Strength Performance of Concrete by Partial Replacement of Fine Aggregate by Bottom Ash

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Abstract- *This project work presents the experimental investigations carried out to study the effect of use of bottom ash as a partial replacement of fine aggregates in preparing concrete. The various strength properties studied consist of compressive strength, and splitting tensile strength. The strength development for various percentage (30-50%) replacement of fine aggregate with bottom ash can easily equated to the strength development of control mix at various ages.*

I. INTRODUCTION

Coal bottom ash is a coarse granular and incombustible by-product from coal burning furnaces. It is composed of mainly silica, alumina and iron with small amounts of calcium, magnesium sulphate. The appearance and particle size distribution of coal bottom ash is similar to that of river sand. These properties of coal bottom ash make it attractive to be used as fine aggregate in the production of concrete. Yet about 80% of bottom ash remains unutilized.

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 utilization of coal ash in normal and high strength concrete is a new scope in concrete mix design and if put to use on large scale would ameliorate the construction industry, by minimizing the construction cost and abating the ash content. This project presents the various experimental investigations carried out to study the effect of use of bottom ash as a replacement for sand, since the investigation on the use of bottom ash has been very limited.

Figure 1.1-Bottom Ash

Objectives Of Present Work

The objectives of the present work are as follows

- ✓ Developing Concrete mixes by replacing different percentages of Sand by Bottom Ash
- ✓ Study of fresh and hardened properties of concrete mix developed in the laboratory.
- ✓ Determining Optimum % of Bottom Ash, which affects the Mechanical properties of Concrete.
- ✓ Comparison of results with Control Mix.
- ✓ To determine the different strength parameters of the bottom ash added concrete cube with the replacement of fine aggregate (sand).
- ✓ To reduce the scarcity of sand.
- ✓ Conserving the natural resources.

II. TESTS ON INGREDIENT MATERIALS

The physical properties of the ingredient materials are obtained from the tests conducted in accordance with Indian Standards and tabulated in the respective tables.

2.1.1Cement:

Ultratech Ordinary Portland cement (OPC) of 43 grades is used in this project. Its physical properties were tested in accordance with B.I.S specification and tabulated below.

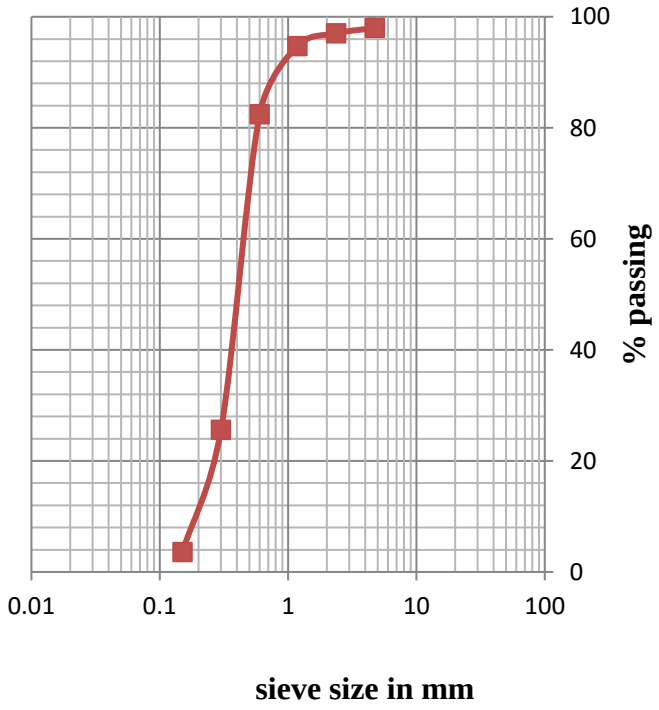
2.1.2Fine Aggregate:

The locally available river sand conforming to grading of Zone II of IS: 383- 1970 was used as fine aggregate in this project work. The physical properties and sieve analysis data are tabulated below table.

Table3.3-Physical Properties sand Sieve Analysis of Fine Aggregate

1	Specific Gravity =2.44
2	Bulk Density =1319.68 kg/m^3
3	Fineness Modulus =(268/100) = 2.68
4	Water Absorption =0.9%

The collected fine aggregate belongs to Zone II of IS: 383-1970



Coarse Aggregate:

The locally available crushed granite material has been used as coarse aggregate. Coarse aggregate of 20 mm nominal size and 12.5 mm nominal size are used in this project work. The physical properties and sieve analysis data of 20 mm nominal size aggregates are tabulated in below Table.

Table3.4-Physical Properties and Sieve Analysis of Coarse Aggregate (20mmNominal size)

1	Specific gravity= 2.62
2	Fineness modulus= 6.9
3	Water Absorption =0.3%

Water:

Clean potable fresh water, which is free from concentration of acid and organic substance, has been used for mixing the concrete..

Bottom Ash:

Bottom ash is a by-product of coal and lignite combustion. The largest producers of bottom ash are power plants, which burn a very high volume of coal and lignite annually to generate electricity. Bottom ash is a coarse material having grains similar to or slightly bigger than that of sand. Bottom ash obtained after burning of Lignite with calorific value of 2600 kcal/kg. Bottom Ash was collected from Udupi Power Corporation Ltd. (LANCO), Padubidri, Udupi Dist.

Table3.9-Physical Properties and Sieve Analysis of Bottom Ash

Specific Gravity =2.12
Bulk Density =1172.56 kg/m^3
Fineness Modulus =(296.7/100)= 2.96

III. EXPERIMENTAL PROGRAMME

3.2 Tests on Fresh Concrete

Mixing of ingredients of concrete is done for the designed mix proportion for M30 grade of concrete mix by replacing sand by bottom ash for different percentages (30%, 40% and 50%). Slump cone test for M30, test measure the workability of fresh concrete mix. The workability tests are carried out as per IS: 1199-1959 [16].

3.2.1 Slump Test

Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. The concrete

is said to be workable if it can be easily mixed and placed, compacted and finished.

Here the slump test is conducted for only normal strength concrete. The slump values for various percentages of Bottom Ash are listed in the Table 4.2.

Table 4.2-Slump values of Concrete for various percentages of Bottom Ash.

Sl. No.	Replacement of Sand by Bottom Ash (%)	Slump (mm)
1	0	62
2	30	55
3	40	52
4	50	48

3.3 Test Programme

The following tests were carried out to establish the mechanical properties of concrete by using bottom ash as a replacement for fine aggregate.

- Compressive strength test
- Splitting Tensile strength test

3.3.1 Compressive Strength

One of the important properties of concrete is its strength in compress on. The strength in compression has a definite relationship with all the other properties of concrete i.e. these properties are improved with the improvement in compressive strength. The size of the mould is usually (150 x 150 x 150) mm. Concrete cubes are tested for 7 days, 14 days and 28 days strength as per IS : 516- 1959 [17]. Rate of application of Compressive Load is tested in a Compression Testing Machine.

Table 4.3-Compressive Strength of Concrete for various percentages of Bottom Ash

Ssl.no	Replacement of fine aggregate by bottom ash %	Compressive strength of bottom ash added concrete in N/mm^2		
		7days	14days	28 days
1	0	29.43	31.90	35.60
2	30	26.54	28.40	32.85
3	40	25.30	27.10	29.80
4	50	23.50	25.75	27.90

4.3.2 Splitting Tensile Strength Cylinder Splitting Tension Test, also sometimes referred as, "Brazilian Test". This test was developed in Brazil in 1943. At about the same time this was also independently developed in Japan.

This test is carried out by placing a cylinder specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter.

Table 4.4-Splitting Tensile Strength of Concrete for various percentages of Bottom Ash

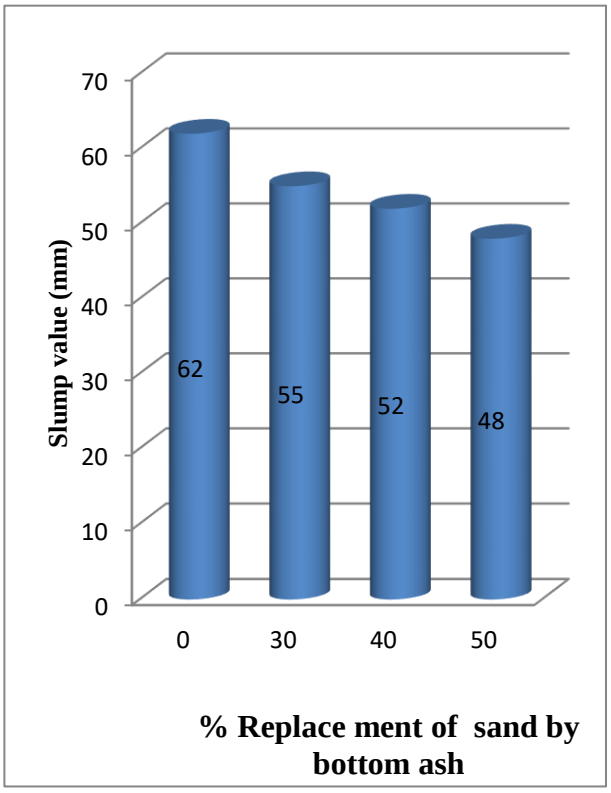
sl no	Replacement of fine aggregate by bottom ash	Splitting tensile strength of bottom ash added concrete in N/mm^2		
		7days	14days	28 days
1	0	2.52	3.21	3.83

2	30	2.39	2.92	3.76
3	40	2.11	2.60	3.52
4	50	1.93	2.28	3.20

IV. RESULTS AND DISCUSSIONS

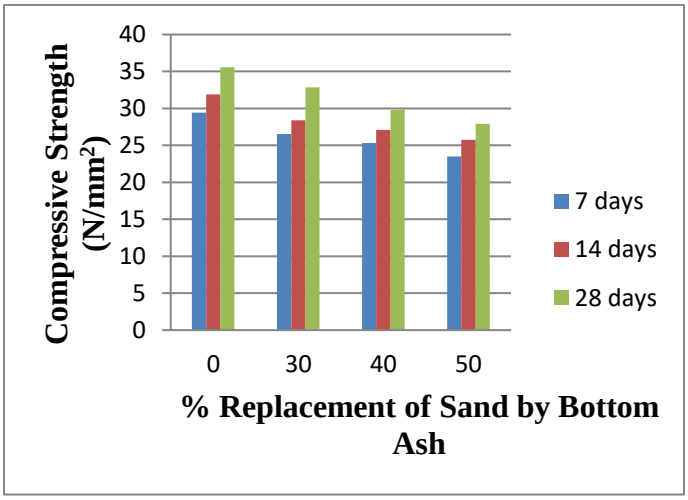
5.1 Fresh Properties of Bottom Ash Concrete

Graph 5.1-Slump Values for Normal Strength Concrete for different percentages of Bottom Ash



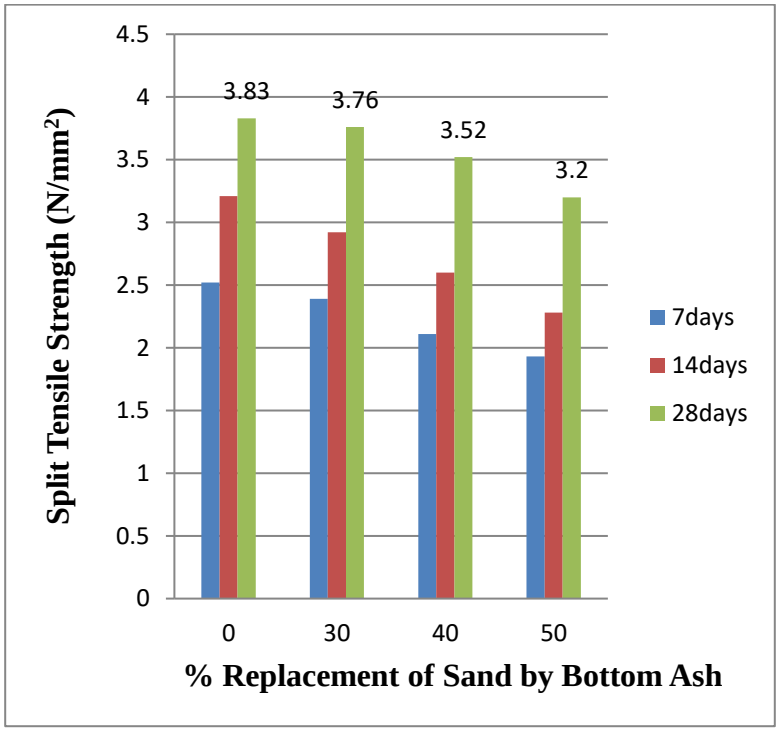
Graph 5.1-Slump Values for Normal Strength Concrete for different percentages of Bottom Ash. The slump values are decreased with the increase in replacement of sand by bottom ash as shown in Graph 5.1. This indicates that the workability decreases with the increase in Bottom ash content. The obtained slump values are within the range of slump for which the concrete mix has been designed, up to 40% replacement of sand by bottom ash; for further replacements, the slump was not in the range. Slump value at 30% replacement gave satisfactory results, since slump value was nearer to the slump value for 0% replacement.

5.2 Hardened Properties of Bottom Ash Concrete



Graph 5.2- Compressive Strength of Normal Strength Concrete for different percentages of Bottom Ash

Graph 5.2- Compressive Strength of Normal Strength Concrete for different percentages of Bottom Ash Compressive Strength of the concrete was increased for the lower percentage replacement of the Sand by Bottom Ash, i.e. up to 30%. Thereafter, the compressive strength of the concrete was decreased for higher % replacements. The Compressive strengths of NSC for different % replacements for various days of curing are shown in Graph 5.2.



Graph 5.3- Splitting Tensile Strength of Normal Strength Concrete for different percentages of Bottom Ash

Splitting Tensile Strength of the concrete was increased for the lower percentage replacement of the Sand by Bottom Ash, up to 30%. Thereafter, the splitting tensile strength of the concrete was decreased for higher % replacements. Graph 5.3 shows the splitting tensile strength of NSC for different percentages of Bottom ash. Therefore, in order to achieve enhanced Splitting Tensile Strength, the optimum % replacement of Sand by Bottom Ash is 30%.

V. CONCLUSIONS

Following Conclusions were drawn from this experimental work:

- Utilization of bottom ash in concrete reduces the use of sand in preparation of concrete.
- Effective use industrial wastes (i.e. bottom ash as effectively used in the construction works)
- From this experimental study we found that the workability of concrete reduces with increasing the bottom ash content. For 30% replacement of sand by Bottom ash workability slightly lower when concrete without any replacement.
- We found That compressive strength, and splitting tensile strength of the harden concrete reduces when it replaced partially sand with bottom ash i.e. 30%, 40%, 50% but the results are increases than the normal limit(compressive strength =20Mpa) with this value the concrete is used for structural applications.
- The utilization of bottom ash in concrete production proves to be an useful solution in terms of economical and environmental aspects.
- In future, further research can be done by using bottom ash in concrete, and adopting different combination of additive, for better results.
- The density of Bottom Ash concrete decreases with the increase in bottom ash content due to the low specific gravity of bottom ash as compared to fine aggregates.

  Specific gravity of bottom ash=2.12

  Specific gravity of fine aggregate=2.44

REFERENCES

[1] Hypo Sludge Paver Blocks - Mithun & Chethan Kumar N T, IJATES, Vol 04, Issue 07, June 2016.

[2] Aggarwal, P., Aggarwal, Y., & Gupta, S. M. (2007, February). Effect of Bottom ash as replacement of fine aggregates in concrete. Asian Journal of Civil Engineering (Building and Housing) (AJCE), 8(1), 49-62.

[3] IS 456 :2000. Plain and Reinforced Concrete - Code of Practice (Fourth Revision). Bureau of Indian Standards (BIS), New Delhi.

[4] IS 10262 : 2009. Concrete Mix Proportioning - Guidelines (First Revision). Bureau of Indian Standards (BIS), New Delhi.

[5] IS : 383 - 1970 (Reaffirmed 2002). Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision). Bureau of Indian Standards (BIS), New Delhi.

[6] M.S.Shetty (2013).Concrete Technology, S.Chand & co Publishing Company.