

# UTILIZATION OF BOTTOM ASH IN HYDRAULIC STOWING FOR REPLACEMENT OF SAND AND FLY ASH

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**Abstract** - Since last few decades river sand has been recognized as a suitable stowing material due to its properties favorable for stowing. Hydraulic sand stowing in underground coal mines has been popular due to its simplicity in its operation. In India. The scarcity of river sand made the sand stowing operation practically infeasible now a days. On the other hand, bottom ash, the coal combustion, the coal combustion by products (CCBs), which are generated from the thermal power plants in abundance, creates environmental problems and requires safe disposals and utilization in bulk, realizing the problem of both the mining and power sectors and studying the properties of fly ash the researchers have identified a suitable alternative to river sand for stowing in an effective manner in India, initiatives have been taken and fly ash stowing in small scale has been done on trial base on two mines PK-1 of Singareni collieries company limited (SCCL) and Durgapur Raitawari number 4 mine in the Chandrapura area of western coal fields ltd. (WCL). In these two mines fly ash stowing has been done. The scarcity of fly ash also increased due to utilization of fly ash in Cement Company so the demand has been increased to the fly ash another alternative has been introduced that is bottom ash as stowing material because it has similar properties of sand. Like it has coarser and heavier than fly ash with a gritty and sand-like texture, collected at the bottom of boiler furnace, bottom ash stowing in small scale has been done on trial bases in one mine named RK-7 of Singareni collieries' company limited (SCCL) the stowing results of these cases is highly encouraging, however, some of the basic problems are to be in the coming stowing and brief case studies of bottom ash stowing status of the above mines.

**Key Words:** Weight machine, Bottom ash (CCBs), Mechanical sieves, Fisher analyzer, Oven, moisture, Muffle furnace.

## 1. INTRODUCTION

Stowing operation in underground coal mines is an important activity for strata control and minimization of surface subsidence. River sand possesses the properties of an excellent stowing material and sand stowing operation has been very much popular and widely adopted in Indian underground coal mines. The hydraulic sand stowing operation is very simple and has got the advantages like easy segregation of sand and water, quicker drainage of water, less clogging of the pores of the barricade and minimal hydrostatic pressure on the barricade, offering maximum consolidation and strength with minimum shrinkage etc.. In present days. The scarcity of river sand leads the mine

management to think for an alternative stowing material which is easily available in the near by coal mines at a minimum cost.

Bottom ash which is generated from the thermal power plants after burning pulverized coal causes environmental problems and requires huge area of land for its disposal. Nearly 75% of India of total installed power generation capacity is thermal, of which is coal-based generation capacity is thermal, of which coal-based generation is 90%. The thermal power stations, besides several captive power plants usually, the underground coal mines and power plants are located very close to each other and as a result the power sector will get safe disposal side for bottom ash and mining sector will get economically filling material yielding better safety and stability in mines. In addition to this, dumper are engaged in transporting coal to thermal power stations can bring bottom ash back to the coal mines for stowing during their return trip. Thus, by mutual cooperation of power plant and mining sector, the problem and cost may highly be reduced at both ends.

Through it is generally felt that bottom ash may not be effective as sand stowing, it can be efficiently utilized as a stowing material along with sand if properly stowed with improved technologies. It will not only be an excellent alternative to sand as a stowing material, but can be beneficial to both the mining as well as power sector in terms of stowing and disposal problems point of views. A number of studies have already been made to ascertain problems and prospects of hydraulic stowing with bottom ash. It has been cited by many authors and researchers that bottom ash can be utilized as stowing material like other stowing materials examples. sand and fly ash (Karfakis et al. 1996). With the utilization of maximum quantity bottom ash for strata control in the underground mines, the aforesaid problems of sand stowing as well as problems, caused by the large quantities of finely divided coal combustion by-products (CCBs) generated by the power plants may be reduced.

### 1.1 Bottom ash-generation and classification

Bottom ash is coarser and heavier than fly ash with a gritty and sand-like texture collected at the bottom of boiler furnace particular material produced out of burning of pulverized coal in the thermal power plant stations during generation of electricity. This micron sized finely which is heavier and collected at the bottom of the furnace. Bottom

ash is known as coal ash. The types of coal ash from coal based thermal power plants are:

- Fly ash: Collected from different rows of electrostatic precipitator.
- Bottom ash : Coarser and heavier than fly ash with a gritty and sand like texture, collected at the bottom of boiler furnaces
- Pond ash: Mixture of bottom ash and fly ash as available in disposal ponds

Of the total ash generated from the thermal power plants where pulverized coal is combusted in a dry-ash dry ash., bottom boiler, nearly 80% is the fly ash 20% is the bottom ash. Fly ash and bottom ash are sluiced together with water has ash slurry to the ash ponds:

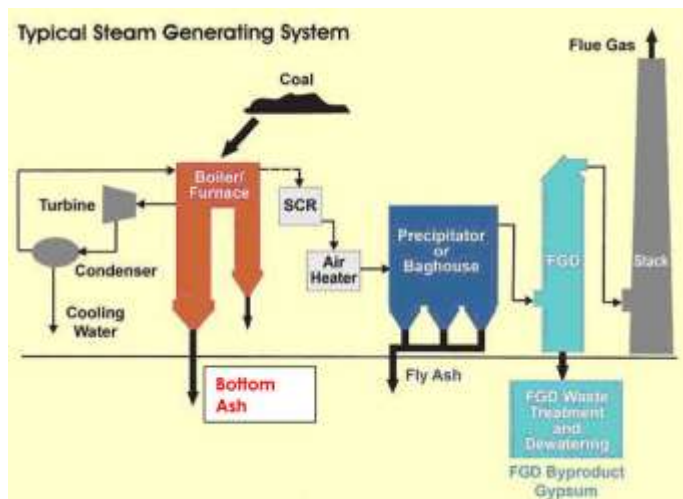


Fig 1: Bottom ash generation in power plant

### 1.2 Chemical composition and classification of bottom ash

The composition of bottom ash varies with the constituents of the coal and influenced to a great extent by the geological and geographical factors related to coal deposit, the combustion conditions, and the removal efficiencies of the control devices. Mainly the nature of the mineral matter and organic constituents in a coal determine the chemical composition of the resulting ash during combustion (guijian et al 2014).

So far the chemical composition is concerned, bottom ash primarily consists of silicon dioxide( $\text{SiO}_2$ ), aluminum oxide( $\text{Al}_2\text{O}_3$ ), iron oxide( $\text{Fe}_2\text{O}_3$ ), and calcium oxide ( $\text{CaO}$ ) (Openshaw et al 1992) with little amount of  $\text{MgO}$ ,  $\text{MnO}$ ,  $\text{P}_2\text{O}_5$ ,  $\text{K}_2\text{O}$  and  $\text{TiO}_2$  (Mishra and Das, 2006).

Table-1 chemical composition

Chemical composition	Bottom ash percentage
Silica, $\text{SiO}_2$	54.8 %
Alumina, $\text{Al}_2\text{O}_3$	28.5 %
Iron oxide, $\text{Fe}_2\text{O}_3$	8.49 %
Titania, $\text{TiO}_2$	2.71 %
Magnesia, $\text{MgO}$	0.35 %
Calcium oxide, $\text{CaO}$	4.2 %
$\text{Na}_2\text{O}$	0.08 %
$\text{K}_2\text{O}$	0.45 %
$\text{P}_2\text{O}_5$	0.28 %
LOI	2.7 %

### 2. Suitability of bottom ash for stowing

The suitability of a particular material for stowing in the underground coal mines depends on its availability, cost, and the stowing system being employed (Karfakis et al. 1996). The material to be used for stowing should be as cheap as possible and plenty available near by, should be inert in nature, should possess minimum abrasiveness to prevent abrasion of the pipe line etc. other parameters which are equally important are particle size distribution, permeability (for successful stowing operation, the rate of drainage through the stowed mass should be high), presence of carbonaceous materials, strength and deformation characteristics, consolidation and shrinkage, compressibility, stability and load bearing characteristics of overlaying strata etc. (Bhattacharya, 2013).

The material to be used for stowing in the underground coal mines should be inert in nature and devoid of carbonaceous matter. The presence of carbonaceous matter causes auto oxidation and responsible for the generation of heat from the proximate analysis, it was found that bottom ash contains very negligible percentage of fixed carbon (F.C) . Also from crossing point temperature (CPT) and ignition point temperature (IPT) analysis, it was found that the ash samples do not reach to the bath temperature till  $200^\circ\text{C}$ . Hence, it is clear that bottom ash is not susceptible to spontaneous heating and can be safely used for stowing material in the underground coal mines (Kumar et al. 2003).

Bottom ash is mainly composed of coarser and heavier than fly ash with a gritty and sand-like texture, collected at the bottom of the furnace having diameter from (4.75 mm) similar to river sand which is favorable for hydraulic transportation during hydraulic stowing due to less head loss, less energy cost and transportation cost through pipes (Ghosh et al. 2006). In other words, energy consumption associated with its transportation for the same volume to be stowed below the ground. Apart from this, no elaborate screening arrangement is required in stowing plant. Coarse

particle sizing and sand like texture and spherical shape particles enhance mix flowability i.e. allowing them to flow and blend freely in mixtures

## 2. LABORATORY INVESTIGATION

**2.1 Sieve analysis of bottom ash:** It is an analysis of bottom ash expressed in terms of various sizes that can be collected at various sizes of bottom ash will be collected in successive sieves and the sieved sample ranging from 600 to 150 micron size can be used for testing for proximate analysis test.



Fig 2: Mechanical sieves

**Proximate analysis of bottom ash:** It is the analysis of bottom ash expressed in terms of moisture, ash, volatile matter and fixed carbon. ISI.NO.IS:1350(PART 1)- 1969

### PROCEDURE

- switch on the fisher analyzer printer and balance set moisture temperature to 108°C
- Take approximately one gram of sample into each crucible by accurately weighting
- Keep the crucibles without lids in the oven and set time duration 1 hour for moisture analysis.
- After 1 hour crucibles are taken out and covered with lids allowed to cool in open and later in desiccators for 15 min and weighed proceed.
- Raise the temperature from 110°C to 900±10 for V.M as per IS: 1350 all the crucible with lids are kept in furnace for exactly 7 minutes at 900 and taken out.
- Allowed to cool in open and later in desiccators for 15 min. and weighed.
- Temperature is set to 815±10 °C time is set to 180 min for analysis of ash.
- After attaining the set temperature the same crucible without lids are transferred to furnace. After 3 hours the crucibles are taken out covered with lids and allowed to cool in open and later in desiccators for 15 min and weighed.
- Results are calculated.

### Moisture

Water (or) liquid diffused (or) condensed relatively small quantity in bottom (solid)

Take nearly 1 gram in silica dish and kept in oven for 1 1/2 hour at 108±2 °C after that loss in

Weight is calculated by the following formula

$$\text{moisture \%} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where,

$W_1$  = Weight in grams of a vessel plus cover

$W_2$  = Weight in grams of a vessel plus covered sample before heating

$W_3$  = Weight in grams of the vessel plus covered and sample after heating

$$1) \text{ Moisture \% } (M_1) = \frac{28.6371 - 28.6271}{28.6327 - 27.5455} \times 100$$

$$2) \text{ Moisture \% } (M_2) = \frac{29.8428 - 29.8384}{29.8428 - 29.0014} \times 100$$

$$(M_2) = 0.52\%$$

Average moisture of both values will be taken as moisture

$$M = \frac{M_1 + M_2}{2} \times 100$$

$$M = 0.52$$

### Ash

It is an inorganic residue left when bottom /coke is heated under specific conditions

Take nearly 1 gram of coal sample in silica dish and kept in furnace for 1 1/2 hour at 815±10°C then it gives ash

Ash is calculated by the following formula

$$\text{Ash} = 815 \pm 10^\circ\text{C} - \text{Temp}$$

For calculation,

$$\text{Ash \%} = 100 \times \frac{W_3 - W_1}{W_2 - W_1}$$

$W_1$  = Empty dish

$W_2$  = Empty dish + sample

$W_3$  = Empty dish + ash (After taking out of sample)

$$1) \text{ Ash \% } (A_1) = 100 \times \frac{W_3 - W_1}{W_2 - W_1}$$

$$= 99.17\%$$

$$2) \text{ Ash \% } (A_2) = 100 \times \frac{W_3 - W_1}{W_2 - W_1}$$

$$= 99.11\%$$

Average moisture of both values will be taken as moisture

$$A = \frac{A_1 + A_2}{2} \times 100$$

$$A = 99.14\%$$

**Volitle matter:** The volatile matter is loss in weight less that due to moisture when coal (or) coke is heated under specific condition

Take nearly 1grams of coal sample in silica dish and kept in furnace for 7 min at 900±10°C with lids. After that loss in weight gives some value and substract the moisture from it.

V. M = 900 ± 10°C - Temp

$$V. M \% = 100 \times \frac{W_2 - W_3}{W_2 - W_1}$$

$$1) \text{ V.M \% } (V_1) = \frac{14.0928 - 14.0916}{14.0928 - 123.3246} \times 100$$

$$(V_1) = 0.16\%$$

$$2) \text{ V.M \% } (V_2) = \frac{13.9734 - 13.9722}{13.9734 - 13.2556} \times 100$$

$$(v_2) = 0.17\%$$

Average moisture of both values will be taken as moisture

$$V.M = \frac{V_1 - V_2}{2} \times 100$$

$$V.M = 0.16$$

**Fixed carbon:** Fixed carbon is obtained by subtracting from 100 the sum of the percentages by

Weight of moisture %, Ash %, volatile mater.

It is mostly carbon with small amount of hydrogen, Nitrogen, sulphur and oxygen

$$\text{Fixed carbon} = 100 - (A\% + M\% + V.M\%)$$

$$= 100 - (0.52 + 99.14 + 0.16)$$

$$= 0.18$$

### 3. RESULTS AND DISCUSSION

Table-2 proximate analysis

S.NO	Tests	Values
1.	Moisture	0.52
2.	Ash	99.14
3.	Volitle	0.16
4.	Fixed carbon	0.18

Table-3 sieve analysis

s.no	Sieve no (micron)	% Retain on sieve
1.	1700	11.22
2.	850	5.62
3.	600	0.40
4.	425	5.74
5.	300	7.45
6.	212	12.81
7.	150	10.52
8.	106	7.44
9.	75	7.66
10.	53	14.98
11.	53	16.18

**Duscussion:** The above tables shows that the results does not have any volatile matter and ash contain in bottom ash. So that the bottom ash used as stowing material in the underground mines is safe and the ash is inert in nature. And ash having retain in 600 to 150 micron size can be used in lab for testing that can give is about 85% to 96% accurate value as per DGMS circular per CMR. And this bottom ash is used in stowing along with the sand by that sand will be consumed less. And also more efficient as stowing material.

### 4. CONCLUSION

Fly ash has got the potential for beneficial use in a variety of applications including construction material, mine land reclamation, soil amendment, structural fills, and extraction of valuable trace elements. So the demand of the fly ash has been increased so another waste produced from the thermal power plants that is bottom ash so the bottom ash is used as stowing material in the place of fly ash. Because the main reason for utilizing stowing material is due to inertness of the bottom ash and having same less chemical composition than fly ash and also having sand like texture. In near future, it is going to be a major alternative to river sand as a stowing material. It has been found that bottom ash and fly ash possess properties suitable of stowing and hydraulic stowing of bottom ash and underground coal mines is gaining popularity in India. In some of the Indian mines bottom ash stowing has been done on trails bases with increasing results, due to its physical and chemical properties, but no mine have gone for large scale stowing yet now a days it was initiated in south Indian mines (SCCL). If proper stowing technique will be adopted for better utilization of bottom ash in future, the hydraulic stowing with bottom ash to be made technically feasible in India. This means of bulk utilization to minimize the problems associated with bottom ash and its disposal in the place of fly ash for hydraulic stowing.



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