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Experimental Study on Iron Ore Tailings and Bottom Ash as Fine Aggregates in Concrete

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***Abstract*— Iron ore tailings (IOT) are waste produced during mining of iron from its ore. Thus sustainable handling of iron ore tailings is of prime concern to all stakeholders who are into iron ore mining. Bottom ash is the waste material, which drops into the bottom of the furnace in latest large thermal power plants. The consumption and demand of construction materials has resulted in the extraction of sand from rivers. The extraction of sand is having adverse effects on rivers, causing degradation of rivers. Hence, in this thesis the effectiveness of iron ore tailings and bottom ash as fine aggregates in concrete is taken for study. Initially replacement of fine aggregate with 10%, 20%, 30%, 40% and 50% iron ore tailings was done. Then replacement of fine aggregate with 10%, 20%, 30%, 40% and 50% bottom ash was also done. The fresh and hardened state properties of concrete in both cases were studied and compared. The various tests have done include slump test, compacting factor test, compressive strength test, split tensile strength test and flexural strength test.**

Keywords*— High strength concrete, Iron Ore Tailings, Bottom Ash.

I. INTRODUCTION

India is one of the biggest iron ore producers and exporter in the world. Mining plays an important role in harnessing natural ore, but during this operation a lot of waste is generated. Proper waste management and disposal of this waste is need of the hour so that it can cause minimal damage to the environment. Iron ore tailings (IOT) are such waste produced during mining of iron from its ore.

The rapid growth in the surface mines led the production of Iron Ore tailings which remains as overburden. In future, the proportion of iron ore wastes generated is likely to increase due to higher demand for iron ore. Moreover, dumping causes loss of valuable land.

Fig.1 Iron Ore Tailing

In India, over 70% of electricity generated is by combustion of fossil fuels, out of which approximately 61% is contrived by coal-fired plants. This results in the origination of around 100 ton of ash.

Fig.2 Bottom Ash

Bottom ash is the coarser material, which drops into the bottom of the furnace in latest large thermal power plants and constitute about 20% of gross ash content of the coal fed in the boilers. It consists of non-combustible materials, and is the residual part from the incineration of household and similar waste. Raw bottom ash is a granular material that consists of a mix of inert materials such as sand, stone, glass, porcelain, metals and ash from burnt materials.

The past two to three decades have witnessed an enormous growth of construction industry in India. The extraction of sand is having adverse effects on rivers, causing degradation of rivers. Hence, partial or full replacement of fine aggregates by other compatible materials is being researched in view of conserving the ecological balance. In order to reduce the adverse impact of indiscriminate mining of natural sand, iron ore tailings and bottom ash can be used as an alternative to the river sand in the manufacturing of concrete.

In this paper, the effects of partial replacement of sand by iron ore tailing and bottom ash in the concrete are experimentally studied. Fresh and hardened state properties of both iron ore tailing concrete and bottom ash concrete were studied and compared.

II. SCOPE AND OBJECTIVE

A. Scope

Concrete contains approx. 80% of aggregates and it's extraction from water bodies leads to various environmental problems. IOT is waste produced during iron ore production which remains as overburden. Bottom ash is a by-product of burning of coal at thermal power plants and India produces approx. 100 million tonnes of Coal ash annually. Replacement of fine aggregate with IOT and bottom ash helps to effectively manage the natural resources and waste materials.

B .Objectives

- To study the effect of iron ore tailings on the property of concrete when used as fine aggregate.
- To study the properties of concrete with bottom ash as partial replacement material for fine aggregate.
- To compare the fresh and hardened state properties of iron ore tailing concrete and bottom ash concrete.

III. METHODOLOGY

A. Literature Review

B. Procurement of Materials

• Ordinary Portland Cement, Coarse Aggregate, Poabs Msand, Iron Ore Tailing (from Lakya Dam site, Karnataka), Bottom Ash (from Hindustan News print Ltd., Kottayam), Super Plasticizer (Master Glenium Sky 8233).

C. Determination of Material Properties

D. Mix Proportioning

• M40 grade mix was selected. Mix design was done as per IS10262:2009.

E. Specimen Preparation

• Specimens were prepared with control mix which contains only OPC, coarse aggregate and M sand.

• Specimens were prepared for varying percentage of iron ore tailings, that is, 10%, 20%, 30%, 40% and 50%.

• Concrete specimens were prepared for varying percentage of bottom ash, that is, 10%, 20%, 30%, 40% and 50%.

F. Tests

• On fresh concrete slump test and compacting factor test were done.

- To determine mechanical properties of hardened concrete Compressive strength test, split tensile strength test and flexural tests were done.

IV. MATERIAL CHARACTERIZATION

A. Cement

OPC 53 grade cement was used in this study

TABLE.1 PROPERTIES OF CEMENT

Standard Consistency	35%
Initial Setting Time	240 min
Specific Gravity	3.125
Fineness	5%

B. Fine Aggregate

As per table 4 of IS 383-1970 the fine aggregate belongs to zone II.

TABLE.2 PROPERTIES OF FINE AGGREGATE

Specific Gravity	2.69
Water Absorption	1.5%
Bulk Density	1.225 kg/l
%Voids	54.44%
Water Content	2.23%

C. Coarse Aggregate

TABLE.3 PROPERTIES OF COARSE AGGREGATE

Specific Gravity	2.67
Water Absorption	0.8%
Bulk Density	1.324 kg/l
%Voids	50.412%
Aggregate Crushing Value	28.66%

D. Iron Ore Tailing

As per table 4 of IS 383-1970 the iron ore tailing belongs to zone II.

TABLE.4 PROPERTIES OF IRON ORE TAILING

Specific Gravity	3.1
Water Absorption	6%

E. Bottom Ash

As per table 4 of IS 383-1970 the bottom ash belongs to zone II.

TABLE.5 PROPERTIES OF BOTTOM ASH

Specific Gravity	2.2
Water Absorption	9%

F. Super Plasticizer

TABLE.6 PROPERTIES OF SUPER PLASTICIZER

Aspect	Light brown liquid
Relative Density	1.08 ± 0.01 at 25°C
pH	>6
Chloride ion content	< 0.2%

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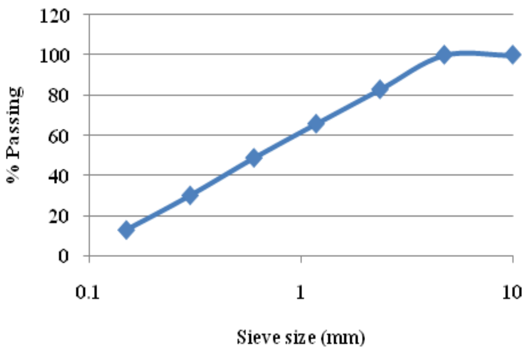

Fig.3 Sieve Analysis of Fine Aggregate

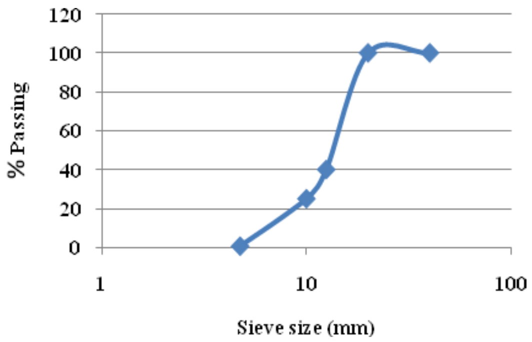

Fig.4 Sieve Analysis of Coarse Aggregate

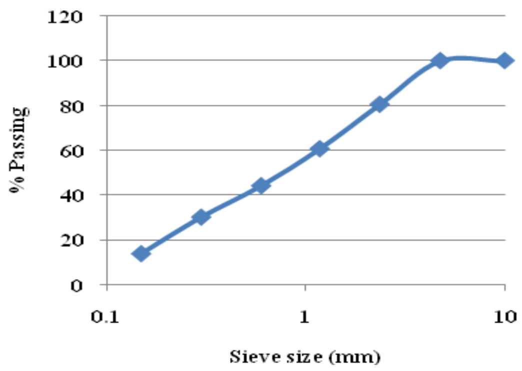

Fig.5 Sieve Analysis of Iron Ore Tailing

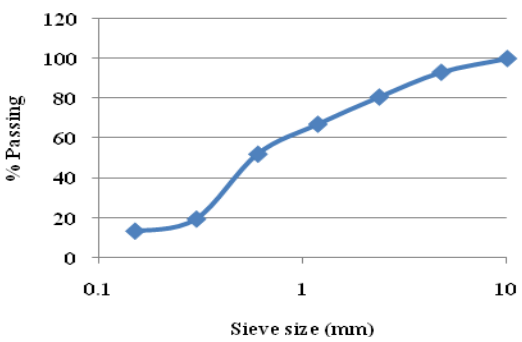

Fig.6 Sieve Analysis of Bottom Ash

V. MIX DESIGN

The various mixes prepared are designated as below.

1. CM : OPC + C.A + M SAND
2. IR10 : OPC + C.A + 10% IOT + 90% M SAND
3. IR20 : OPC + C.A + 20% IOT + 80% M SAND
4. IR30 : OPC + C.A + 30% IOT + 70% M SAND
5. IR40 : OPC + C.A + 40% IOT + 60% M SAND
6. IR50 : OPC + C.A + 50% IOT + 50% MSAND
7. BA10 : OPC + C.A + 10% BA + 90% M SAND
8. BA20 : OPC + C.A + 20% BA + 80% M SAND
9. BA30 : OPC + C.A + 30% BA + 70% M SAND
10. BA40 : OPC + C.A + 40% BA + 60% M SAND
11. BA50 : OPC + C.A + 50% BA + 50% M SAND

TABLE.7 MIX PROPORTION FOR VARIOUS MIXES (kg/m^3)

Mix	OPC	C.A	M Sand	IOT	BA	SP	Water
CM	415	1096.4	801.2	-	-	1.244	178.4
IR10	415	1096.4	721.1	92.4	-	1.244	182.8
IR20	415	1096.4	641.3	184.8	-	1.244	187.1
IR30	415	1096.4	561.2	277.2	-	1.244	191.5
IR40	415	1096.4	481.0	369.6	-	1.244	195.8
IR50	415	1096.4	400.8	461.9	-	1.244	200.1
BA10	415	1096.4	721.1	-	65.6	1.244	183.1
BA20	415	1096.4	641.3	-	131.2	1.244	187.8
BA30	415	1096.4	561.2	-	196.7	1.244	192.5
BA40	415	1096.4	481.0	-	262.3	1.244	197.2
BA50	415	1096.4	400.8	-	327.8	1.244	201.9

VI. RESULTS AND DISCUSSIONS

TABLE.8 FRESH STATE PROPERTIES OF MIXES

Mix	Slump value (mm)	Compacting factor
CM	110	0.92
IR10	110	0.92
IR20	100	0.90
IR30	100	0.89
IR40	90	0.88
IR50	80	0.86
BA10	110	0.91
BA20	100	0.89
BA30	100	0.89
BA40	90	0.88
BA50	90	0.88

From the Table.8 it is clear that the slump value and compacting factor decreases when the amount of iron ore tailings or bottom ash in the mix increases. Because both iron ore tailings and bottom ash are finer materials. Hence workability of the mix reduces with increase in iron ore tailing or bottom ash.

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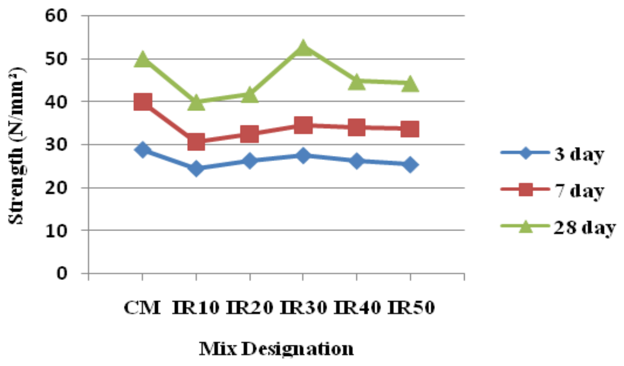

Fig.7 Compressive Strength of CM and IOT Mixes

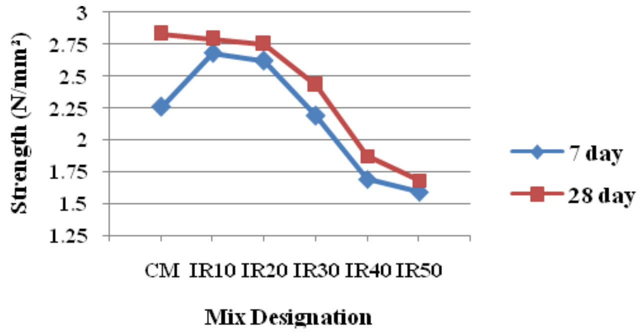

Fig.8 Split Tensile Strength of CM and IOT Mixes

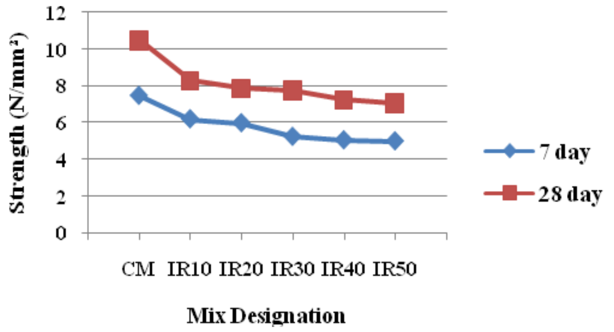

Fig.9 Flexural Strength of CM and IOT Mixes

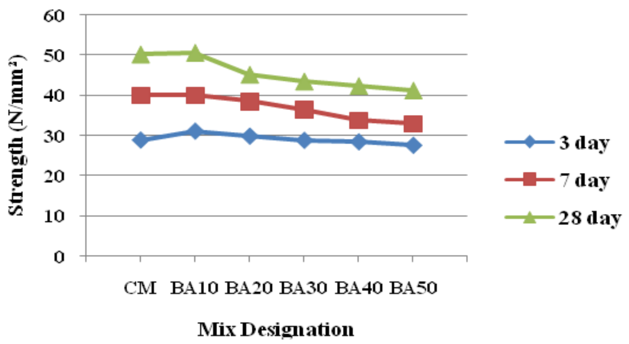

Fig.10 Compressive Strength of CM and BA Mixes

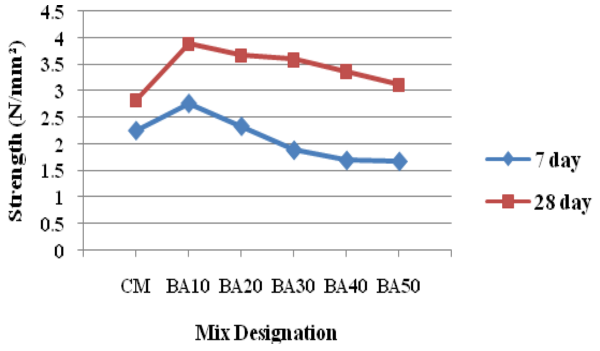

Fig.11 Split Tensile Strength of CM and BA Mixes

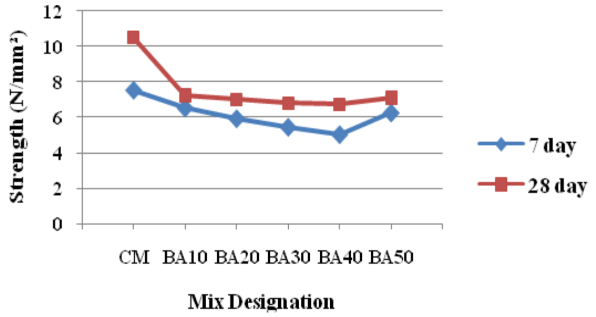

Fig.12 Flexural Strength of CM and BA Mixes

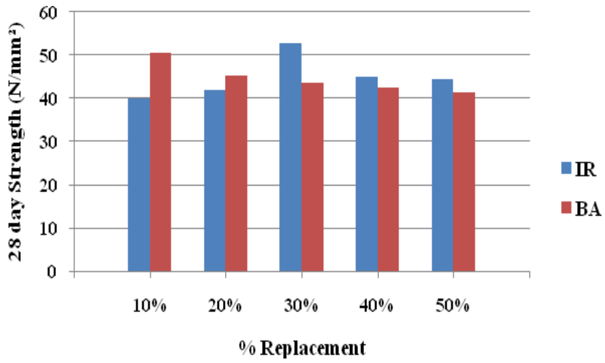

Fig.13 Compressive Strength of IOT and BA Mixes

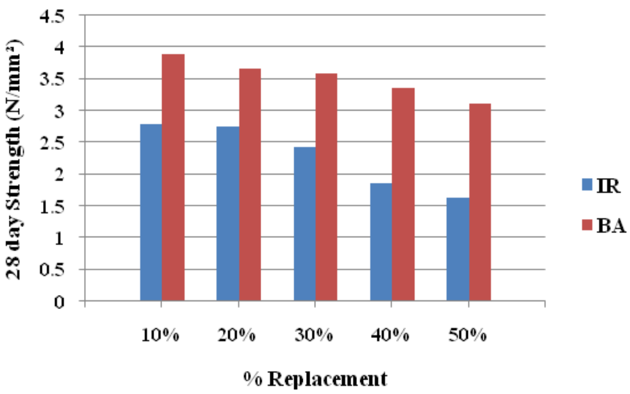

Fig.14 Split Tensile Strength of IOT and BA Mixes

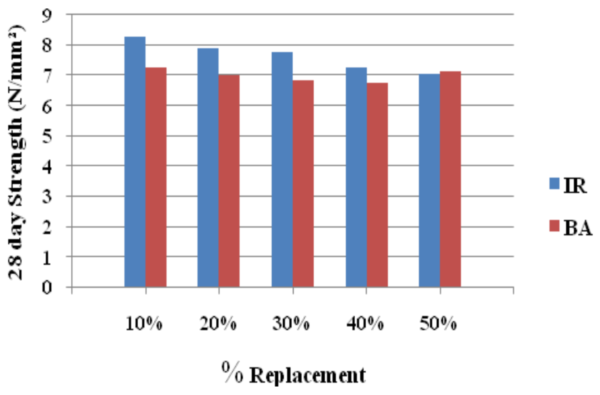

Fig.15 Flexural Strength of IOT and BA Mixes

VII. CONCLUSIONS

- Specimens were prepared with varying percentages of IOT and Bottom Ash.
- Maximum compressive strength obtained for IR30 and BA10.
- For IR30 compressive strength increased by 5.32% from control mix. For 10%, 20%, 40% and 50% IOT, compressive strength of the mix reduced from that of control mix by 20.17%, 16.51%, 10.61% and 11.5% respectively.
- Split tensile strength of 10%, 20%, 30%, 40% and 50% IOT mixes reduced by 1.38%, 2.79%, 14.10%, 33.9% and 42.03% respectively from that of control mix.
- For 10%, 20%, 30%, 40% and 50% IOT mixes the flexural strength decreases by 21.14%, 24.95%, 26.19%, 30.95%, and 32.86% respectively from control mix.
- Compressive strength increased by 0.84% when 10% BA was used. For 20%, 30%, 40% and 50% BA compressive strength reduced by 9.92%, 13.26%, 15.47% and 17.7% respectively.
- Split tensile strength was increased by 37.5%, 29.73%, 26.9%, 19.12% and 9.89% for 10%, 20%, 30%, 40% and 50% BA respectively.
- Flexural strength of BA mixes reduced compared to that of control mix by 30.86%, 33.33%, 35.05%, 35.7% and 32.19% respectively for 10%, 20%, 30%, 40% and 50% BA.
- IOT and BA are very fine materials, hence they reduce the workability of the mix.
- Compressive strength and flexural strength of IR30 is greater than that of BA10 by 4.44% and 6.75% respectively. But split tensile strength of BA10 is 60.08% greater than that of IR30.
- Replacing fine aggregates by 30% IOT is effective than replacement with 10% BA. Thus 30% of fine aggregates can be saved.

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