Experimental Study on Properties of Concrete Using Bottom Ash with Addition of Polypropylene Fibre

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Abstract- Bottom ash is a hazardous by-product from coal based thermal power plants. In this study fine aggregate in concrete mix has been replaced with bottom ash and Polypropylene fibre is additionally used to enhance the strength characteristics of concrete. The concrete mix design is done for M25 grade concrete. The mix is prepared for different combinations of 0%, 10%, 20% and 30% of replacement of sand by bottom ash with 0.5% of polypropylene fibre by total weight of the Cube. The mechanical properties were compared with control mix and it was found that the optimal combination as 30% bottom ash and 1.0% polypropylene fibre. Flexural strength was compared by testing beams of size 1.5 x 0.25 x 0.15m under two point loading. Results showed that there was no degradation of strength for beams with bottom ash as replacement for fine aggregates.

Index Terms- Bottom ash, flexure, Polypropylene fibre, Stiffness, Ultimate load.

I. INTRODUCTION

Plain cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Recent trends in concrete technology are to improve the work ability, strength and resistance to smaller cracks in the concrete. The fibres of short length and small diameters can be used in concrete to convert its brittle nature to a ductile one. The coarser material which collects in furnace bottom in thermal power plants is known as bottom ash. This paper presents the experimental investigations carried out to study the effect of use of bottom ash as a replacement of fine aggregate. Earlier research work in the usage of bottom ash as replacement for fine aggregates shows degradation in characteristic compressive strength of concrete apart from increasing the work ability of concrete.

The usage of fibres to improve the strength of reinforced concrete is also justified in the past studies. On different volume fractions of polypropylene fibres showed that work ability of concrete decreased with the increase in bottom ash content and concluded that compressive strength, splitting tensile strength and flexural strength of fine aggregates replaced bottom ash concrete specimens were lower than control concrete specimens at all the ages. It was concluded that bottom ash concrete containing 50% bottom ash is acceptable for most structural applications. The results showed increase in the workability of concrete, and decreased compressive strength, at fixed cement content and w/c ratio.

II. EXPERIMENTAL INVESTIGATION

A. Cement(C)

Portland Pozzolana Cement confirming to IS: 12269-1987 and the specific gravity of cement were found to be 3.15.The physical properties of cement given in Table 2.1.

B. Fine Aggregate (FA)

Locally available River sand having bulk density 1860 kg/m^3 was used and the specific gravity is 2.64. The Fineness modulus of river sand is 2.79.

C. Coarse Aggregate (CA)

Crushed angular aggregate with maximum grain size of 12.5mm and downgraded was used and having bulk density 1691kg/m^3. The specific gravity and fineness modulus was found to be 2.89 and 2.75 respectively.

D. Water (W)

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

E. Bottom Ash (BA)

Bottom ash used in this study is from Mettur thermal power plant. The plant produce about 100 ton of ash. Most of the ash has to be disposed of either dry, or wet to an open area available near the plant or by grounding both the fly ash and bottom ash and mixing it with water and pumping into artificial lagoon or dumping yards. This causes the pollution in water bodies and loss of productive land. The bottom ash is replaced for fine aggregate starting from 10%, 20%, 30% in concrete. Specific gravity of bottom ash is 1.76.

III. MIX DESIGN

The concrete mix is designed as per IS 10262 – 1982 and IS 456-2000 for the conventional concrete and Polyethylene added at the range of 0.5%, 1%, and 1.5% by the weight of cement for M25 grade of concrete with 30% of cement replaced by bottom ash. The mix proportions of M25 concrete are given in the table 3.1.

A. Test Specimens and Test Procedure

For this experimental work cubes, cylinders and beams were casted in the laboratory. Cubes and cylinders were casted using concrete mixes with fine aggregate replaced by bottom ash of 10%,20%,30% along with 0.5%, 1.0%, 1.5% of poly propylene fibre by weight of cement.

Compression test on cubes as per IS: 516-1959, the cube specimen of the size150 x 150 x 150 mm were tested after curing

for period of 7 and 28 days for different combinations and results were compared with control specimens.

Split tensile strength on cylinders as per IS: 516-1959, the test was carried out for 7 and 28 days on cylindrical specimens 150mm diameter (D) and 300mm (L) placed horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter. The optimum replacement percentage was chosen as 30% and the replacement of fine aggregate with bottom ash along with1.0% of Polypropylene fibre by weight of cement.

A1. Beam Reinforcement Details

Two beam specimens of size– 1.5m x 0.15m x 0.25m were casted. One was used as control beam and another one was casted with mix. Two numbers of 12mm diameter bars at bottom and two numbers of 12mm diameter bars at top were used as main reinforcement. Shear reinforcement consists of 8mm diameter 2-legged stirrups @ 180mm c/c throughout the length of the beam.

A2. Testing of beams

Flexural test on beams were carried out in universal testing machine of capacity 1000kN. Deflectometers were fixed to measure the deflection at salient points.

IV. RESULTS AND DISCUSSIONS

4.1 Cube compressive strength

The Compressive strength test results of specimens are shown in table 4.1. 30% replace of bottom ash with addition of 1.0% of ppf has attain the higher compressive strength. The initial strength gain is at slower rate, since pozzolanic action of bottom ash at early age is slow which do not contribute for the strength of concrete. The cube compressive strength for different mixes at period of 7 and 28days are given as below.

4.2 Cylinder split tensile strength

The split tensile strength of specimens also showed that the optimum mix with 20% of bottom ash with 1.0% ppf. The split tensile strength for different mixes at period of 7 and 28 days are shown in table 4.2 below.

4.3. Flexural strength

Loading of control beam and higher compression attained mix proportion were carried out as shown in Table 4.3

4.4 Deflection of Beams

In order to study the performance of the beam with replacement of OPC, the experiment is to be carried out as below. The aim of this work is to study the flexural behaviour of the beams. All the tests have been carried out in loading frame with a capacity of 500 KN.

The beam is simply supported and the two point loading is applied. Demountable mechanical Strain gauges are used to measure the strains in the beam specimens.

Then LVDT is used to measure deflection of the beams. Also loads are calculated using Load cell. The load is to be applied in small increments of 5 kN. At each load increment the deflection measured is recorded. All the specimens are loaded up to the failure. Figure 5 shows the maximum deflection was attained in 2.45 mm. The intial crack is attained in 0.28 mm deflection at two point loading and 0.21 mm deflection at three point loading. Deflection of the beam is reduced.

V. CONCLUDING REMARKS

The study was conducted to evaluate the strength characteristics of concrete with bottom ash and polypropylene fiber. The concrete mix design was done for M_{25} grade concrete. The following points were concluded from this study.

- The 7 days cube compressive strength results shows reduced strength of concrete due to slow pozzolonic action.
- The strength of concrete cubes at 28 days with 30% replacement of bottom ash along with 1% of polypropylene fibre shows an increase of 110% in compressive strength.
- Addition of polypropylene fibre increases the tensile strength of the specimens.
- The addition of fibres reduces the workability of concrete which was overcome by the addition of bottom ash as replacement of fine aggregate.
- 30% Bottom ash with 1% ppf showed high flexural strength and high modulus of elasticity compared to control specimen.
- Experimental result shows that 30% Bottom ash with 1% ppf retained the stiffness similar to that of control beam.
- Fibres in 30% Bottom ash with 1% ppf checked the development of cracks and thereby had many flexural cracks of reduced width.
- Result showed that 30% Bottom ash with 1% ppf had similar moment curvature relationship as control beam with enhanced moment carrying capacity.
- In this study, bottom ash is a hazardous material used as a replacement for fine aggregate to bring down the pollution. The reduction in strength and stiffness of concrete due to bottom ash is overcome by adding polypropylene fibre to the mix.

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Table 2.1 PROPERTIES OF CEMENT

Sl. No.	Properties of Cement	Values	As per IS:12269-1976
1.	Fineness	7.5%	3.15
2.	Initial setting time	32 min	>30
3.	Final setting time	190 min	<600

Table 3.1 MIX DESIGN

Cement	**F A**	**C A**	**W/C**
1.69	1.69	2.76	0.45

Table 4.1 Compressive Strength of Cubes

SL. No.	**10% B.A**		**20% B.A**		**30% B.A**	
Age of specimen	7 days	28 days	7 days	28 days	7 days	28 Days
0.5% ppf	24.32	33.12	27.51	34.7	28.23	36.26
1.0% ppf	26.2	35.85	28.41	37.62	29.02	38.25
1.5% ppf	21.25	28.32	23.14	25.36	24.22	27.5
Conventional	26	35				

Fig -1 Graph showing the compressive strength

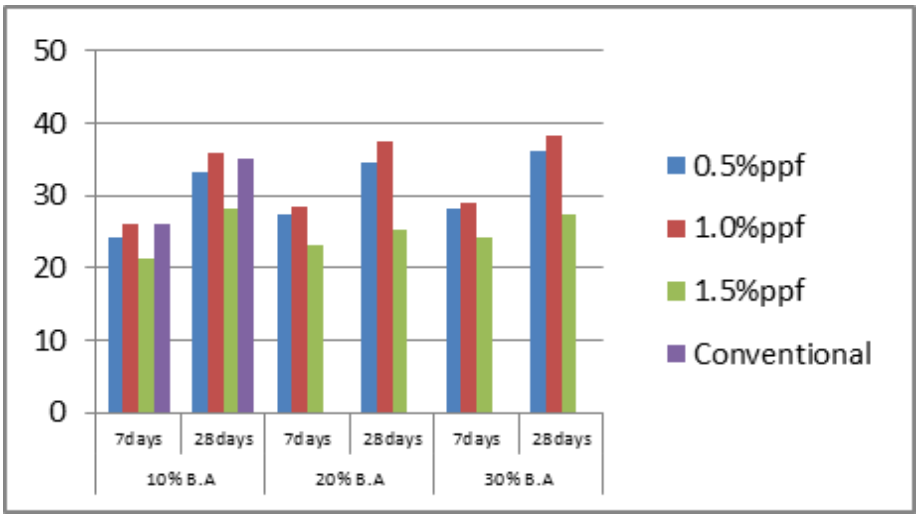

Table 4.2 Split Tensile Strength of Cylinders

SL. No.	**10% B.A**		**20% B.A**		**30% B.A**	
Age of specimen	7 days	28 days	7 days	28 days	7 days	28 Days
0.5% ppf	2.43	2.49	2.36	2.42	2.21	2.36
1.0% ppf	2.62	2.70	2.51	2.58	2.4	
1.5% ppf	2.53	2.59	2.47	2.50	2.33	2.52
Conventional	2.5	2.61				

Fig -2 Graph showing the split tensile strength

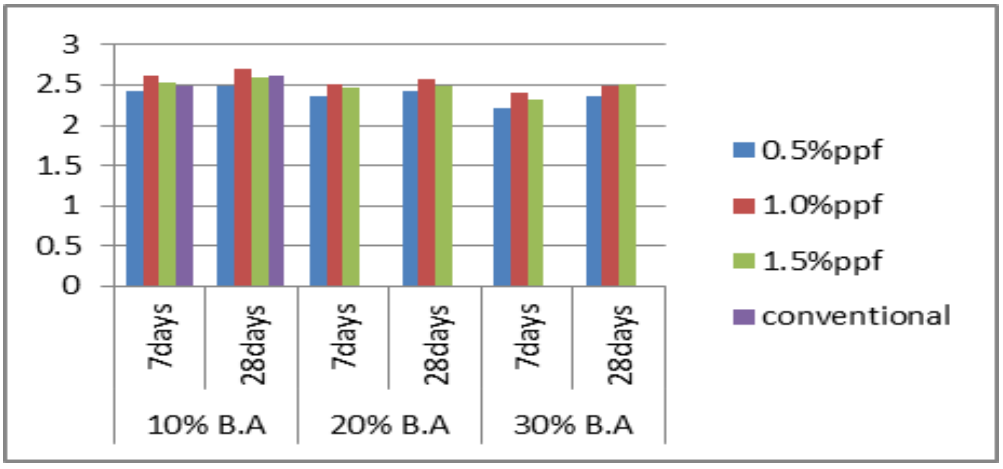

Table 4.3 – Flexural strength test results

Polypropylene Fiber	10% Bottom ash	20% Bottom ash	30% Bottom ash
0.5%	4.80	4.95	5.10
1%	4.86	4.87	5.45
1.5%	4.91	4.75	5.15
Conventional	4.90		

Fig. 3 Casting of Beam

Fig. 4 Experimental set up for deflection of beams

Table 4.4 RESULT FOR DEFLECTION OF BEAMS 30 % Bottom ash with 1% ppf

S. No	**Load in KN**	**Deflection at L/2 in mm**	**Deflection at L/3 in mm**	**Remarks**
1	0	0	0	
2	5	0.52	0.5	
3	10	0.13	0.10	
4	17	0.28	0.21	Initial Crack
5	20	0.35	0.25	
6	25	0.58	0.42	
7	30	0.7	0.5	
8	35	0.95	0.8	
9	40	1.25	1	
10	45	1.7	1.2	
11	47	2.45	2	Ultimate

Fig 5 Deflection at 30 % Bottom ash with 1% ppf