INDUSTRIAL BY-PRODUCTS AS PARTIAL SAND REPLACEMENT IN CONCRETE

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ABSTRACT

A Partial replacement of sand in concrete with the utilization of industrial by-products offers technical, economic and environmental advantage which of great importance in the present context of sustainability in the construction sector. The substituting industrial by-Products are waste foundry sand and bottom ash. This experimental study investigates the mechanical properties (compressive & split tensile strength only) on concrete made by those industrial byproducts partially replaced in equal quantities upto 60% at the interval of 10% and it should be equated to the strength of conventional concrete to check the development of strength. It investigates the possibility of substituting river sand with industrial by-products such as waste foundry sand and bottom ash which is producing in larger quantities.

Keywords: ***Industrial byproducts, bottom ash, waste foundry sand, partial replacement of sand, strength development.***

1. INTRODUCTION

Concrete is an extensively used material for most of the civil engineering projects. The rapid advance of globalization and population growth has resulted in the increasing rate of building construction that leads to a higher demand of the construction materials especially river sand. The general purpose of the present experimental study aims not only at saving natural raw materials and to reduce energy consumption, but also reuse industrial by-products.

Bottom ash is a byproduct of coal and lignite combustion. The largest producers of bottom ash are thermal power plants, which burns very high volume of coal and lignite annually to generate electricity. It is a coarse material having grains similar to or slightly bigger than that of sand. Hence it is used as a replacement of sand. Bottom ash was collected from NLC in Neyveli, Tamilnadu.

Waste Foundry sand is a by-product of iron and steel casting industry. It is mainly composed of silica and hence it is suitable for the replacement of natural sand. Waste foundry sand was collected from foundries in Coimbatore, Tamilnadu. Coimbatore has cluster of foundries, out of all an individual industry dumps the waste foundry sand about 3.2 tons per day.

2. EXPERIMENTAL PROGRAM

2.1 MATERIALS

2.1.1 CEMENT

Ordinary Portland cement 43 grade conforming to IS: 8112 – 1939 was used. Its properties are shown in Table.1

Table.1 Cement Test results

S.No	Physical properties	Experimental values
1.	Consistency	30 %
2.	Fineness	3.6 %
3.	Specific gravity	3.0
4.	Initial setting time	28 minutes
5.	Final setting time	8 hours

2.1.2 BOTTOM ASH

Bottom ash was screened to remove the oversized particles and materials passing through 4.75 mm were used with a specific gravity 2.0 and water absorption 15%. It is composed of mainly silica, alumina, iron and small amounts of calcium and magnesium sulfate. The grading curve for bottom ash is shown in fig.1.

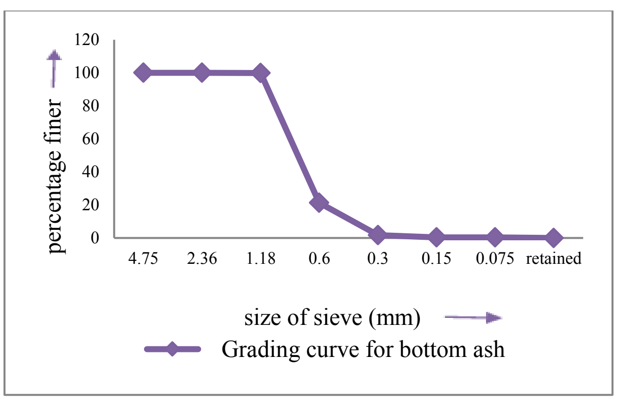

Fig.1 grading curve for bottom ash

2.1.3 WASTE FOUNDRY SAND

Waste foundry sand was used with specific gravity 2.5 and water absorption 1.1 %.It is composed of mainly silica, alumina & small amounts of iron. The grading curve for waste foundry sand is shown in fig.2.

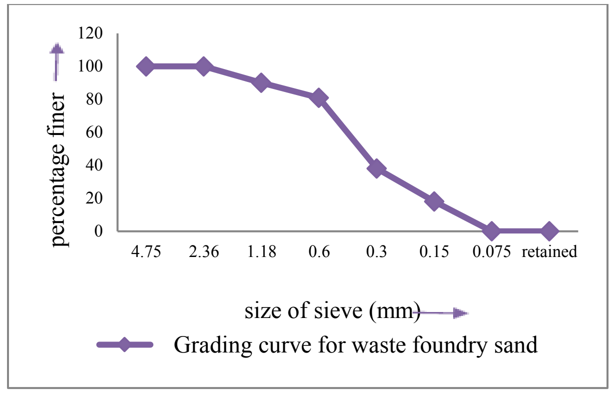

Fig.2 grading curve for waste foundry sand

2.1.4 FINE AGGREGATE (RIVER SAND)

River sand was conforming to zone 2 by the experimental results. The maximum size of fine aggregate was taken to be 4.75 mm. It was used with specific gravity 2.61 and water absorption 2 %.The testing of sand was done as per Indian standard specifications IS: 383 – 1970.The grading curve for river sand is shown in fig.3.

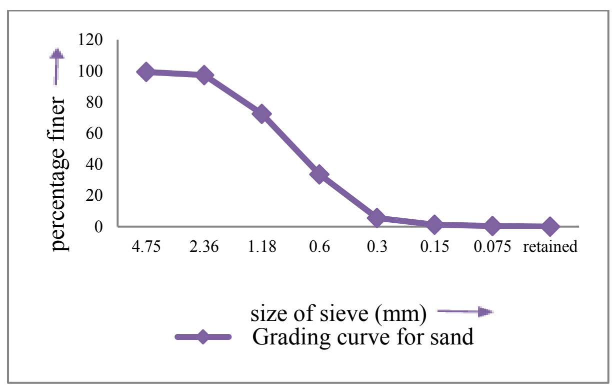

Fig.3 grading curve for sand

2.1.5 COARSE AGGREGATE

Coarse aggregate was used with 20mm nominal size by the following experimental results. It was used with specific gravity 2.76 and water absorption 1%. The testing was done as per Indian standard specifications IS: 383 – 1970.The gradation results are tabulated in table 2.

Table.2 Sieve analysis result for coarse aggregate

IS sieve designation	Weight retained on sieve (gm)	Percentage of passing
40 mm	0	100
20 mm	0.58	42
16 mm	0.301	11.9
10 mm	0.103	1.6
4.75 mm	0.016	0
2.36 mm	0	0

2.2 MIX PROPORTIONS

Nineteen mix proportions were made with alternate fine aggregates. First was control mix (using natural sand only) and next six mixes contained bottom ash & then other six mixes contained waste foundry sand and further six mixes contained both industrial by-products. Fine aggregate (river sand) was replaced with industrial by-products by weight. The proportions of fine aggregate replacement ranged from 10% to 60% at the interval of 10%. The control mix without industrial by-products was proportioned as per Indian standard specifications IS: 10262 – 1982, to obtain a 28 days strength of 20 MPa. Hand mixing was done for the concrete mixes. Table.3 shows the details of Mix design.

Table.3 Details of mix design

Title	Specifications
Grade of concrete	M20
Type & grade of cement	OPC 43
Target strength	26.6 N/mm^2
Water cement ratio	0.5
Mix proportion	1: 1.7: 3: 0.5

2.3 PREPARATION AND CASTING OF TESTING SPECIMENS

The 150mm concrete cubes were cast for compressive strength, 150×300 mm cylinders for splitting tensile strength. For the above mix proportions, corresponding quantities of materials were weighed. Then it was hand mixed and casted in mould. All the moulds were properly oiled before casting. After casting, its surface was finished smoothly using a steel trowel. Then those test specimens were stored at room temperature. They were demoulded after 24 hours, and were put into a water-curing tank for 28 days.

2.4 CONCRETE PROPERTIES

In Mechanical properties, compressive and splitting tensile strength of concrete was studied in this case. After 28 days of curing, the test specimens were taken out from the curing tank and their surfaces were wiped off. Then it was subjected to the test using compression testing machine. The compressive strength, splitting tensile strength tests are performed at 28 days in accordance with the provisions of the Indian standard specifications IS: 516 – 1959.

3. RESULTS & DISCUSSIONS

The various aspects were studied during the test such as the effect of compressive and splitting tensile strength on the concretes made by industrial by-products.

3.1 COMPRESSIVE STRENGTH

The compressive strength of concrete mixes made with and without industrial by-products was determined at 28 days. The test results are given in Table 4.The variation of compressive strength with respect to the percentage replacement of industrial by-products is shown in fig.4, fig.5, fig.6.

Table.4 Results of Compressive Strength Test

Fine aggregate used	Mix designation	Percentage of replacement	Average Compressive strength (f_c) (N/mm^2)
Natural sand	C1	100%	21.62
Bottom ash	B1	10%	19.99
	B2	20%	21.55
	B3	30%	21.97
	B4	40%	18.16
	B5	50%	17.96
	B6	60%	17.37
Waste foundry sand	F1	10%	23.61
	F2	20%	25.13
	F3	30%	25.02
	F4	40%	22.30
	F5	50%	20.78
	F6	60%	20.28
Partially both industrial by-products	BF1	10%	22.14
	BF2	20%	25.54
	BF3	30%	26.94
	BF4	40%	23.27
	BF5	50%	25.80
	BF6	60%	21.73

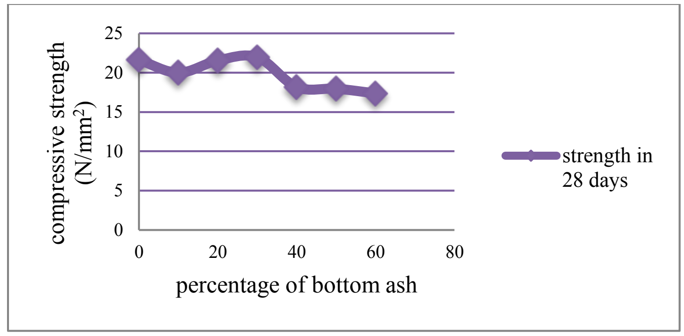

Fig.4 Variation of compressive strength with percentage of bottom ash

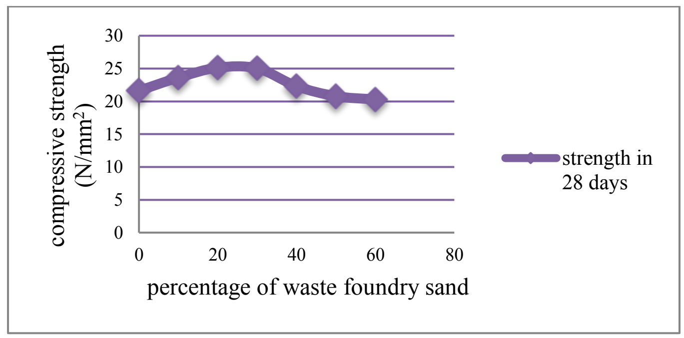

Fig.5 Variation of compressive strength with percentage of waste foundry sand

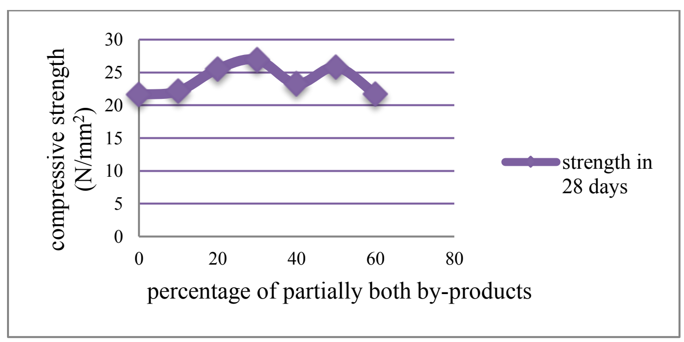

Fig.6 Variation of compressive strength with percentage of partially both by-products

3.2 SPLITTING TENSILE STRENGTH

The splitting tensile strength variation with respect to the percentage replacement of industrial by-products is as shown in fig.7, fig.8, fig.9. The splitting tensile strength test results are given in Table 4.

Table.5 Splitting Tensile Strength test results

Fine aggregate used	Mix designation	Percentage of replacement	Splitting tensile strength (N/mm^2)
Natural sand	C1	100%	2.47
Bottom ash	B1	10%	2.55
	B2	20%	2.74
	B3	30%	2.94
	B4	40%	2.61
	B5	50%	1.83
	B6	60%	1.69
Waste foundry sand	F1	10%	2.66
	F2	20%	2.86
	F3	30%	2.58
	F4	40%	2.26
	F5	50%	2.15
	F6	60%	2.05
Bottom ash + Waste foundry sand	BF1	10%	2.46
	BF2	20%	2.62
	BF3	30%	2.78
	BF4	40%	2.53
	BF5	50%	2.24
	BF6	60%	1.45

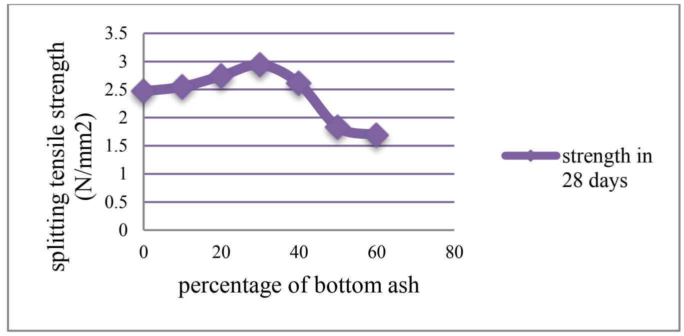

Fig.7 Variation of splitting tensile strength with percentage of bottom ash

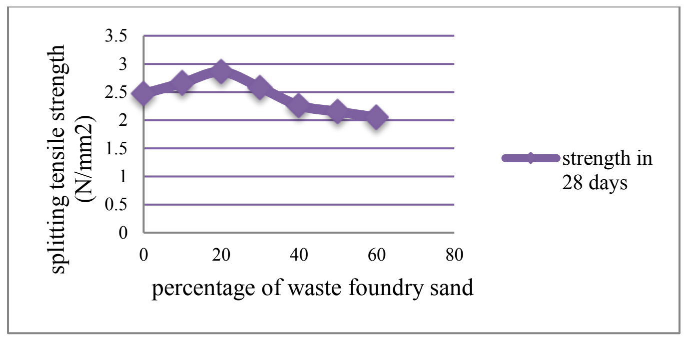

Fig.8 Variation of splitting tensile strength with percentage of waste foundry sand

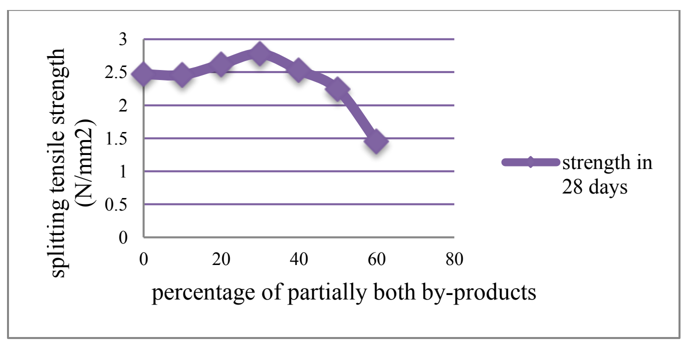

Fig.9 Variation of splitting tensile strength with percentage of partially both by-products

4. CONCLUSION

Based on the experimental study undertaken the following conclusion are drawn.

1. Partial replacement of river sand with bottom ash at 30% increases the strength properties (compressive & splitting tensile strength) of concrete.

2. Waste foundry sand gives optimum strength (compressive & splitting tensile strength) at 20% of partial replacement.
3. Compressive and splitting tensile strength of fine aggregate replaced industrial by-products concrete specimens were continued to increase with the percentage of replacement upto 30% and decreased for further replacement.
4. By replacing sand with partially both industrial by-products in the range of 30%, attains higher strength compared to the strength of conventional concrete at 28 days.
5. Thus, the industrial by-products are the good replacement of fine aggregate. It is very economical as well as eco-friendly.
6. In future, the further research will be made on various grades of concrete.

5. ACKNOWLEDGEMENT

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