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SIEVED COAL BOTTOM ASH CONCRETE

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Abstract: In this paper an experimental analysis of sieved coal bottom ash concrete described over replacement of natural sand. Compressive strength, flexural strength, split tensile strength, and water permeability were carried out to investigate the properties of SCBA Concrete. The natural fine sand was replaced with SCBA by incremental percentage by weight, at fixed water- cement ratio.

Keywords —sieved coal bottom ash (SCBA), workability, permeability, split tensile strength.

I. INTRODUCTION

World at present produces around approximately 1528 Million Tons of coal bottom ash when India at present produces around 120 Million Tons of Ash per annum[9]. There is a critical need to find new methods for using bottom ash for its highest and best use. In this paper an experimental analysis of sieved coal bottom ash concrete described over replacement of natural sand by incremental percentage by weight, at fixed water- cement ratio. Burning of low quality coal generates a significant amount of coal combustion products (CCP) in thermal power plants; therefore coal ash recycling is an important environmental issue. Nevertheless, world-wide lots of research have shown number of ways of optimizing the usage of coal residues based into value added product in construction industry.

Sand is most important ingredient of concrete is diminishing in its quantity around the world, which creates a need for finding an alternative. Bottom ash has particle size similar to sand. Hence this can be used as a replacement for fine aggregate in concrete [14].

II. WORK CONSIDERATIONS

This research, focused on the effects of different bottom ash percentage on the workability, compressive strength and porosity of concrete containing bottom ash as fine aggregate replacement. And for this some primary work considerations were decided as:

- The percentage of bottom ash in this study is 0% as the control, meanwhile 20%, 30%, 35%, 40%, 60%, 80% and 100% were used to replace the fine aggregate.
- Water-cement ratio of 0.43 was used in concrete mixture.
- The concrete slump was about 50-80mm.
- The size of specimens was *150 x* 150 x 150mm each for compressive test.
- 20mm size of aggregates were used
- Cubes were tested at the age of 7, 14, 28 days.
- Concrete workability was tested on fresh concrete using slump test method.

III. PROPERTIES OF MATERIALS

A) Properties of Cement

Among the chemical constituents of cement, the most important ones are C3A (tricalcium aluminates), C3S (tricalcium silicate) and C2S (dicalcium silicate). The C3A portion of cement hydrates and reduces the workability more rapidly in fresh concrete which release large amount of heat of hydration. After reviewing all requirements 53 grade ultra tech Ordinary Portland Cement is used throughout experiment. For cement we are conducting test like sieve analysis, soundness test and initial final setting time as per is 12269 - (1987).

We obtained following results:

TABLE NO. 1

No.	Test	Reading
1.	Fineness Test	8.14
2.	Initial and Final setting time	34min &291min
3.	Soundness	1.8 mm
4.	Specific Gravity	3.17

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B) Properties of Fine aggregate

River sand is used as a fine aggregate. Among various characteristics, the most important one for fine aggregate is its grading. Coarser sand may be preferred because finer sand required more water demand of concrete and very fine sand may not be essential in fine aggregate as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, silica fume etc. The sand particles should also pack to give minimum void ratio, as the test result show that higher void content leads to requirement of more mixing water. Properties such as void ratio, gradation, specific gravity and bulk density have to be assessed to design a dense fine aggregate mix with optimum cement content and reduced mixing water. The sand should be tested properly as it is the ingredient of the concrete that is to be partially replaced in this project. For Fine aggregate we are conducting test like Fineness Modulus, Specific Gravity test and Water Absorption as per IS 383-(1970).

We obtained following results:

TABLE NO. 2

No.	Test	Reading
1.	Fineness Modulus	3.13
2.	Specific Gravity	2.64
3.	Water Absorption	1.05%

C) Properties of Coarse aggregate

The properties such as moisture content, water absorption, etc., would help in adjusting the quality of mixing water for the concrete mix. The strength properties of coarse aggregate such as aggregate crushing abrasion value, aggregate impact value, compressive strength, aggregate crushing value(10% fine value) etc. would determine the limits of strength of coarse aggregate which can be achieved with a given aggregate and these limits need to be investigated for creating database for rational design of. Locally available crushed stone aggregates with size 5mm to 12.5 mm and of maximum size 20 mm are used. For Coarse aggregate we are conducting test like Fineness Modulus, Specific Gravity test and Water Absorption as per IS 383 – (1970).

We obtained following results:

TABLE NO. 3

No.	Test	Reading
1.	Specific Gravity	2.61
2.	Water Absorption	1.08%

D) Properties of Coal Bottom Ash

Non-combustible residues after combustion from a furnace or incinerator are called as Bottom ash. In an industrial it called coal combustion. The portion of the ash that escapes up in the chimney or stack is referred as fly ash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is referred to as bottom ash too. For Coal bottom ash we are conducting test like Fineness Modulus, Specific Gravity test and as per IS 5816 – (1959).

We obtained following results:

TABLE NO. 4

No.	Test	Reading
1.	Fineness Modulus	3.50
2.	Specific Gravity	1.45

E) Chemical composition of sieved bottom ash

The chemical composition of the sieved bottom ash is analyzed by gravimetric method according to IS: 1727- 1967 on 600g sample and the results are tabulated in Table 3.2.4.1.1 It is found the sieved bottom ash used in this project consists of (Silica + Alumina + Iron Oxide) and Silica of and 91.25 and 60.63 which is greater than minimum requirement as per IS mentioned. The loss of ignition is 6.04 which is slightly greater than the IS requirement.

TABLE NO. 5

Chemical composition	Sieved Bottom Ash Weight Percent	IS: 3812-1981 Requirement
$SiO_2 + Al_2O_3 + Fe_2O_3$ (Silica + Alumina + Iron Oxide	91.25	70 min
SiO_2 (Silica)	60.63	35.0 min
CaO (Alumina)	1.09	Not Specified
MgO (Magnesia)	0.40	5.0 max
SO_3	0.58	3.0 max
Na_2O	0.45	1.5 max
Total Chlorides	0.058	0.05 max
Loss on Ignition at 1000oC	6.04	5.0

F) Mix Design For M35 Grade Of Concrete (As per I.S Code 10262-2009) Quantity of material for 1 m^3 volume of concrete

TABLE NO. 6

Material	Cement	Fine Aggregate	Coarse Aggregate	W/C ratio
Proportion	1	1.8	3.2	0.42
Weight	432	640	1160	184

IV. EXPERIMENTAL ANALYSIS

A) Effect of sieved coal bottom ash on compressive strength

Compressive strength of concrete mixed made with and without coal bottom ash of cubes size 150 mm × 150 mm × 150 mm was determined at 7, 28, 56, and 112 days.. The maximum load reading was taken at failure and the average compressive strength is calculated using the following relation:

$$\text{Compressive strength } (N/mm^2) = \frac{\text{Ultimate load in N}}{\text{Area of cross section } (mm^2)}$$

B) Effect of sieved coal bottom ash on split tensile strength

The specimen of size 150 mm in diameter and length of 300 mm is casted and tested under the digital CTM of capacity 300 ton. The specimen is kept under CTM at the centre with play wood at top and bottom and load was applied with pace rate 1.3 KN/seconds and ultimate loading was noted. The spilt tensile strength was calculated according to IS - 5816-1970 and IS 516 – 1959 code using following formula:

$$\sigma bt = \frac{2P}{\pi DL}$$

Where,

σbt = split tensile strength in N/mm^2,
P = Maximum load at failure,
L = span,
D = Diameter of specimen.

C) Effect of Sieved coal bottom ash on flexural strength

The beam specimen of size 100 mm × 100 mm × 500 mm was tested for single point load at the midpoint under the UTM of capacity 100 ton. The flexural strength is calculated as per IS 456 – 2000 and IS 516 – 1959 by using following relation:

$$\sigma b = \frac{PL}{bd^2}$$

Where,

σb= Modulus of rupture in N/mm2,
P = Maximum load,
L = span,
b = width of specimen,
d = depth of specimen.

V. RESULTS AND DISCUSSION

Compressive strength gained of sieved bottom ash concrete with age is:

TABLE NO. 7

MIX	7 days In N/mm^2	14 days In N/mm^2	28 days In N/mm^2
CC	27.69	33.35	42.90
20SBA+80 S	27.90	33.90	44.84
30SBA+70 S	28.38	34.25	45.43
35SBA+65 S	28.46	34.60	45.65
40SBA+60 S	26.71	32.38	37.84
60SBA+40 S	23.24	28.25	32.28
80SBA+20 S	20.63	24.58	31.24
100 SBA+0S	19.79	23.50	22.76

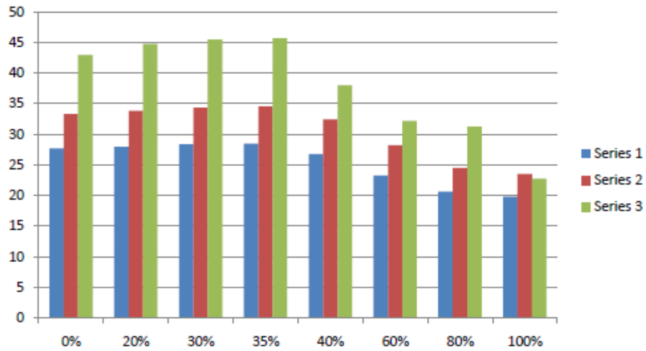

Fig. 1. Compressive Strength of Concrete with Incremental % of Ash

Here 0 to 100 % of coal bottom ash was replaced with sand and optimum percentage of replacement was obtained at 35 % replacement of bottom ash with sand. For controlled concrete the compressive strength was found to be 28.48 and 45.47 N/mm^2 for 7& 28 days respectively. It was observed that for 20% and 35 % sand replacement the compressive strength was increased compared with controlled concrete. Then after that compressive strength were decreased. The sieved bottom ash concrete gains strength at a slower rate in the initial period and acquires strength at faster rate after 28 days due to pozzolanic action of bottom ash.

Split Tensile Strength gained of sieved bottom ash concrete with age.

TABLE NO. 8

MIX	7 days In N/mm^2	14 days In N/mm^2	28 days In N/mm^2
CC	3.02	3.24	3.96
20SBA+80 S	3.30	3.46	4.23
30SBA+70 S	3.35	3.54	4.29
35SBA+65 S	3.9	4.15	5.15
40SBA+60 S	2.90	3.11	4.29
60SBA+40 S	2.65	2.80	3.32
80SBA+20 S	2.36	2.45	2.84
100 SBA+0S	1.82	1.93	2.67

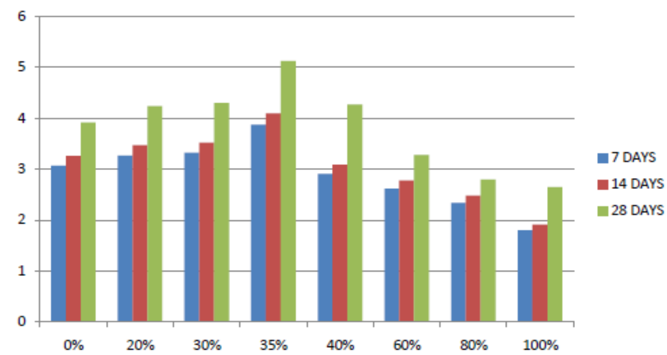

Fig. 2. Tensile Strength of Concrete with Incremental % of Ash

The split tensile strength for controlled concrete was found 3.07, 3.92 for 7, 28days respectively. It was observed that for 7 days the split tensile strength was increased from 9.45to 8.14

% for 10% to 30% replacement after that there was decreased in strength from 5.21 % to 41.4 % for 40% to 100% replacement. It was found that the split tensile strength for 28 days was increased from 9.18 % to 2.04 % up to 30 % thereafter decreased from 9.30 % to 32.40 %.

Flexural Strength & % variation in strength of sieved bottom ash concrete with age.

TABLE NO. 9

MIX	7 days In N/mm^2	14 days In N/mm^2	28 days In N/mm^2
CC	4.42	5.02	6.16
20SBA+80 S	4.33	4.95	5.63
30SBA+70 S	4.34	4.96	5.55
35SBA+65 S	4.59	5.24	5.9
40SBA+60 S	4.28	4.89	5.43
60SBA+40 S	3.83	4.36	4.99
80SBA+20 S	3.72	4.23	3.93
100 SBA+0S	2.75	3.12	3.00

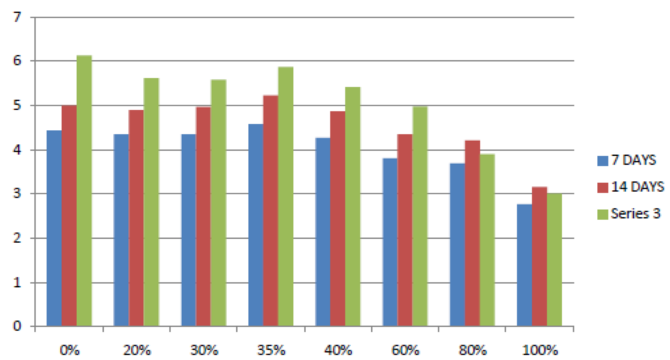

Fig. 3. Flexural Strength of Concrete with Incremental % of Ash

The sieved bottom ash concrete gains flexural strength with the age that is comparable but less than that of the controlled concrete. It is believed to be due to the poor interlocking between the aggregates, as bottom ash particles are spherical in nature.

VI. CONCLUSION

The compressive strength of Sieved Coal Bottom Ash Concrete of 7, 14 and 28 days were increased up to 35% ash replacement with natural sand and after that compressive strengths were decreased from 40% to 100% ash replacement with natural sand. The split tensile strength of Sieved Coal Bottom Ash Concrete was increased at 7, 14 and 28 days for 10% to 35% ash replacement with natural sand and after that tensile strengths were decreased from 40% to 100% ash replacement with natural sand. The flexural strength was increased for 10 %, 35% replacement and after that it was decreased.

Bottom ash concrete can be utilised in construction of pavement and buildings. Thus bottom ash is utilised in an eco-friendly way and sand quarrying can be reduced. Fine aggregates replacement with Bottom ash enables the large utilization of waste product.

Hence we are concluded that the coal bottom ash can be used up to 35% to obtain the maximum strength.

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