Experimental investigation on partial replacement of fine aggregate by the effect of Coal bottom ash in concrete

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Abstract. The fine aggregate is one of the most important constituent in concrete. It will enhance the property like strength, thermal and elastic characteristic of concrete. Owing to minimize the use of “fine aggregate in concrete, the considered amount” of its weight has to be replaced with some other alternative material. Performance of the concrete becomes economically feasible when coal ash powder is used for concrete. “In this investigation, fine aggregate is replaced” with coal bottom ash in different proportions like 20%, 30% and 50%. The strength properties like compression and split tension were compared with two different days of curing. The result reveals the increased in compressive strength was found to vary from 13.2% to 45.57% and maximum split tensile strength was from 12.43% to 54.91% in 28 days of curing the concrete.

1. Introduction
The strength characteristics of concrete will always depend upon the different materials used for construction. Aggregate used in concrete to enhance the strength, thermal and elastic property. In this project, coal bottom ash powder is taken as alternate material for fine aggregate. The coal ash is replaced at different levels 20 %, 30 % and 50 % by weight of fine aggregate in concrete. The results were analyzed with the control specimen with no replacement. According to P.Chindaprasirt et al\textsuperscript{2} (2004) the effect of coal bottom ash will enhanced the various properties of concrete such as workability, bleeding, setting times, compressive strength, split tensile strength, flexural strength, shrinkage etc.

2. Material Used and Description of Materials
All the materials used in this project are accordingly to I.S. specifications

2.1 Cement
The cement which we had used in this work is 43 grade of Ordinary Portland Cement conform according to IS: 8112-1989. And the specific gravity was found using pycnometer bottle is 3.15

2.2 Water
Drinking water available in Concrete Laboratory was used for casting of all the specimens. Based on the requirements of IS: 456-2000 the quality of water is tested and satisfies.

2.3 Fine Aggregate
The fine aggregate is brought from Cauvery River sand, Trichy. It has a specific gravity of 2.72. Sieve analysis for fine aggregate was conducted and the sand used conforming Zone III grading. The fine aggregate had sieved which passes through 4.75 mm I.S sieve.

2.4 Coarse Aggregate
The coarse aggregate used was hard broken granite stone. The coarse materials was sieved which is passes through 12.5 mm and retain on 4.75 mm IS sieves were used for this investigation.
2.5 Coal Bottom Ash
The coal Bottom ash as an alternate material is from Thermal power station at Allundur, near Trichy. According to M. Singh et al. (2013) the coal bottom ash is mainly comprise of fused coarse ash particles which is of fined mix powder is under Class C type of fly ash. The specific gravity was found to be 2.7. The physical property like Grey color and angular texture in shape and of well graded sand size materials and found to be 28 % of dry weight were observed.

3. Design Mix Proportion
In this work, M25 grade of concrete is taken as a mix proportion. Mix proportion which we adopt has water cement ratio of 0.36 under M25 grade of concrete is 1:1:2. In this fine aggregate weight is replaced by 20%, 30%, and 50 % of coal bottom ash.

3.1 Tested Specimens
In this project the strength properties like Cube Compression test and split tensile test is undergone. So totally two numbers of dimension (300mm height and 150 mm diameter) cylinder and dimension (150mm x 150mm x 150mm) cubes were tested. And it is examine separately for minimum 7 days and maximum for 28 days of curing.

| Mix No | Percentage Replacement of Coal Bottom Ash | Number of Casted cubes | Number of Casted cylinder |
|--------|------------------------------------------|------------------------|----------------------------|
|        |                                          | 7 days | 28 days | 7 days | 28 days |
| A1     | 0%                                       | 2      | 2       | 2      | 2       |
| A2     | 20%                                      | 2      | 2       | 2      | 2       |
| A3     | 30%                                      | 2      | 2       | 2      | 2       |
| A4     | 50%                                      | 2      | 2       | 2      | 2       |

4. Experimental Investigation
For any successful project work, numerous testing methods have to be performed and analyze before coming into the final discussion. The various tests to be performed for the present work are.

1. Compression Test on Cubes.
2. Split Tensile Test on Cylinders

4.1 Test Programme
The above two mentioned tests are conducted on M25 grade concrete with different proportions of Coal Bottom ash powder.

4.2 Cube Compression Test
Specimen used for the test is of standard dimension cubes were casted, cured and undergone through Compression Testing Machine of capacity 450 kN. The compression test was carried out with uniform stress of 14 N/sq mm / minute after the specimen had been centered in the testing machine.
4.3 Split Tensile Test
Cylindrical specimen of standard size of (diameter 150 mm and height 300 mm), is kept horizontally under Compression Testing Machine with the maximum load is applied throughout the specimen until the failure is observed through the surface.

5. Result and Discussion
This experimental test of different proportion of coal bottom ash is made to replace for fine aggregate shows that the increasing in strength like compression and split tension occur in maximum percentage of replacement.

5.1 Cube Compression Test
5.1.1 Effect on 0% Replacement
The Cube Compressive strength for 0% replacement coal bottom ash for fine aggregate shows that 13.4 N/mm$^2$ and 19.09 N/mm$^2$ for different days of curing.

Table 2: Cube compressive strength of concrete

| Mix No | Cube Compressive strength N/mm$^2$ at 7 days | Cube Compressive strength N/mm$^2$ at 28 days |
|--------|---------------------------------------------|---------------------------------------------|
| A1     | 13.4                                        | 19.09                                       |
| A2     | 13.6                                        | 23.73                                       |
| A3     | 13.8                                        | 24.2                                        |
| A4     | 14.3                                        | 27.79                                       |

5.1.2 Effect on 20% Replacement with Coal Bottom Ash
When 20% replacement of coal ash made in concrete reveals that increasing its compressive strength by 1.49% for 7 days and 13.82% for 28 days.

Figure 1. Cube Compressive strength for 20% replacement of Coal bottom ash
5.1.3 Effect on 30% Replacement
When 30% of replacement of coal bottom ash is made for fine aggregate shows that increasing its strength by 2.98% for 7 days and 27.02 % for 28 days.

![Figure 2](image2.png)

**Figure 2.** Cube Compressive strength for 30% replacement of Coal bottom ash

5.1.4 Effect on 50% Replacement with Coal Bottom Ash
Compressive strength for 50% replacement of fine aggregate was found to be increasing its strength by 6.71% for 7 days and 45.57 % for 28 days.

![Figure 3](image3.png)

**Figure 3.** Cube Compressive strength for 50% replacement of Coal bottom ash
Table 3. Percentage increase in compressive strength

| Mix No | % Increase in strength at 7 days (N/mm²) | % Increase in strength at 28 days (N/mm²) |
|--------|----------------------------------------|----------------------------------------|
| A1     | 0                                      | 0                                      |
| A2     | 1.49                                   | 13.82                                  |
| A3     | 2.98                                   | 27.02                                  |
| A4     | 6.71                                   | 45.57                                  |

5.2 Split Tensile Test

5.2.1 Effect on 0% Replacement

Split tensile strength for 0% replacement shows that 1.73 N/mm² and 2.83 N/mm² for 7 and 28 days respectively.

Table 4. Details of split tensile strength

| Mix No | Split tensile strength (N/mm²) | Split tensile strength (N/mm²) |
|--------|-------------------------------|-------------------------------|
| A1     | 1.73                          | 2.83                          |
| A2     | 1.94                          | 3.24                          |
| A3     | 2.16                          | 3.57                          |
| A4     | 2.68                          | 3.93                          |

5.2.2 Effect on 20% Replacement

For 20% replacement of coal bottom ash for fine aggregate shows that increase its strength by 12.23% for 7 days and 14.48% for 28 days respectively.

Figure 4. 20% replacement Split tensile strength
5.2.3 Effect on 30% Replacement
The split tensile strength for 30% replacement shows that increase its strength 24.85 % for 7 days and 26.14 % for 28 days.

Figure 5. Split tensile strength for 30% replacement

5.2.4 Effect on 50% Replacement
When 50% of coal bottom ash is made replacement in concrete shows that increase its tensile strength by 54.91 % for 7 days and 38.86 % for 28 days.

Figure 6. Split tensile strength for 50% replacement of coal bottom ash

5.2.5 Percentage increase in Split tensile Strength $N/mm^2$

Table 5. Total percentage increase in Split tensile strength

| Mix No | % Increase in Split Tensile test 7 days | % Increase in Split Tensile test 28 days |
|--------|-----------------------------------------|-----------------------------------------|
| A1     | 0                                       | 0                                       |
| A2     | 12.43                                   | 14.98                                   |
| A3     | 24.85                                   | 26.14                                   |
| A4     | 54.91                                   | 38.86                                   |
6. Conclusion

The test results reveal that on partial replacement of Coal bottom ash powder with fine aggregate shows the maximum compressive strength of 14.3 N/mm² for 7 days and 27.79 N/mm² for 28 days and it leads to improvement in percentage increase of its strength by 6.71% and 45.57% for 7 days and 28 days respectively and for split tensile strength it was observed that 2.68 N/mm² for 7 days and 3.93 N/mm² for 28 days, which develop the improvement in percentage increased in strength of 54.91% for 7 days and 38.86% for 28 days. Therefore it concludes that maximum replacement of coal bottom ash powder in concrete will improves the strength characteristics of concrete.

7. References

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