bottom ash as partial replacement for fine aggregate.

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