SAND-STOWING

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SUMMARY

Sand-stowing was first tried at Ballarpur about 1914 and subsequently introduced in the Jharia, Raniganj and other coalfields. Stowing has both advantages and disadvantages; the main objection is economic because it raises the cost of production of coal.

Hydraulic stowing is most suitable in India as there are apparently adequate supplies of sand and water in the rivers near the coalfields. The Coal Mines Stowing Board, set up in 1939, for providing for safety in coal mines by stowing, grants assistance for stowing for certain specific purposes. Although some private firms have been stowing in the different coalfields for safety in the mines while aiming at maximum extraction, it is a fact that sand-stowing so far has been extended for safety only and not also for conservation. The scope of stowing, therefore, should include the conservation aspect as well.

The Jambad-Kajora and the Jharia fields are in urgent need of stowing in the immediate future, where 3½ to 4 and 27 million tons respectively of sand will be required. The scope of stowing will further increase if and when underground gasification of coal is undertaken in this country.

As regards the sand in the rivers adjacent to the Raniganj and the Jharia coalfields, it has been estimated that in the former area 990 million tons of sand containing about 15 to 20% of clay are available, while in the latter some 140 million tons of sand together with 25 to 30 million tons of older alluvium are available. The quantity is considered to be sufficient for the Raniganj coalfield, but the amount is inadequate to meet the probable future requirements of the Jharia field. Hence there is the necessity for extensive research for finding out new material for stowing.

The question of the annual replenishment of sand will be more complicated after dams have been built across the Damodar and its tributaries, when practically all the sand and silt will be deposited in the reservoirs and they will have to be removed by dredging. The afforestation programme of the Damodar Valley Corporation in the catchment of the Damodar river system may further reduce the annual replenishment of sand in the rivers.

INTRODUCTION

The Damodar Valley has been referred to as the Ruhr of India. The coalfields in this valley are responsible for about 80% of the total output of coal in India valued at 35 crores of rupees. For the efficient and maximum extraction of coal, sand-stowing is becoming more and more important in the coalfields in the Damodar Valley and in other areas. Sand-stowing is the process of filling up with sand of the space which was previously occupied by coal but subsequently emptied by the extraction of the latter. This was practised for the first time in the United States of America about the year 1892 with the object of protecting buildings on the surface and also the surface itself. In India the introduction of this process is comparatively new; it was first tried at Ballarpur in Madhya Pradesh about 1914 and subsequently introduced in the Jharia coalfield about 1919. Since then it has gained further popularity and the method has since been introduced in certain parts of the Raniganj and Bokaro coalfields in Bengal and Bihar and also in other coalfields in India. At present there is one other country, viz. Poland, which practises hydraulic stowing comparable to that in India and where for the present production of 70 million tons of coal, 11 million cubic metres of sand are stowed; the respective quantities for India being 31 million tons of coal and 38 lakhs tons of sand in 1949.

ADVANTAGES AND DISADVANTAGES OF STOWING

By recourse to stowing most of the dangers arising from subsidences, fires, premature collapses, explosions and flooding in coal mines can be avoided and also

by this the maximum percentage of recovery can be effected without any loss of unworked coal and in a general way the working conditions for miners are made more safe. Stowing also helps in the concentration of operations in connection with winning of coal, improves ventilation and makes haulage and traffic underground much safer. As against the above advantages the main objection to stowing is economic—it involves a cost which goes to increase the cost of production of coal, thus putting the mines that take recourse to stowing in a disadvantageous position *vis-a-vis* those who do not stow. In some cases, however, when stowing becomes absolutely necessary for a particular colliery for extracting coal it has no other alternative but to take to it and run into additional financial commitments.

Cost of Stowing

The cost of stowing varies but usually it is not cheap; in fact it constitutes the major portion per ton of coal raised. Mr. L. J. Barraclough (1950), mentions that although longwall working has been resorted to in India for stowing to avoid disastrous major 'bumps', it has no direct advantage over normal pillar extraction with complete stowing in so far as cost is concerned. Mr. Barraclough gives comparative figures of cost for the two systems which are Re. 1-5-8 and Re. 0-9-4 for two collieries 1,460 feet and 916 feet deep and carrying out the longwall working and pillar extraction respectively. He further mentions that, 'The extra cost for longwall work mainly is due to the number of extra men required for erecting and removing boxings and the cost of boxing materials.' Mr. A. B. Guha (1950), who was in charge of a group of collieries in Madhya Pradesh during the last War, where hydraulic stowing in longwall faces was carried out, has pointed out that the cost thereof was comparatively lower. It is therefore necessary to ascertain whether reduction is possible 'of this particular item, otherwise winning of coal by longwall methods and specially by sand-stowing may not be remunerative and colliery owners may hesitate to adopt longwall system of winning coal by hydraulic stowing'.

Method of Stowing

Stowing can be done by hand; it can also be pneumatic and hydraulic. Hand-packing is a dry and slow process which is comparatively less costly as it does not require any water used for the work to be pumped out. This, however, can be practised only in small operations. Pneumatic stowing is also a dry process in which compressed air forces the stowing material into the required position. This is rather expensive and is only suitable for deep mines from which the pumping of underground water involves some high cost and in cases where there is no adequate supply of water for hydraulic stowing. In India the hydraulic stowing is most suitable for the simple reason that there are apparently sufficient supplies of sand and water in the rivers in the neighbourhood of most of the coalfields where the inclination of the seams is generally suitable for the process.

Stowing Material

It goes without saying that sand is the most suitable material for sand-stowing wherefrom the name has been derived. Some other materials such as ash and cinder from boulders, rock debris and surface soil (suitably crushed wherever necessary) occurring in the neighbourhood of the stowing places are also conveniently used for stowing. Sand, for stowing, does not require to be crushed and it has the further advantage that it is subject to very little compression after settling.

Contributions to Stowing

The Mining, Geological and Metallurgical Institute of India has taken a keen interest in the matter of sand-stowing and it is responsible for some of its members

producing fine papers on the subject. One of the latest is a valuable contribution to the subject of hydraulic stowing by its President, Mr. L. J. Barraclough (1950). Some of the company members of the Institute, such as, the Bengal Coal Co., Messrs. MacNeill & Barry Ltd., Bird & Co., Tata Iron & Steel Co., etc., have been responsible for doing a lot of stowing in their collieries and thereby also helping in the research on the subject.

Legislation for Stowing

The Coal Mining Committee of 1937 recommended for the creation of a Statutory Authority for controlling stowing operations in the collieries. But the Government of India set up, instead, the Coal Mines Stowing Board. The Coal Mines Safety (Stowing) Act, which was concerned only with the safety in coal mines, came into operation from the 27th May, 1939, and had been applicable to the whole of British India except Assam and the Punjab. The objects of the Act are as follows:—

(i) To make further provision for safety in coal mines, by taking measures to facilitate or require therein the carrying out of the operations known as stowing; and

(ii) to provide for the creation of a Fund for the assistance of such operation.

The Chief Inspector of Mines in India or an Inspector of Mines under him, according to the Act, has got powers to order the owner, agent or manager of a colliery to execute such protective measures, including stowing as the Chief Inspector of of Mines may consider necessary if the former is of opinion that:—

(*a*) the extraction or reduction of pillars in any part of the mine is likely to cause the crushing of pillars or the premature collapse of any part of the workings or otherwise endanger human life or the mine, or

(*b*) adequate provision against the outbreak of fire or flooding has not been made by providing for the sealing off and isolation of any part of the mine or for restricting the area that might be affected by fire or flooding, as the case may be.

As regards the creation of a Fund, the Government of India had fixed annas two per ton as cess on coal and soft coke and annas three per ton on hard coke from the 1st December, 1939. These cesses have, subsequently, been increased by 50 per cent with effect from the 1st May, 1947. The collection is made by the Railway Administration and the total amount, after deducting the collection charges, is handed over to the Stowing Board.

Rules for Grant of Assistance

The Stowing Board has formulated the principles which are to govern the grant of assistance from the Stowing Fund to the owners, agents or managers of collieries and rules have been framed under the Coal Mines Safety (Stowing) Act. According to the rules, the Stowing Board has authority to grant assistance for the following purposes:—

(*a*) For stowing or other protective measures which are required to be undertaken by an order issued by the Chief Inspector of Mines in India under sub-section (3) of Section 9 of the Act;

(*b*) For any protective measures which in the opinion of the Board are essential for the effective prevention of the spread of fire to, or the inundation by water of, any coal mine from an area adjacent to it;

(*c*) For stowing operations voluntarily undertaken by the owner, agent or manager of the mine in the interests of safety; and

(*d*) For research connected with safety in mines.

As regards protective works under (*a*), a number of orders have been issued and important protective works, especially in the Jharia and the Karijore fire areas, have been undertaken for some time past and are still being continued as provided for under (*b*). Regarding voluntary stowing as provided under (*c*), the greatest activity has been on record in this connection.

Order of Priority for Giving Assistance

The following order or priority is kept in view when applications asking for assistance for voluntary stowing are considered by a Standing Advisory Committee appointed by the Stowing Board:—

(*a*) Anticipated immediate danger to themselves and to other collieries.
(*b*) Anticipated major danger to their workers.
(*c*) Lesser degree of urgency under the above heads.
(*d*) Abnormal working conditions due to geological features involving added risks.
(*e*) Working under fire areas or under water (*vide* Regulations 67-E, 72-B or 75 of the Indian Coal Mines Regulations).

Stowing for Conservation of Coal

It will appear, therefore, that the scope of the Act is confined to stowing for safety only and not for conservation. In view of the heavy losses of coal due to fire and collapses it is felt that time has come for enforcing stowing for conservation also and in view of the rather limited reserves of good metallurgical coal and of the proposed expansion in the iron and steel industry in the country, compulsory stowing appears to be essential. Mr. Treharne Rees, as early as 1919, recommended the introduction of hydraulic stowing in the Jharia and Raniganj coalfields and the Coal Committee of 1920, which considered his report, came to the conclusion that no improvement in the prevailing wasteful methods could be expected without State interference and that sand-stowing should be made compulsory within certain limits with provision for compensation. The Coal Mining Committee of 1937, which was primarily concerned, under its terms of reference, with safety in mines, while considering the importance of conservation of the country's resources of good quality coals realized that stowing for safety in mines and preservation of the admittedly limited resources of coal were essential. The Indian Coalfield's Committee, 1946, stressed the necessity for extending stowing for conservation also. But so far the Government of India have thought fit to extend stowing for safety only and not also for conservation.

The Metallurgical Coal Conservation Committee of 1949 is believed to have also realized that the scope of stowing should include the conservation aspect as well. It is not known if the Government of India will introduce stowing also for conservation of at least the good quality coals.

Underground Gasification of Coal and Stowing

The scope of stowing will further increase, if and when underground gasification of coal is undertaken in this country. The first idea for underground gasification of coal occurred to Sir William Ramsay of Great Britain, where, as also in the United States, no effort was made to give a practical shape to it. The great Russian scientist, Mendeleef, independently advised the conversion of coal into gas in the coal seams and the Soviet Government in its turn took up the problem of underground gasification and preliminary work was started on an experimental basis in 1932. The development of the technique in U.S.S.R. has been dealt with in a recent paper by Dr. A. K. Shaha (1950). In India, no work so far has been done towards the underground gasification of coal, but here the requisite type of coals may be available.

This is, however, still in its infancy in Russia and we will have to await the development of requisite technique for satisfactory work. Underground gasification includes injection of air and steam through burning coal underground, whereby a mixed gas containing CO, CO_2, H_2, CH_4, C_nH_m, N_2, etc., is produced. To ensure that the injection of air and steam reaches the proper place, it is absolutely necessary that the void created by the burning of coal be properly filled up. This filling could be done by (i) natural fall of earth, (ii) pneumatic filling, and (iii) hydraulic stowing. It will be clear that hydraulic stowing does not require the introduction of steam as it serves the double purpose of sealing and steaming. Thus, if and when underground gasification of coal is undertaken in India, additional quantities of sand will also be required for filling up the space created by the burning of coal underground.

Reserves of Sand

It has already been mentioned in a general way that sand and water are available in sufficient quantities in the vicinity of the coalfields. It is now necessary to consider to what extent the stowing material will be available and also to understand the economics of stowing. Mention has been made that such materials as ordinary earth, broken stone excavated from quarries and such incombustible substance as ash from boilers have been used in some cases mainly for stabilizing underground workings where sand is not readily available; but the available quantities of such material are very limited. India has been very fortunate in so far as the availability of sand is concerned from her rivers, especially from those in the vicinity of the two main coalfields, viz. the Jharia and the Raniganj coalfields. As regards the quantities readily available in the neighbourhood of the two above-mentioned coalfields, the Indian Coalfields' Committee of 1946, considered the position as satisfactory and stated (on page 92) in its report that—

> 'On the whole, the available evidence points clearly to the existence of adequate sand deposits in the three rivers (Damodar, Barakar and Ajay). But the position has been complicated by the plans for the construction of dams across the Damodar for flood control and irrigation and much genuine concern has been felt about the prospects of sand replacement in the future.'

The quantities of sand available from the present bed of the Damodar river within the Jharia coalfield were estimated by Sir Cyril Fox (1930) on a very limited data. Messrs. Bird & Co., who hold the lease for sand in the Damodar adjacent to the Jharia coalfield, have undertaken sand-drilling operations in the river from Kalhajhor (23° 40½′: 86° 35½′) up to Tetengabad (23° 43′ : 86° 20½′) and have estimated that some 140 million tons of river sand occur at present as the fixed deposit of the river in the Jharia field. In addition, the older alluvium of the Damodar in the above area, which might also be a suitable material for stowing, was estimated by Sir Cyril Fox at 25 to 30 million tons.

The Coal Mines Stowing Board has for some time under consideration a scheme for the supply of sand for stowing at collieries in the Jambad-Kajora and Toposi areas in the eastern part of the Raniganj coalfield from the Damodar river at Shrirampur (24° 34′ : 87° 12½′) and from the Ajay river near Ramnagar (23° 44′ : 87° 15½′) using aerial ropeways. Advice was sought from the Geological Survey of India regarding the quantity of river sand available in the two areas. In furtherance of the above programme and in connection with the general sand-stowing programme for conservation of coal and the safety of mines in the Bengal and Bihar coalfields, the Geological Survey of India, in order to arrive at fairly definite estimates of river sand, carried out extensive sand drilling operations by making drill-holes at suitable intervals in the following areas:—

(i) In the Damodar river from near Shrirampur (24° 34′ : 87° 12½′) upstream to its junction with the Barakar river,

(ii) in the Barakar river from its junction with the Damodar upstream to near the proposed Maithon dam site, and
(iii) in the Ajay river from the north-western end of the trans-Ajay field near Pariarpur (23° 50′ : 87° 03′) to north of Madhaipur (23° 43′ : 87° 21½′).

The holes were put down at intervals of 1,000 feet both along and across the river beds and the total number of holes was 321. The results obtained, by the Geological Survey, are given below in a summarized form:—

Reserves of Sand in the Damodar, Barakar and Ajay Rivers within the Raniganj Coalfield

River	Area	Average thickness of sand	Total in million tons
(A) Damodar river ..	Baska (23° 34′ : 87° 10½′) to Pinjrapole (23° 33′ : 87° 14′).	29½ ft.	70 (including 10% clay).
Ditto ..	Baska to junction of Damodar and Barakar.	32½ ft.	510 (including 10% clay).
(B) Barakar river ..	Junction of Barakar and Damodar to Maithon (23° 47′ : 86° 49′).	42½ ft.	120 (including 20% clay).
(C) Ajay river ..	Ramnagar (23° 44′: 87° 15½′) to Chhatrishganda (23° 44′: 87° 13½′).	8 ft. 19 ft.	3 } (including 40% clay). 17 }
Ditto ..	Pariarpur (23° 50′: 87° 03′) to Chhatrishganda and Ramnagar to Madhaipur (23° 43′: 87° 21½′).	35½ ft.	270 (including 20% clay).
	Total	....	990 million tons.

Sand in some quantities is also available in the Damodar, Bokaro and Konar rivers within the Bokaro coalfield and although the actual quantity has not yet been estimated it is believed that it may not exceed a quarter of that in the Damodar river in the Jharia coalfield. Further up the Damodar river, in the Karanpura field, the bed of the river is still more rocky and the accumulation of sand is very scanty.

Replenishment of Sand

As regards the questions of availability of water and the annual replenishment of sand in the rivers, Dr. Auden is dealing separately on them. In the Jharia coalfield, Dr. Gee (1947) mentions that, even if we 'allow a total of about 200 million tons of readily available stowing material as the fixed deposit, it is quite apparent that, in order to provide an annual quantity of even 20 million tons per annum to meet the needs of the Jharia coal industry, a very large annual replenishment of river-sand during the flood-period of the monsoon is essential, otherwise supplies will be depleted within a short period of years.' The present rate of annual replenishment of the sand is not known with any degree of accuracy, but it is said to be of the order of 11 million tons. When the dams are built across the Damodar and its tributaries most of the sand, if not the whole of it, will be deposited in the reservoirs from where the sand and silt will have to be removed by dredging and distributed to the collieries for stowing.

I may also make a brief mention here of the proposed afforestation programme of the Damodar Valley Corporation in the catchment of the Damodar river system which may further reduce the annual replenishment of sand in the rivers. Afforestation is one of the measures which has been found useful in combating soil erosion. In the catchment of the Damodar river system it has been observed that 60–70% of the area has a cover of subsoil and decomposed rock varying from 0 to 6 inches, while the remaining 30–40% has a soil cover varying from 6 inches to 3 feet and above. In the former area afforestation will aid reclamation while in the latter it will help soil conservation.

Planning and Research

Mr. L. J. Barraclough (1950), in responding to the toast at the Annual Dinner of the Mining, Geological and Metallurgical Institute of India in December, 1949, observed as follows:—

> 'The question of planning with regard to sand-stowing occupies our minds. The Jambad-Kajora field which produces high volatile coals is now in urgent need of stowing and from 3½ to 4 million tons of sand will be required yearly. For the Jharia field the quantity of sand will increase to 27 million tons per year starting in 1955. It is of great urgency that complete schemes be drawn up now for stowing in the Raniganj and the Jharia fields.'

In the discussions following a very recent paper of Mr. R. R. Khanna (1950), it has been evident that certain mechanical difficulties are being encountered in the matter of stowing. These require proper attention from competent people who are in a position to solve them.

Also, although the quantity of available sand in the rivers traversing the Raniganj field may be considered to be sufficient for stowing purposes in this area, the sand together with the quantity of older alluvium in the Damodar river in the Jharia field is not considered to be enough to meet the probable future requirements of this field and also there may not be adequate quantities of sand readily available in the rivers in close proximity to other coalfields, where stowing operations are to continue or are likely to be introduced in future.

It has been suggested that the ash from the Bokaro Thermal Plant may be used for stowing. Although the material could be used with advantage locally in the Bokaro coalfield, it is doubtful whether it could be transported cheaply to the Jharia coalfield, wherein exist most of the good quality caking coals of India which have to be stowed for their efficient and maximum extraction.

It is, therefore, felt that there is now the urgent necessity for planning for stowing and for extensive research not only in the development of the technical methods, but also for finding out new materials suitable for stowing, which could be made available to the collieries at a reasonably small cost.

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Discussion

Mr. P. K. Ghosh.—I would like to take this opportunity of thanking the author for his excellent paper giving so much information as regards the availability of sand in the rivers adjoining the coalfields of Bengal and Bihar.

Though it has been considered until recent years that the sands required for stowing in the Raniganj and Jharia coalfields are more or less sufficient for the purpose of safety in the mines, with the dams now to be built across the Damodar and its tributaries, the annual replenishment of sands in the rivers may not be sufficient for future needs. Practically all the sand and silt will be deposited in the reservoirs, and these will have to be removed by dredging. This will mean extra cost. It is now time, therefore, that we should think also of other stowing materials besides sand. There will be a good amount of washery refuse (when coal washing plants are installed), boiler ash, screening plant rejections, shales, surface soil, sub-soil, etc., ready available within the easy reach of mines. These materials can at least supplement sand as stowing materials. As regards the sesubstituted stowing materials, an interesting paper was written by Dr. S. K. Roy in 1938 (*Trans. Min. Geol. Inst. Ind.*, Vol. 33, Pt. 4, pp. 443–454). Dr. Roy has mentioned that this 'muttee' (including shale, soil, sub-soil, ash, etc.) alone may be able to supply stowing materials for the important mines (raising 1st class coal), situated in Sheets 3, 7 and 8 of the Jharia coalfield. It may be worth while investigating these materials in the rest of the Jharia coalfield, and in other coalfields as well. Some of the collieries in Jharia and other fields have already been utilizing boiler ash as stowing material.

It is time that we should also consider the possibility of adopting different methods of stowing, such as pneumatic or mechanical stowing, in addition to hydraulic stowing. Perhaps, with pneumatic stowers, ordinary 'muttee' along with substitutes may be used. For the collieries which are fortunate in having adequate sand supplies, hydraulic stowing may be best suited; but in the case of collieries miles away from sand supplies and with plenty of other materials available, different methods of stowing may be adopted. Mr. J. Thomas published an excellent paper on this aspect of stowing in 1939 (*Trans. Min. Geol. Inst. Ind.*, Vol. 35, Pt. 1, pp. 51–128).

Mr. A. B. Dutt replying to Mr. P. K. Ghosh said that, the question of sand-stowing is not so acute in any other area as it is in the Jharia coalfield, where, according to recent estimates, there are nearly 1,500 million tons of good quality coking coals, which require to be stowed. Taking the maximum quantity of stowing material readily available in this coalfield to be about 200 million tons and assuming 27 million tons or, say, roughly 25 million tons of sand as the quantity required per year, it is evident that the supplies will be exhausted within a short time unless there is a very large annual replenishment of river-sand during the monsoon floods. The replenishment, however, will not take place to the same extent with the dams built across the rivers in the Damodar river systems.

Regarding the use of the ash from the Bokaro Thermal Plant for stowing, it may be said, that although it could be used with advantage locally in the Bokaro coalfield, it is doubtful whether it can be transported cheaply to the Jharia field. That means the cost of stowing material and necessarily that of stowing will increase further, thus upsetting the price-structure of coal. Moreover, the quantity will hardly be over 1 million tons per year.