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RESEARCH ARTICLE

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BEHAVIOR OF CONCRETE PRODUCED BY REPLACING CEMENT BY MINERAL ADMIXTURE AND SAND BY BOTTOM ASH

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ABSTRACT

Out of many industrial waste materials available, fly ash, silica fume, bottom ash are few of them. The use of waste materials in civil engineering applications can solve the problem of the disposal and also it offers a cost-effective substitute for conventional materials. Here 20% of cement is replaced by fly ash and silica fume and natural sand is replaced by bottom ash at different percentages such as 0%, 10%, 20%, 30%, 40%, 50%, 60% and 70%.The experiments are conducted on M30 grade concrete with 28 days of curing. The strength properties studied in the work are compression, tensile, flexural, shear and impact strength. Also the workability characteristics are studied through slump cone, compaction factor, flow table, & Vee-Bee consistometer tests. Also an attempt is made to study the water absorption and sorptivity characteristics.

KEY WORDS: Bottom ash, Fly ash, Silica fume, Industrial waste, Compression test, Split tensile test, Flexure test.

I. INTRODUCTION

Concrete is a widely used construction material, which can exhibit better strength and durability characteristics. At present in India, it is estimated that the annual consumption of cement concrete is 400 metric tons. This will definitely cause an equal demand on the materials like sand, aggregates and other materials required to produce huge quantity of cement concrete. This will gradually decrease all the natural resources connected in producing cement concrete every year. In this direction, FA, GGBFS, SF, rice husk ash, and metakaoline are some of the pozzolanic materials have shown promising results to replace cement partially or fully.

II. TESTING PROGRAMME

In the present study various tests on material such as cement, fine aggregate, coarse aggregate and the waste material from industries were performed as per the Indian Standards.

Materials used

1. Cement: Ordinary Portland cement of 43 grade was purchased from the local supplier and used throughout this project. The properties of cement used in the investigation are presented in table 1.

2. Fly ash: In this experimental work, class F- fly ash from Raichur thermal station confirming to IS 3812 (Part 1) – 2003 was used.

3. Silica fume: In this experimental work, silica fume is collected from the Sai Durga Enterprises, Bangalore, India. Confirming to IS 3812 (part 1):2003 was used.

Table1. Properties of Cement

Sl. No	Property	Value
1	Specific Gravity	3.15
2	Fineness	
3	Standard Consistency	32%
4	Initial Setting Time	45 min
5	Final Setting Time	345 min
6	Fineness Modulus	4%

4. Fine Aggregate: Natural sand confirming IS 383-1970 of Zone II is used. Specific gravity, fineness modulus of fine aggregate is calculated according to the procedures confirming to IS 2386**.**

5. Bottom ash: In this experimental work, bottom ash as collected from the dumping yard of electric thermal power plant, Raichur, India. Confirming to IS 3812 (part 1):2003 was used.

6. Coarse Aggregate: Locally available crushed aggregate confirming to IS 383-1970 is used.

7. Water: Water used in this project is potable water.

8. Super Plasticizers: The optimum dosage of "Conplast SP-430" to meet specific requirement should always be determined by trail mixes using the materials and conditions that will be experienced in use. In the experimentation suitable dosage of 1 % is added to achieve high workability and slump value for flowability.

III PREPARATION OF SPECIMENS

Based on the above results the water quantity, cement, fine aggregate and coarse aggregate required for design mix of M30 were calculated as per IS 10262-2009. The final mix ratio was 1:1.485:2.542 with water cement ratio of 0.45.Weigh batch method was used for material mix proportions. Concrete was placed in moulds in 3 layers by tamping each layer. The specimens were casted by keeping the moulds on the vibrator for better compaction. The casted specimens were removed from moulds after 24 hours and the specimens were kept for water curing for 28 days.

The details of mix designation and specimens used in experimental program are given in table 2.

Fig 1 Moulds

Table 2 Mix Details (For both fly ash and silica fume 20% is in fixed proportion)

Sl. No.	% replacement of Bottom ash	Cement	Sand	Aggregates	Bottom ash
1	0	18.272	33.82	58	0
2	10	18.272	30.438	58	3.382
3	20	18.272	27.056	58	6.764
4	30	18.272	23.674	58	10.146
5	40	18.272	20.292	58	13.528
6	50	18.272	16.91	58	16.91
7	60	18.272	13.528	58	20.292
8	70	18.272	10.146	58	23.674

Fig 2 Demoulded Specimens

IV TESTING OF SPECIMENS

For each batch of concrete, 3 cubes of 150mm x 150mm x 150mm size were tested to determine compressive strength of concrete, 3 cylinders of 150mm diameter and 300 mm length were tested to determine split tensile strength of concrete, 3 prisms of 100mm x 100mmx 500mm were tested to determine flexural strength of concrete, 3 L-Shape specimens of 150mm x 150mmx 90mm were tested to determine shear strength of concrete and 3 cylinders of 150mm diameter and 60mm height were tested to determine impact strength of concrete.

V RESULTS AND DISCUSSIONS

Table 3 Compressive strength test results at 28 days curing

% replacement of cement and sand	Compressive strength of concrete produced with FA and BA (MPa)	Compressive strength of concrete produced with SF and BA (MPa)	% increase of compressive strength (SF+BA) as compared to (FA+BA)
(0% + 0%)	30.52	30.52	-
(20% + 0%)	31.26	31.41	0.48
(20% + 10%)	31.78	32.14	1.13
(20% + 20%)	32.15	33.18	3.2
(20% + 30%)	33.04	34.37	4.03
(20% + 40%)	29.92	35.26	17.85
(20% + 50%)	22.37	29.63	32.45
(20% + 60%)	16.3	24.59	50.86
(20% + 70%)	14.67	22.67	54.53

From the above table it is observed that the compressive strength was found to be maximum at 30% (33.04 MPa) for Fly ash and 40% (35.26 MPa) for Silica fume. The replacement of cement by industrial wastes fly ash and silica fume, which gives the greater strength than the conventional concrete. The compressive strength goes on increases upto 30% replacement of Fly ash and 40% replacement of Silica fume. And also it is observed that silica fume concrete gives better results as compared to fly ash concrete.

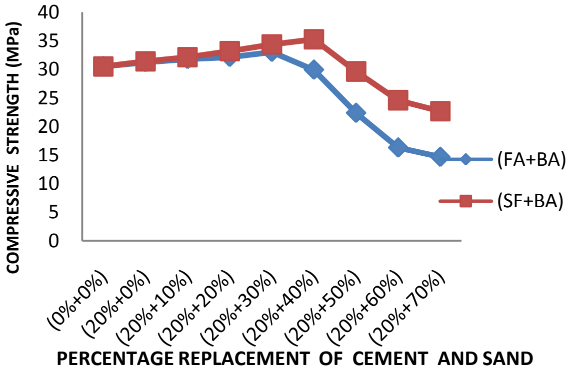

Fig 3 Variation of compressive strength

Table 4 Split Tensile Strength Test Results at 28 days curing

%replacement of cement and natural sand	Split tensile strength of concrete produced with FA and BA (MPa)	Split tensile strength of concrete produced with SF and BA (MPa)	% increase of compressive strength of (SF+BA) as compared to (FA+BA)
(0% + 0%)	2.12	2.12	-
(20% + 0%)	2.07	2.17	4.8
(20% + 10%)	2.21	2.26	2.26
(20% + 20%)	2.36	2.45	3.81
(20% + 30%)	2.5	2.69	7.6
(20% + 40%)	2.41	2.92	21.16
(20% + 50%)	1.88	2.41	28.19
(20% + 60%)	1.79	2.22	24.02
(20% + 70%)	0.7	2.07	195.71

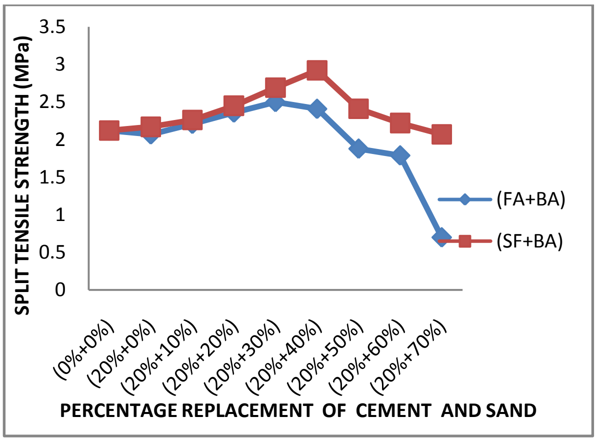

Fig 4 Variation of split tensile strength

From the above table it is found that the Split tensile strength was found to be maximum at 30% (2.50 MPa) for fly ash and 40% (2.92) for Silica fume. The replacement of cement by industrial wastes fly ash and silica fume, which gives the greater strength than the conventional concrete. The split tensile strength goes on increases upto 30% replacement of Fly ash and 40% replacement of Silica fume. And also it is observed that silica fume concrete gives better results as compared to fly ash concrete.

Table 5 Flexural Strength Test Results at 28 days curing

%replacement cement and sand	Flexural strength of concrete produced with FA and BA (MPa)	Flexural strength of concrete produced with SF and BA (MPa)	% increase of flexural strength of (FA+BA) as compared to (SF+BA)
(0%+0%)	5.4	5.4	-
(20%+0%)	5.27	5.47	3.79
(20%+10%)	5.6	5.67	1.25
(20%+20%)	5.67	5.87	3.53
(20%+30%)	5.8	6.07	4.76
(20%+40%)	5.4	6.2	14.81
(20%+50%)	5	5.73	14.6
(20%+60%)	3.07	5.2	69.38
(20%+70%)	2.4	5.07	111.25

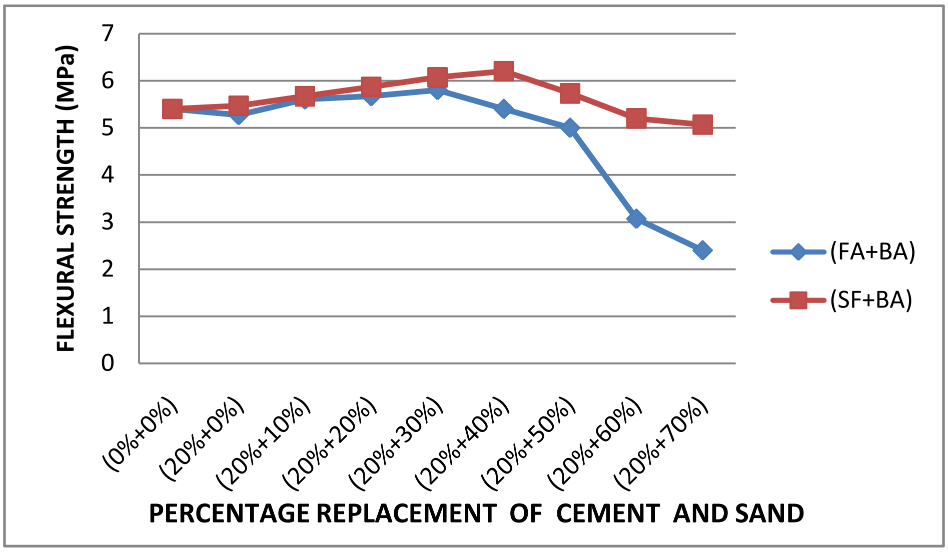

Fig 5 Variation of flexural strength

From the above table it is observed that the flexural strength was found to be maximum at 30% (5.80 MPa) for Fly ash and 40% (6.20 MPa) for Silica fume. The replacement of cement by industrial wastes fly ash and silica fume, which gives the greater strength than the conventional concrete. The flexural strength goes on increases upto 30% replacement of Fly ash and 40% replacement of Silica fume. And also it is observed that silica fume concrete gives better results as compared to fly ash concrete.

Table 7 Shear Strength Test Results at 28 days curing

Percentage replacement of cement and natural sand	Shear strength of concrete when cement and sand is replaced by FA and BA (MPa)	shear strength of concrete when cement and sand is replaced by SF and BA (MPa)	Percentage increase of shear strength of (SF+BA) as compared to (FA+BA)
(0% + 0%)	3.15	3.15	-
(20% + 0%)	3.33	3.52	5.71
(20% + 10%)	3.52	3.89	10.51
(20% + 20%)	3.89	4.44	14.14
(20% + 30%)	4.23	4.81	13.71
(20% + 40%)	3.70	5.56	50.27
(20% + 50%)	3.33	4.62	38.74
(20% + 60%)	3.15	4.26	35.24
(20% + 70%)	2.96	3.52	18.92

From the above table it is observed that the shear strength was found to be maximum at 30% (4.23 MPa) for Fly ash and 40% (5.56 MPa) for Silica fume. The replacement of cement by industrial wastes fly ash and silica fume, which gives the greater strength than the conventional concrete. The shear strength goes on increases upto 30% replacement of Fly ash and 40% replacement of Silica fume. And also it is observed that silica fume concrete gives better results as compared to fly ash concrete.

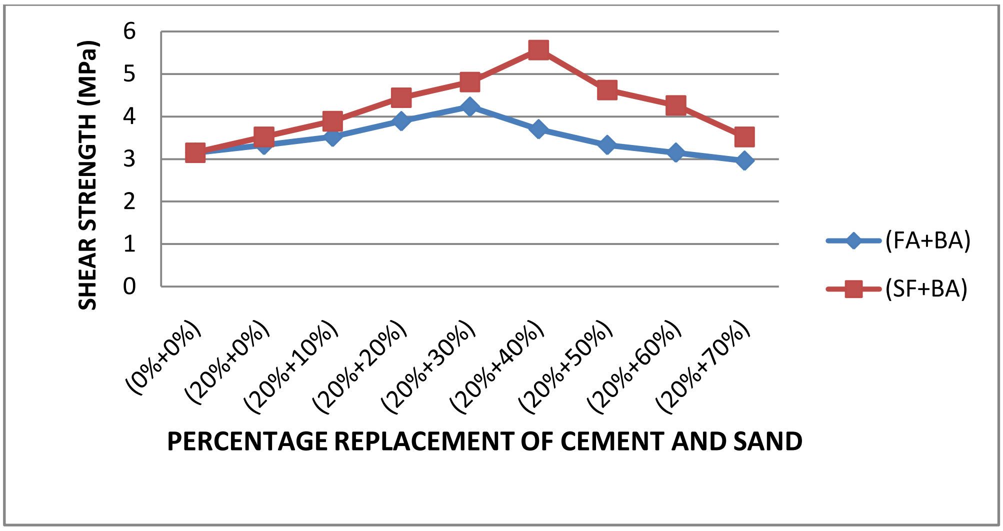

Fig 6. Variation of shear strength

Table 8 Impact strength test results at 28 days curing

Sl. No.	% replacement of bottom ash	Impact strength (N-m)		Impact strength (N-m)	
		Initial crack for 20% fly ash	final crack for 20% fly ash	Initial crack for 20% silica fume	Final crack for 20% silica fume
1	(0+0)	380.38	449.53	449.54	518.70
2	(20+0)	421.87	497.95	504.87	594.77
3	(20+10)	442.62	511.78	539.45	615.52
4	(20+20)	532.52	608.60	677.76	746.92
5	(20+30)	843.74	919.82	857.57	933.65
6	(20+40)	643.85	712.34	940.57	1016.65
7	(20+50)	421.87	504.86	657.01	726.13
8	(20+60)	318.13	394.21	491.03	560.19
9	(20+70)	255.89	325.05	394.21	456.45

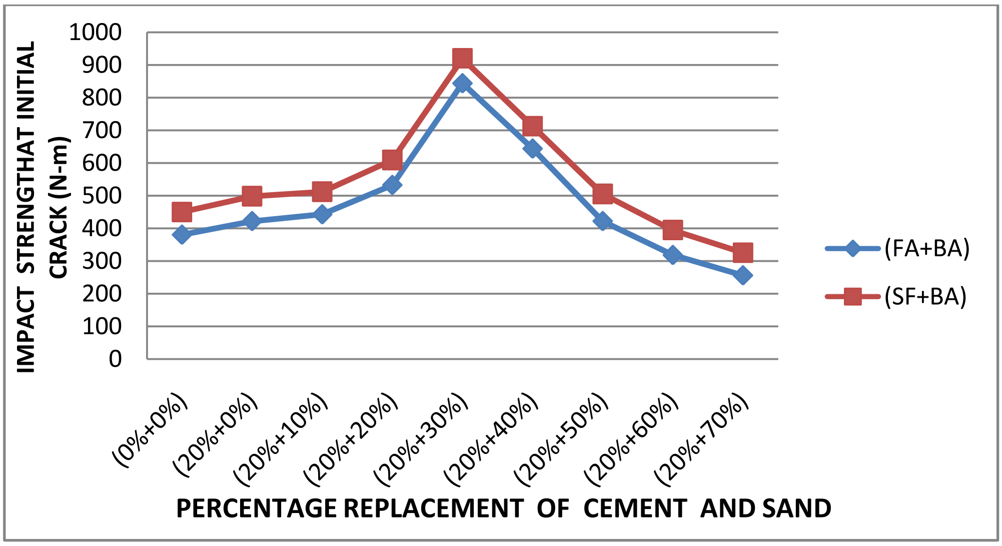

Fig 7. Variation of impact strength for initial crack

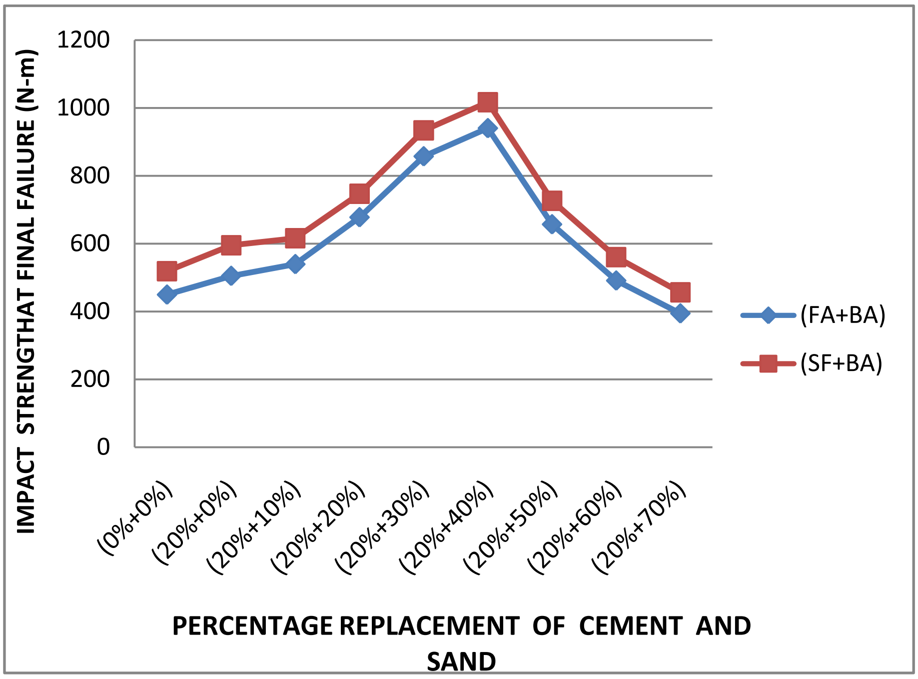

Fig 5.8 Variation of impact strength for final failure

VI CONCLUSION

The following conclusions may be drawn based on the experimentation conducted on the behavior of concrete produced by replacing cement by mineral admixture and natural sand by bottom ash. The compressive strength, tensile strength, flexural strength, shear strength and impact strength of concrete reaches higher value when 30% natural sand is replaced by bottom ash with cement replaced by fly ash. Also it can be concluded that the strength of concrete reaches the higher value when 40% natural sand is replaced by bottom ash with cement replaced by silica fume.

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