Effect on Compressive and Split Tensile Strength of Concrete by Partial Replacement with Coal Bottom Ash

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***ABSTRACT* - Concrete is one of the most widely recognized development material for the most part delivered by utilizing locally accessible ingredients. The present trend in concrete technology is towards increasing the strength of concrete to meet the demands of the modern construction. The aim of the study is to study the effect of coal bottom ash in the concrete. Coal bottom ash is a waste material thus replacement of coal bottom ash with fine aggregate reduced the use of fine aggregate and waste material come into use. In the present work the compressive and split tensile strength studies are carried out by the partial replacement of coal bottom ash with the fine aggregate. The coal bottom ash is added 15%, 25%, 35% and 45% for M20 grade concrete. Result shows the percentage increase in compressive and split tensile strength for 28 days.**

Key words: Coal bottom ash, Concrete, Compressive strength, Split tensile strength.

1. INTRODUCTION

Concrete is one of the most widely recognized development material for the most part delivered by utilizing locally accessible ingredients. The development of concrete has bought about the essential need for additives both chemical and mineral the performance of concrete. Concrete is used more than any other manmade material in the world. Hence varieties of admixtures such as coal bottom ash, fly ash, coconut fibre have been used so far.

At present, India is the third largest consumer of coal. About 524 million tons of coal is burnt in coal fired thermal power annually. They are the main source of production of coal ash. Indian coals have higher ash content up to 45% depending upon the source of the coal and result in large volumes of coal ash. As per Central Electricity Authority, India, report , 143 no coal fired thermal power plants with installed capacity of 133381 MW produced about 173 million tons of coal ash annually. With the capacity addition of 22282 MW by the end of 2017, the production of coal ash is estimated to about 220 million tons per year.

2. LITERATURE REVIEW

Many researchers have investigated the properties of concrete containing coal bottom ash as a replacement of natural sand in the past. Based on their studies, effects of coal bottom ash on properties of concrete containing coal bottom ash as fine aggregate are discussed.

Kim and Lee (2011) investigated the effect of fine coal bottom ash as a replacement of sand in concrete on compressive strength at 7 and 28 days. They observed that the compressive strength of bottom ash concrete mixtures was not strongly affected by the replacements of sand with fine coal bottom ash. The effect of coal bottom ash on compressive strength was lower due to higher cement paste in concrete.

Arumugam et al. (2011) observed that concrete mixtures incorporating 20% pond ash as sand replacement showed improvement in compressive strength over the control concrete at all the curing ages. However, compressive strength of concrete mixtures reduced with further addition of pond ash as sand replacement level from 20%.

Sani et al. (2010) found that at 3 days, the compressive strength of bottom ash concrete mixtures containing 20% and 30% washed coal bottom ash as replacement of sand was the highest as compared to compressive strength of other washed bottom ash concrete mixtures. Bottom ash concrete mixture containing 30% washed coal bottom ash as sand replacement recorded highest compressive strength at all the curing ages up to 60 days. They concluded that 30% replacement of sand with washed coal bottom ash in concrete is the optimum amount in order to get favourable strength, environment saving and a lowering cost.

Topcu and Bilir (2010) examined the effect coal bottom ash as fine aggregate replacement on the compressive strength of cement mortar at the age of 7 and 28 days. They observed that compressive strength of cement mortar decreased with the increase in coal bottom ash content and the decrease rate in 7-day compressive strength was similar to 28-day compressive strength. Compressive strength values of mortar incorporating coal bottom ash were lower than that of control mortar sample.

Kou and Poon (2009) investigated the effect of coal bottom ash on the properties of concrete. Saturated surface dry sand and coal bottom ash were used in their study. They observed that at a fixed water-cement ratio, the compressive strength of bottom ash concrete mixtures decreased with the increase in the coal bottom ash content at all the ages. However, at fixed slump range,

the compressive strength of bottom ash mixtures was higher than that of control concrete at all the ages. The improvement in compressive strength could be attributed to the decrease in free water-cement ratio.

Kurama and Kaya (2008) studied the effect of coal bottom ash as partial replacement of cement in concrete and observed that compressive strength increased with increase in quantity of coal bottom ash replacement up to 10%. At 56 days, compressive strength of concrete mixture containing 10% coal bottom ash as cement replacement surpassed by 5% to the compressive strength of control concrete. The additions of coal bottom ash higher than 10% lead to decrease in compressive strength at lower age of 7 and 28 days. However, at 56 days, compressive strength of bottom ash concrete mixtures at replacement levels up to 15% was higher than that of control concrete mix. Compressive strength of bottom ash mixtures with 25% replacement level was marginally lower than that of control concrete.

Yuksel and Genc (2007) investigated the possibilities of using coal bottom ash as fine aggregate in concrete. They found that 28-day compressive strength of bottom ash concrete mixtures decreased with increase in bottom ash content. Compressive strength of bottom ash concrete mixture containing 50% coal bottom ash as sand replacement was lower by 31.8% than that of control concrete. With 10% sand replacement with coal bottom ash, 90- day compressive strength of concrete decreased by 6.9%. This shows that coal bottom ash retards the gain in compressive strength of bottom ash concrete mixtures.

Andrade et al. (2007) observed that concrete mixtures made with coal bottom ash as equivalent volume replacement, correcting coal bottom ash quantities according to the moisture content showed very significant loss in compressive strength. However in case of concrete mixtures prepared with the addition of coal bottom ash as non equivalent volume replacement, without correcting coal bottom ash quantities according to the moisture content the compressive strength of bottom ash concrete was similar to that of control concrete.

Aggarwal et al. (2007) investigated the effect of coal bottom ash with varying levels from 20 to 50% as sand replacement on properties of concrete. They observed that compressive strength of bottom ash concrete mixtures was lower than that of control concrete mixture at all the ages. The difference in compressive strength of bottom ash concrete mixtures and control concrete mixture was less distinct after 28 days. Compressive strength of bottom ash concrete mixtures continued to increase with the age. At 90 days, bottom ash concrete mixture containing 30% and 40% coal bottom ash as sand replacement, achieved compressive strength equivalent to 108% and 105% of compressive strength of normal concrete at 28 days, respectively.

Yuksel and Genc (2007) observed that up to 10% sand replacement with coal bottom ash, there was no change in splitting tensile strength and thereafter, it decreased considerably with increase in coal bottom ash content. The maximum decrease in the splitting tensile strength was 58% for bottom ash concrete mixture containing 50% coal bottom ash as replacement of sand. The decrease in splitting tensile strength of bottom ash concrete mixtures was almost linear with increase in coal bottom ash content.

Aggarwal et al. (2007) found that splitting tensile strength of bottom ash concrete mixtures were lower than that of control concrete mixture at all the ages. At 90 days of age, bottom ash concrete attains splitting tensile strength in the range of 121-126% of 28-day splitting tensile strength of normal concrete.

Aramraks (2006) demonstrated that the compressive strength of bottom ash concrete mixtures incorporating 50 and 100% coal bottom ash as sand replacement was approximately 20 to 40% lower than that of natural sand concrete mixtures.

Bai et al. (2005) studied the effect of coal bottom ash as fine aggregate on compressive strength of concrete mixtures designed with fixed water-cement ratio and slump range. They observed that at fixed water-cement ratio, compressive strength decreased with the increase in bottom ash content in concrete mixture, while at fixed slump range of 30-60 mm, there was an improvement in compressive strength over that of control concrete at all the ages. For fixed slump range, the improvement in compressive strength could be attributed to reduction in water demand on use of coal bottom ash in concrete.

Chun et al. (2004) noticed that the compressive strength of concrete differed by the content of pond ash collected from each disposal site. With increase in content of pond-ash, there was relatively greater increase in compressive strength, compared to normal concrete, and such trend might be a consequence of decreased water-cement ratio induced by the absorption of mixing water.

Ghafoori and Cai (1998) investigated the effect of coal bottom ash on properties of roller compacted concrete. They observed that compressive strength development of bottom ash roller compacted concrete was similar to that of conventional concrete. At 7 days, bottom ash concrete mixtures achieved nearly 75% of the 28-day compressive strength. For bottom ash concrete mixtures containing 9, 12 and 15% cement, 90-day compressive strength exceeded 28-day compressive strength by an average of 19, 15 and 12%, respectively. At the end of 180 days of curing, the 28-day compressive strength was surpassed by 26%.

From the above literature review we have studied that as percentage of coal bottom ash increase the strength of the concrete increases. So we have concluded to add 0%, 15%, 25%, 35% and 45% of coal bottom ash in concrete to test for 7 and 28 days.

3. MATERIALS

The materials used are cement, coarse aggregate, fine aggregate, water and coal bottom ash.

Cement: The PPC (Pozzolena Portland Cement) of Ultratech was used in this study.

Fine Aggregate: The Fine aggregate used in the study confirms the properties of IS: 383-1970 in the grading zone II.

Coarse Aggregate: Crushed stone locally available zone III coarse aggregate confirming with code book IS 393-1970.

Water: Potable water for Experiments.

Coal bottom ash: Coal bottom ash used in this study was a waste product obtained from Guru Nanak Dev Thermal Plant at Bathinda-Malout Road, Bathinda, Punjab. With specific gravity 2.46.

4. METHODOLOGY

Total 60 concrete specimens were casted which Includes 30 cubes & 30 cylindrical specimens of M20 mix with different CBA % (i.e. 0%, 15%, 25%, 35% and 45%), of each CBA% 6 cubes and 6 cylindrical samples were casted, out of which 3 cubes having dimensions 150mm x 150mm x 150mm and 3 cylindrical specimens having dimensions 150mm x 300mm are casted for 7 days and three cube and three cylinder for 28 days strength determination.

5. RESULTS AND DISCUSSION

In this work M20 grade of concrete is selected for the proportions of 1:1.5:3 and water ratio of 0.5 and various studies are conducted to observe the responses. In addition to ingredients coal bottom ash is added of percentages 0%, 15%, 25%, 35% and 45%.

5.1. Effect of Compressive Strength

The compressive strength results are tabulated in table.1. The graph is plotted on X-axis the percentage addition of coal bottom ash and on Y-axis compressive strength in fig.1.

Table 1 Compressive Strength

S.no.	% of addition	Compressive strength (N/mm^2) 7days	Compressive Strength(N/mm^2) 28 days
1	0	13.04	20.07
2	15	11.48	22.96
3	25	10.74	24.07
4	35	6.08	27.03
5	45	6.00	24.14

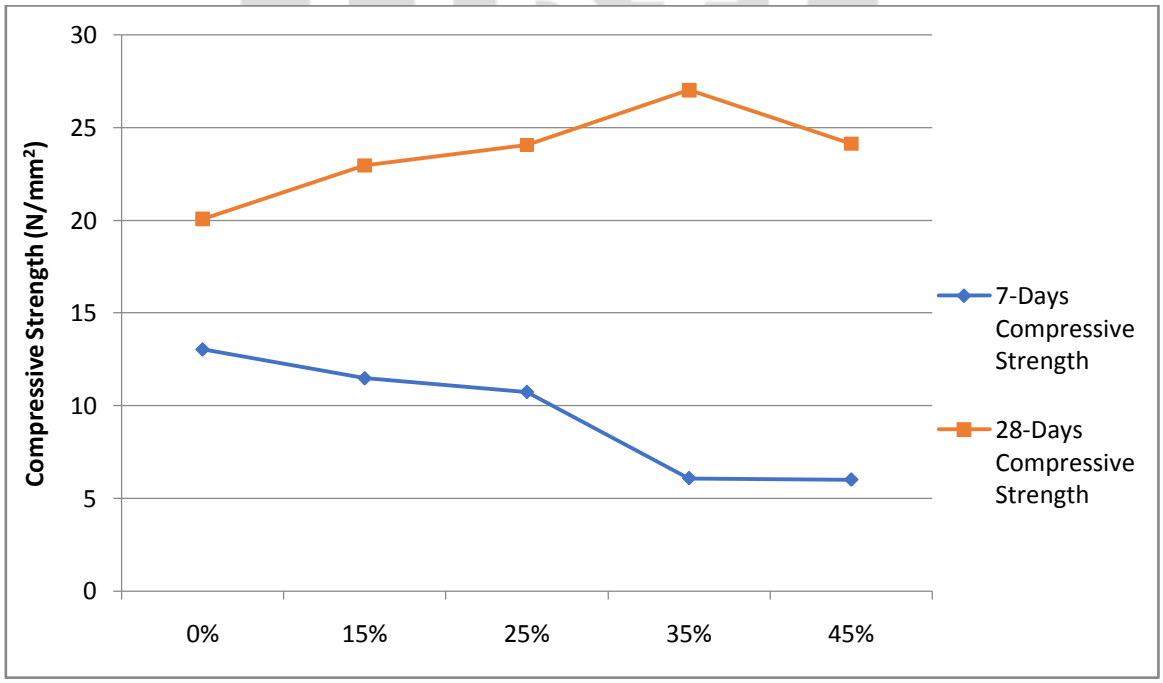

Fig. 1: Effect on Compressive Strength

5.2. Effect of Split Tensile Strength

The Split tensile strength results are tabulated in table.2. The graph is plotted on X-axis the percentage addition of coal bottom ash and Y-axis Split tensile strength in fig.2.

Table 2 Split Tensile Strength

S.no.	% of addition	Split tensile strength (N/mm^2) 7 days	Split tensile strength (N/mm^2) 28 days
1	0	1.97	3.10
2	15	1.78	2.72
3	25	1.15	3.26
4	35	1.03	3.50
5	45	0.63	3.36

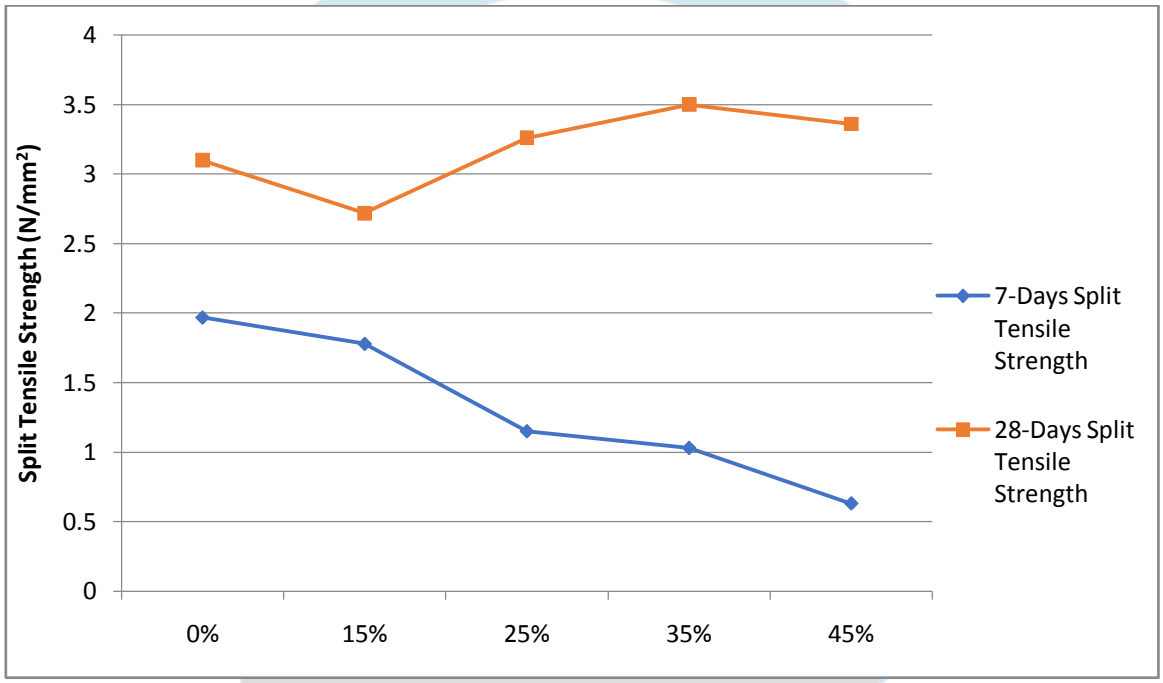

Fig. 2: Effect on Split Tensile Strength

6. CONCLUSION

From the present study the following conclusions can be drawn:

As the percentage addition of coal bottom ash in concrete increases, its 7- Days compressive Strength decreases whereas 28-Days compressive strength increases, maximizing at 35%, after which the strength starts decreasing. In case of split tensile strength test, similar trend of reduction in 7-Days split tensile strength was observed as the percentage of coal bottom ash in the concrete increases and increase in 28-Days Split tensile strength was observed upto 35% after which it starts decreasing.

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