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Laboratory studies on air permeability to find suitability of fly ash and over burden materials for filling of voids in fire affected mine

Coal mine fire is a major threat from safety and economic point of view. It poses danger to safety of human life, land subsidence and environment problems. Surface blanketing by incombustible material is required to control long standing and extensive surface fires. Scarcity of suitable soil for blanketing the cracks and filling of voids, have generated need to search for alternative filling material. Overburden (OB) of opencast projects alone may not serve the purpose due to existence of passage of air path and carbonaceous shale present in it. Utilization of fly ash in combination with suitable proportion of OB. may be a viable alternative to soil for filling and blanketing in fire affected areas. Thus it may be a major thrust area for research.

Studies were conducted in the laboratory using a specially designed set up to study the efficacy of fly ash in different combinations with OB as a filling material. The paper discuses, the set up used for the study, experimental procedure and results of investigation. The experimental results indicated that the air leakage characteristics through OB and fly ash packing individually or in combination vary significantly. Further, the air leakage rate also increases on drying of the mixture.

Introduction

The problem of coal mine fire particularly in Jharia coalfield is one of the major threats from safety point of view. It has been reported [1-3] that around 70 active fires covering an area of about 9.5 sq. km exist in this coalfield. Fire has come out up to the surface through cracks and subsided areas due to shallow cover. The coal companies have already lost millions of tonnes of coal and substantial economic losses due to fire. The present scenario of fire at many locations is critical and a major threat for the safety of the people living in and adjoining areas and important surface structures viz. road and rail lines passing through the affected zones [4-5].

To control these long standing and extensive fires, surface blanketing by incombustible material is required. However shortage of suitable soil for surface blanketing is a major constraint. It is therefore necessary to develop suitable and cost-effective filling material to overcome the problem.

Filling/packing [6] with OB of opencast projects alone may not serve the purpose as sufficient air space is left in it. Furthermore, carbonaceous shale generally present in OB may also cause spontaneous heating.

At many places fly ash has been tried for filling of voids/ surface blanketing, as the risk of spontaneous heating is minimum. Coal fly ash has been successfully used as a structural fill or embankment material for highway construction projects in a number of different locations throughout the United States [7-10]. However, fly ash does not have self binding property [11] and may cause air leakage on drying. Availability of fly ash in adequate quantity in Jharia coalfield is also a problem.

In view of the above studies were conducted in the laboratory to study the air permeability characteristics of over burden and fly ash separately as well as in different combinations. This paper discusses in brief the experimental set up specially designed for the purpose and the results of investigation. From the study it is evident that there is considerable reduction in air leakage rate through the mixture of fly ash and overburden. However it is observed that addition of setting agent in the fly ash may yield further advantages and improvement.

Experimental

The set up

A special type of set up has been designed, shown in Fig.1, to determine the leakage through over burden, fly ash and its mixture. The set up consist of:

(1) A GI pipe with a diameter of 0.15 m and 1.5 m long, has two numbers of detachable lids. One nipple on either of the lids for connecting the pipes.

(2) A compressor for passing the air through the experimenting material.

(3) A Benz manometer to record the pressure.

(4) A wet gas flow meter to record the air flow rate.

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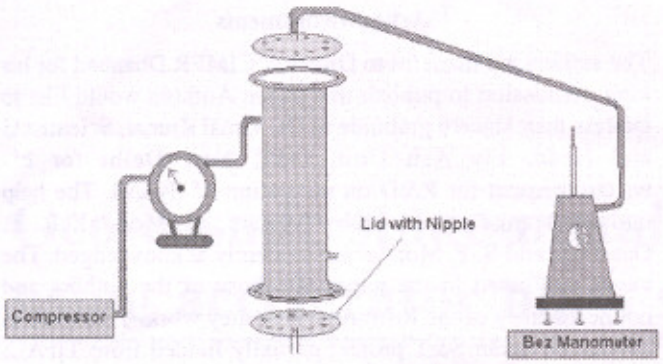

Fig.1 Experimental set up for determination of air leakage

EXPERIMENTAL PROCEDURE

About 30 kg of OB sample was collected from a running opencast project of BCCL for the study of leakage rate was collected. The OB sample collected contained mainly sandstone, shaly sandstone, carbonaceous shale and shale with a few pieces of coal also. The average size of the overburden lumps were between 1" and 5". Fly ash sample was taken from Chandrapura thermal power station.

Air permeability characteristics of overburden and fly ash were studied in laboratory separately for OB and fly ash as well as in combination. Five set of experiments were conducted in the laboratory using the above set up. Brief description of the experimental procedure and the results are discussed below.

Study of leakage characteristics through overburden

To study the leakage characteristics through overburden in a specially designed experimental set up discussed earlier was used. First of all the air flow through set up under blank condition was determined. After the study of the blank condition, the pipe was packed with the overburden collected from running OCP of BCCL. Nearly 30 kg of overburden were taken for the experiment. This contained mainly sandstone, shelly sand stone, carbonaceous shale and shale with a few pieces of coal also. The average size of the overburden lumps were between 1" and 5".

30 kg of overburden was consumed for packing of the 1.5m length and 0.15m diameter GI pipe. Top and bottom lids of the set up as shown in Fig.1 was closed. A wet gas flow meter having the least count 20cc/minute was connected from nipple of top lid with the help of PVC tubing. A Benz manometer was connected with the nipple provided towards the bottom end of the pipe.

The air flow through the pipe, packed with overburden was provided through air compressor. To determine the air leakage rate through the overburden, air flow rate at different pressure were recorded. For measuring air flow rate wet gas flow meter and for pressure at different pressure Betz Manometer was used.

Study of leakage characteristics through over burden and fly ash

First of all around 16.5 kg of fly ash and water slurry was poured into the G.I pipe in the ratio of 1:1.5 (fly ash : water) and 30 kg of overburden consisting of mainly sandstone, shelly sandstone, carbonaceous shale and shale with a few pieces of coal was packed into the pipe and allowed to settle. The bottom of the pipe was sealed with jute to allow the water to pass through it. After the settlement of material both the lids were closed and a wet gas flow meter was connected to the upper nipple of the pipe to control the flow of air at known rate. A Betz manometer was connected to the side lower nipple of the pipe to record the pressure developed due to passage air through the material.

Results

Air leakage through the blank set up, cylinder filled with OB, with OB and fly ash and with fly ash only was determined. The results are graphically depicted in Figs.2 to 5 respectively.

Further, another set up of experiment was conducted to determine efficacy of fly ash under different mode of packing. In this experiment 1m of the cylinder was packed with OB and fly ash as mentioned above and the remaining 0.5m topmost portion of the cylinder was filled with fly ash slurry only. The results of the experiment are graphically represented in Fig. 6.

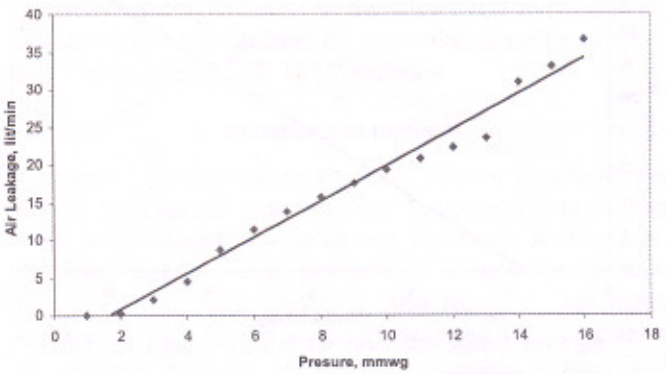

Fig.2 Air leakage in blank condition

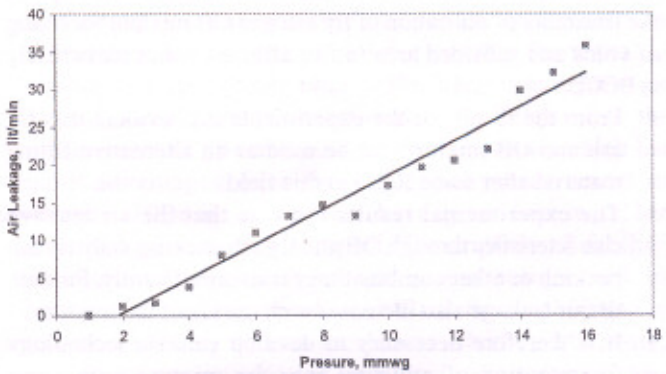

Fig.3 Air leakage filled with OB

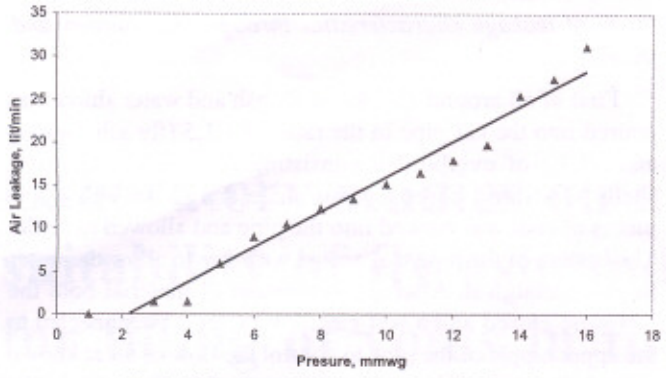

Fig.4 Air leakage filled with OB and fly ash

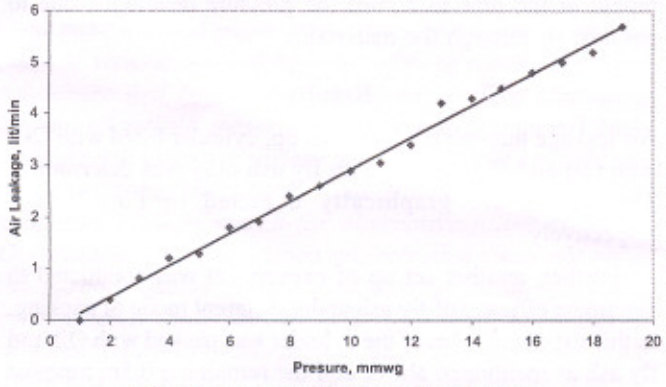

Fig.5 Air leakage filled with fly ash only

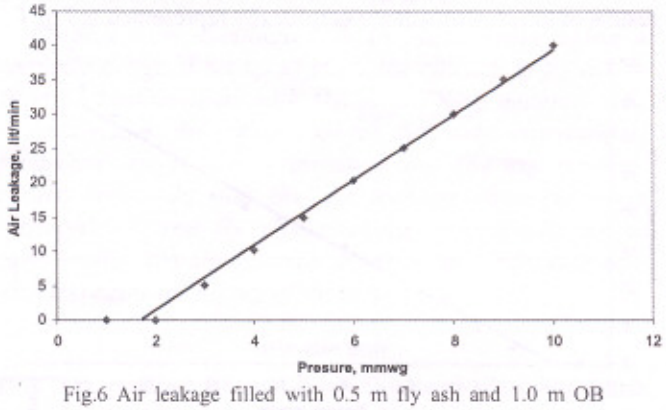

Fig.6 Air leakage filled with 0.5 m fly ash and 1.0 m OB

Conclusion

The experiments conducted in the laboratory were to explore the feasibility of utilization of fly ash and OB mixture for filling of voids and subsided area in fire affected zones particularly in BCCL.

- From the results of the experiments it is evident that fly ash and OB mixture can be used as an alternative filling material after some R&D in this field.
- The experimental results indicate that the air leakage characteristics through OB and fly ash packing, only fly ash packing or other combination varies significantly. Further, the air leakage also increases with drying of the mixture.
- It is therefore necessary to develop suitable technology for retention of moisture into the mixture with some cementing property for effective sealing.

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References

1. Coward, H. F. (1957): "Research on spontaneous combustion of coal in mines - A review", SMRE, research Report No 142.
2. Banerjee, S. C. (2000): "Spontaneous combustion of coal and mine fires", Publisher: Oxford and IBH publishing Co. Pvt. Ltd., Kolkata, pp.165.
3. Kaku, L C. (2004): "D G M S Circulars" Circular No 2/1967, Edition October, Lovely Prakashan, Dhanbad, pp. 375.
4. Mitra, D. K. (1996): "Fire in Indian coal mines - An overview", Proc. MIF, pp. 43-63.
5. Banerjee, S. C., Singh R. G and Bagchi, S. (1976): "Surface coal fires", Seminar on Surface fires at CMPDIL Ranchi, 20 May.
6. Jhanwar, J. C., Nanday, D. K., Banerjee, S. C. (1992): "Identification of causative factors influencing the fire risk in panels involving thick seams of Jharia field" Int. Symposium on thick seam mining - Problems and Issues, 19-20 Nov., CMRI, Dhanbad, pp 647-656.
7. Collins, Robert J. and Ciesielski, Stanley K. (1994): "Recycling and Use of Waste Materials and By-Products in Highway Construction", Volume 2 - Technical Appendix. National Cooperative Highway Research Program Synthesis of Highway Practice No. 199, Transportation Research Board, Washington, DC.
8. Patelunas, G. M. (1986): High Volume Fly Ash Utilization Projects in the United States and Canada. Electric Power Research Institute, Report No. CS-4446, Palo Alto, California, May.
9. Collins, R. J. and Srivastava, L. (1989): "Use of Ash in Highway Construction: Delaware Demonstration Project" Final Report. Electric Power Research Institute, Report No. GS-6540, Palo Alto, California, November.
10. DiGioia, Anthony M., Jr. and Nuzzo, William L (1972): "Fly Ash as Structural Fill," Proceedings of the American Society of Civil Engineers, *Journal of the Power Division*, New York, NY, June.
11. Yang, Yu-Fen (2006): "Surface modification of purified fly ash and application in polymer", *J. Hazarardous Materials*, Issues 1-3, pp. 276-282.