

Experimental Investigation on Partially Replacement of Fine Aggregate by Washed Bottom Ash

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ABSTRACT: This paper presents the use of washed bottom ash as fine aggregates in special concrete. The WBA is a waste material that is taken from electrical power plant and the source material is called as bottom ash. To substitute the amount of carbon usage in concrete the bottom ash was utilized and fully submerged in water for 3 days to produce WBA with low carbon composition. The aim of study is to investigate the feasibility and potential use of washed bottom ash in concreting and concrete applications. The results of physical and chemical properties of WBA were discussed. The mechanical properties of special concrete with 30% WBA replacement by weight of natural sand is found to be an optimum usage in concrete in order to get a favourable strength and good strength development pattern over the increment age.

KEYWORDS: Washed Bottom Ash, Special Concrete.

I. INTRODUCTION

Generation of Washed Bottom Ash:

Washed Bottom Ash is produced by five different foundry classes. The ferrous as foundries produce the most ash aluminium, copper, brass and bronze produce the rest. The three thou ash Washed Bottom Ash in the United States generates 6 million to 10 million tons of Washed Bottom Ash per year. While the ash is typically used multiple times within the foundry before it becomes a by product. Only 10% of Washed Bottom Ash was reused in 2001. Washed Bottom Ash is basically Fine aggregate it can be used in many of the ways as manufactured ashes. This includes civil engineering applications such as port land cement concrete.



Fig: 1.1 Washed Bottom Ash

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- Washed Bottom Ash (WBA) from electrical power plant is estimated to increase in the developed country such as china, Malaysia.
- The bottom ash is physically course, porous, glassy, granular, and incombustible material that is collected from the bottom of the furnace that burn coal.
- The type of ash produced depends on the type of furnace and also the source of coal. From the burning process of coal, 80% of product will become fly ash and remain 20% will become bottom ash.
- Bottom ash is collected at the bottom of the combustion chamber in a water-filled hopper, is removed by means of high-pressure water jet.
- The specific gravity of bottom ash is around 2-3 and shows the higher carbon content that ensuring in lower specific gravity.

Physical properties of bottom ash:

Properties	Bottom ash
Specific gravity	2.1-2.7
Dry unit weight	7.07-15.75 kN/M ³
plasticity	none
absorption	0.8-2.0%

Applications:

Ranking	Application
1	Embackment/Structaral Fill
2	Road Base/Sub Base
3	Hot Mix Ashpali
4	Soil/Horticultural
5	Cement And Concrete Product
6	Traction Control
7	Other Application

II. MIX DESIGN

Mix design for M20 grade of concrete

a) Design stipulation: (as per IS 10262-2009 and IS 456-2000)

- | | |
|--|-------------------------------------|
| a) Grade designation | -M20 |
| b) Type of cement | -Pozzolonas slag cement |
| c) Maximum nominal size of aggregate | -20mm |
| d) Maximum water-cement ratio | -0.48 (IS 456) |
| e) Workability | -100mm (slump) |
| f) Degree of super vision | -Good |
| g) Type of aggregate | -Crushed angle aggregate |
| h) Chemical admixture | -Conplast X421IC |
| i) Minimum cement content (for severe) | -375kg/m ³ (IS 456:2000) |

b) Test data for materials:

- | | |
|---|------|
| a) Cement specific gravity | -3.1 |
| b) Specific gravity of coarse aggregate | -2.4 |
| c) Specific gravity of fine aggregate | -2.8 |

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- | | |
|--|-------|
| d) Water absorption coarse aggregate | -0.5% |
| e) Water absorption fine aggregate | -1% |
| f) Free (surface) Moisture of coarse aggregate | -NIL |
| g) Free (surface) Moisture of fine aggregate | -NIL |

c) Target mean strength for mix proportioning (M20):

$$F_t = f_{ck} + 1.65s$$

Where

F_t = Target average compressive mean strength at 28days

f_{ck} = Characteristic compressive mean strength at 28days

s = Standard deviation = 4.6N/mm² for M20 grade of concrete(From table 1 of IS 10262 -2009)

Target mean strength $f_t = 20 + 1.65(4.65) = 27.59$ N/mm²

d) Selection of water – cement ratio:

From table 5 of IS 456-200

Maximum water cement – ratio = 0.48

Based on experience adopt water – cement ratio = 0.39

e) Strength of water content:

From table 2 of IS 10262- 2009

Maximum water content = 180 lit (This is for 25 to 50 mm slump range)

Estimated water content for 100mm slump = 180 + 6% of w.c (IS 10262-2009)

$$= 180 + 6\% (186)$$

$$= 191 \text{ lit}$$

As plasticizer is used the w.c can be reduced up to 20% and above. Based on trails with plasticizer water content reduced of 29% has been achieved hence the arrived w.c 191- 29% (191) = 135.61 lit = 136 lit

f) Calculation of cement content:

Water –Cement ration= 0.48

Cement content = 180/0.48 = 375 kg/m³

From table 5 of IS 456 – 2000 minimum cement content for severe exposure condition = 320 kg/m³

$$375 \text{ kg/m}^3 > 320 \text{ kg/m}^3$$

Hence ok.

g) Proportion of volume of coarse aggregate and fins aggregate:

From table 3 of IS 10262 – 2009

- Volume of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (zone =III) for water – Cement ration of 0.5 = 0.64
- In present case Water – Cement ratio is 0.48
- Volume of Coarse aggregate is required to be increased to decrease the fine aggregate content
- As the water – cement ratio is lowered by 0.11 the proportion of volume of coarse aggregate is increased by 0.022
- The volume of coarse aggregate = 0.66
- Volume of fine aggregate = 1- 0.66 = 0.34

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h) Mix Calculations:

The mix calculations are per unit volume of concrete shall be as follows

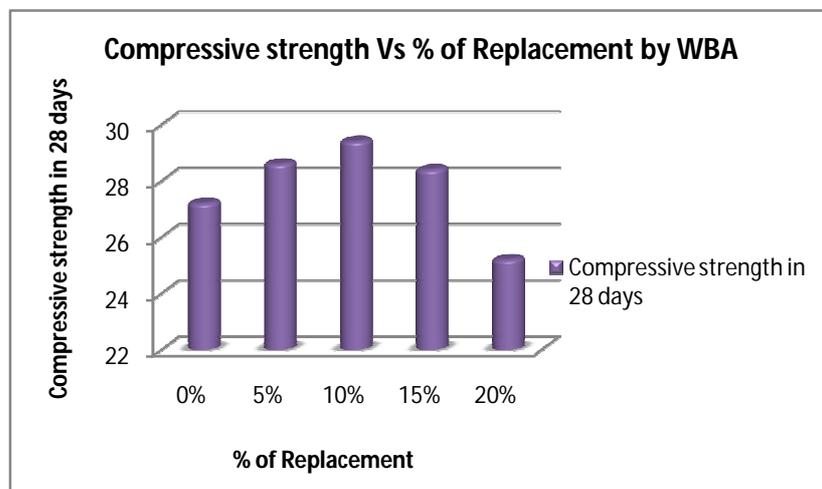
- a) Volume of concrete = 1m^3
- b) Volume of cement = $\frac{\text{mass of cement}}{\text{sp. gravity of cement} \times 1000}$
 $= \frac{375}{3.1 \times 1000}$
 $= 0.120\text{ m}^3$
- c) Volume of water = $\frac{\text{mass of water}}{\text{sp. gravity of water} \times 1000}$
 $= \frac{180}{1 \times 1000}$
 $= 0.180\text{ m}^3$
 Volume of all aggregates = $[a - (b + c)]$
 $= [1 - (0.120 + 0.180)]$
 $= 0.7$
- d) Mass of coarse aggregate = $(\text{Volume of all aggregate}) \times (\text{Volume of coarse aggregate}) \times (\text{sp. gravity of coarse aggregate}) \times 1000$
 $= 0.7 \times 0.662 \times 2.4 \times 1000$
 $= 1112.16\text{kg}$
- e) Mass of fine aggregate = $0.7 \times 0.34 \times 2.8 \times 1000$
 $= 666.4\text{kg}$

III. EXPERIMENTAL RESULTS

Replacement of Fine Aggregate by Washed Bottom Ash

(a) Influence of Washed Bottom Ash on compression strength

Graph:7.1 Compressive strength Vs % of fine aggregate replacement by Washed Bottom Ash.



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% of Replacement	0%	5%	10%	15%	20%
Compressive strength in 28 days	27.2	28.6	29.4	28.4	25.2

Table:7.1.1 Compressive Strength of Cube

S.NO	% Replacement of Washed Bottom Ash	Compressive strength in (N/mm ²)	% increase in strength
1	0	27.2	-
2	5	28.6	5.14
3	10	29.4	9.65
4	15	28.4	8.8
5	20	25.2	2.79

Table: 7.1.2 Mix proportion of Cube

Mix design	Nominal mix	mix -1	mix-2	mix-3	mix-4
%replacement of Washed Bottom Ash	0	5	10	15	20
w/c ratio	0.48	0.48	0.48	0.48	0.48
Cement content(kg)	5	5	5	5	5
Fine aggregate(kg)	8	7.6	7.2	6.8	6.4
Coarse aggregate	14	14	14	14	14
Water(lit)	2.5	2.5	2.5	2.5	2.5
Plasticizer (ml)	12.5	12.5	12.5	12.5	12.5
Compressive strength 28days (N/mm ²)	27.2	28.6	29.4	28.4	25.2
Washed Bottom Ash(kg)	0	0.4	0.8	1.2	1.6

In the present investigation Washed Bottom Ash has been used as replacement of fine aggregate up to a max. of 20%. The compressive strength for different % of Washed Bottom Ash and % increases or decreases in strengths with respect to M20 grade concrete listed in the table. By taking normal M20 grade as referring %, percentage of increase or decrease in compressive strength other % is calculated. Considering the normal M20 with 0% admixtures the compressive strength is 27.2 N/mm². When 5% replacement is used, the compressive strength is 28.6 N/mm². considering 10% replacement, the compressive strength is 29.4 N/mm². 15% Of replacements, the compressive strength is 28.4 N/mm². 20% of replacement, the compressive strength is 25.2 N/mm² and there is a little increase in the strength.

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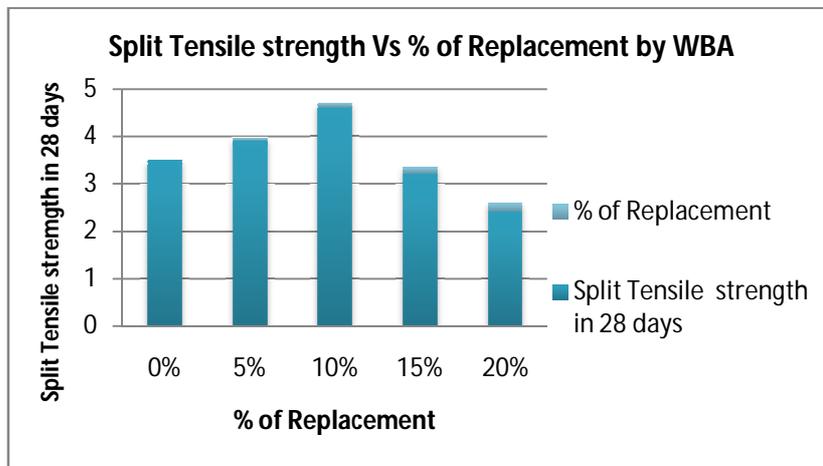
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7.2 Split Tensile Strength:

(b) Influence of Washed Bottom Ash on Tensile strength

Graph: 7.2 Tensile strength Vs % of fine aggregate replacement by Washed Bottom Ash



% of Replacement	0%	5%	10%	15%	20%
Split Tensile strength in 28 days	3.5	3.9	4.6	3.2	2.4

Table: 7.2.1 Mix Proportion of Cylinder

Mix design	Nominal mix	mix -1	mix-2	mix-3	mix-4
% replacement of Washed Bottom Ash	0	5	10	15	20
w/c ratio	0.48	0.48	0.48	0.48	0.48
Cement content(kg)	7.8	7.8	7.8	7.8	7.8
Fine aggregate(kg)	13	12.35	11.7	11	10.4
Coarse aggregate	22.5	22.5	22.5	22.5	22.5
Water(lit)	3.6	3.6	3.6	3.6	3.6
Plasticizer (ml)	19.5	19.5	19.5	19.5	19.5
Tensile strength 28days (N/mm ²)	3.5	3.9	4.6	3.2	2.4
Washed Bottom Ash(kg)	0	0.65	1.3	2	2.3

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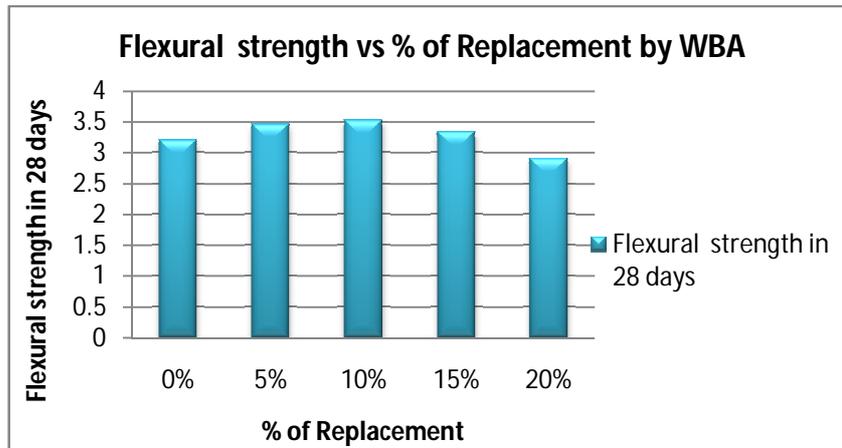
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7.3 Flexural Strength:

(c)Influence of Washed Bottom Ash on Flexural Tensile Strength:

Graph: 7.3 Flexural Tensile Strength Vs % Of Washed Bottom Ash



% of Replacement	0%	5%	10%	15%	20%
Flexural strength in 28 days	3.2	3.46	3.52	3.34	2.9

Table: 7.3.1 Mix Proportion of Beam

Mix design	Nominal mix	mix -1	mix-2	mix-3	mix-4
%replacement of Washed Bottom Ash	0	5	10	15	20
w/c ratio	0.5	0.5	0.5	0.5	0.5
Cement content(kg)	6.8	6.8	6.8	6.8	6.8
Fine aggregate(kg)	11.5	10.9	10.35	9.7	6.4
Coarse aggregate	19.7	19.7	19.7	19.7	19.7
Water(lit)	3.25	3.25	3.25	3.25	3.25
Plasticizer (ml)	17	17	17	17	17
Flexural strength 28days (N/mm ²)	3.2	3.46	3.52	3.34	2.9

IV. CONCLUSIONS

From the test results obtained it is evident that ordinary concrete blocks can be made high strength and thereby

1. It can be used in construction of shear walls, load bearing walls, infill walls etc. It can also be used in earthquake prone areas for higher lateral resistance.
2. Incorporation of waste Washed Bottom Ash increases the strength of blocks and optimum percentage of replacement was found between 20 to 30 %.

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3. For 100% replacement efflorescence was noted which may be due to heavy salts present in waste Washed Bottom Ash.
4. Hence 100% replacement is not advisable as it may be harmful for connected R.C.C works like footings, columns, beams, slabs etc.
5. The Indian Standard codes IS 2185(1979) prescribes strength up to 5 N/mm² for concrete masonry blocks Where as burnt clay bricks are available in different grades starting from a strength of 3.5N/mm² to 35N/mm² as per IS 1077(1992).
6. For special applications heavy duty burnt clay bricks are available in strengths of 40N/mm² and 45 N/mm² as per IS 2180(1988). In the present scenario the code prescribed strengths for concrete masonry blocks are very insufficient to cater the loads especially in seismic regions. So the Indian standard code for the concrete blocks has to be revised accordingly to accommodate a wide range of strengths for different applications.
7. Volumetric batching specified in the code has to be changed to weigh batching in line with the good construction practices as modern weigh batching equipments are available in affordable cost for the commercial production to ensure durability and consistent strength for the manufactured blocks.

V. CONCLUSIONS

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