

Application Prospect of Backfill Technology for Pillar Recovery in Room and Pillar Mining Method, Pakistan

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Abstract

Pakistan is one of the richest coal deposit country in the world. But unfortunately, Pakistan facing the biggest electricity shortfall and planning to generate the electricity by coal fired power plants. The wastage of coal during pillar extraction in room and pillar mining method in Pakistan is the biggest issue nowadays. This is the first time to research on it and redesign the mining method with small modifications to reduce the wastage of coal in Pakistan. Backfilling technology is the only technique to reduce the wastage of coal during pillar extraction, use the waste material as Backfill material, reduce the environmental pollution and make the environment green and healthy.

Key words: Room and Pillar Mining; Pillar Recovery; Backfill Technology; wastage of coal; Immediate Roof Pressure; Waste Material; Environment Pollution

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INTRODUCTION

Pakistan is one of the rich coal country in the world after the discovery of Thar coal reserves. The total reserves are about 185,175 million tons. But, unfortunately Pakistan is facing the biggest electricity crises nowadays. The short fall is about 4000 to 7000 MW and it will increase with the passage of time (Mahmood et al., 2014; Satti et al., 2014). Recently the Government of Pakistan signed some agreements with power generation and mining companies to install the new coal fired power plants. So it is necessary to save our coal and reduce the wastage of coal for future use. The reserves by province are shown in Figure 1.



Figure 1: The coal reserves of Pakistan

Due to lack of latest mining technology and lack of infrastructure about 70 to 80 percent of coal is wasted

and could not be mined (Qiang et al., 2012) Pakistan has five provinces but only three of them are currently producing the coal.

Sindh province

Sindh province has the largest coal deposits about 184,623 million tons and is one of the largest coal producing province in the country (Mahmood et al., 2014). Currently only Jhampir, and Lakhra, two coal fields are producing the coal. Lakhra is one of the largest coal producing fields in Pakistan. The area is about 500 sq. km and the coal reserves are about 1,328 Million tons. The coal quality is lignite-A. Room and Pillar mining method is used for the excavation of coal and the coal seam is flat. The dip is about 1° and contains parting. Due to lack of technology, infrastructure and bad geological conditions, about 80% of coal is not excavated and wasted to provide the support to roof (Qiang et al., 2012; Ghasemi et al., 2012). Due to many small faults roof fall is one of the big problems. Moreover, the wooden supports are used for the roof support. The coal mines are non-gassy. The quality of Coal is suitable for the power generation. Table 1 shows the chemical analysis of coal.

Balochistan province

Balochistan province has the third largest coal deposits of the country. The coal reserves are about 217 million tons and three working coal fields Sor-Range/Degari, Sharagh and Muchh are currently producing the coal. The coal quality is

sub-bituminous (Mahmood et al., 2014). Short wall mining method is used for extracting the coal. The seam is inclined and the dip is about 35°. About 60% of coal is wasted and could not be mined to provide the supports to roof. All the coal mines are gassy mines and the quality of coal is sub-bituminous, as shown in Table 1.

Punjab province

Punjab province has second largest coal deposits of the country. The coal reserves are about 235 million tons and two working coal fields Salt-Range and Makarwal presently producing the coal (Mahmood et al., 2014). Short wall and Room and Pillar mining methods are used for extracting the coal. The coal seam is fairly flat and dip is about 2°. The type of coal is also sub-Bituminous. About 80 percent coal is wasted and not excavated to provide the roof support (Mahmood et al., 2014; Satti et al., 2014). All the coal mines are non-gassy and the quality of coal is sub-bituminous. The detail is shown in Table 1.

Table 1: Chemical analysis of Pakistan coal deposits by Provinces (Mahmood et al., 2014; Satti et al., 2014)

Chemical Analysis	Sindh Province	Balochistan Province	Punjab Province
Moisture (%)	09.00-48.00	01.70-18.90	02.80-10.80
Ash (%)	02.70-52.00	04.90-38.00	06.40-44.20
Volatile Matter (%)	16.10-44.20	09.30-50.00	21.50-48.10
Fixed Carbon (%)	08.90-58.80	25.50-50.80	25.70-44.90
Sulfur (%)	00.20-15.00	00.60-09.55	02.60-10.70
Calorific Value (Btu/lb)	5,533-13,555	9,637-15,499	9,472-15,801

Key Environmental Problems induced by Coal Mining

The coal mining industry of Pakistan mainly faces three problems. i.e. wastage of coal, improper dumping of waste material (carbonaceous shale) and the fly ash.

Wastage of Coal

Pakistan's coal mining industry faces the biggest problem that is the wastage of coal and the recovery ratio is very low. The coal remained in abundant area will never be mined again and lost forever. Due to lack of mechanization, much amount of coal cannot be mined to provide the support to the immediate roof.

Carbonaceous Shale

The waste is too much in Pakistan coal, because usually the over lying bed and in between the coal seam there is some small layers of Carbonaceous shale, as shown in Figure 2. So when the miner mines the coal the huge waste also comes over the surface with coal. Usually the companies dump the waste over the surface. The carbon shale has the property of spontaneous combustion (Kebblish, 1975). So, it takes fire very quickly and the fire remains for several months which produce the

hazardous fumes and make the area and environment pollutant, as shown in figure 3. In addition, transporting the waste material to the surface also increase the transportation charges.

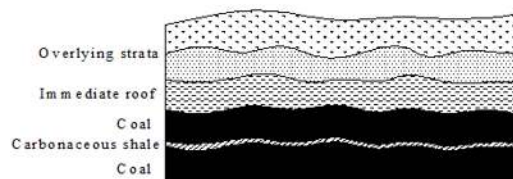


Figure 2: showing the structure of strata.

(a)



(b)



Figure 3:

- (a) Spontaneous combustion in waste material on surface.
- (b) Waste material dumped over surface.

Fly ash

The coal fired Power Plant of 150 MW at Lakhra coal field is also producing the fly ash, which also dumped over the surface openly near the Lakhra

collieries, as shown in Figure 4. The particle size of the fly ash is 0.005–0.05mm, which very easily dilute in the air and increase the air pollution in the region. The living things affected too much in the region.



Figure 4: fly ash dumped over the surface

Furthermore, when the fly ash mixed with rain water, the water became polluted and acidic which is also another serious problem in the vicinity.

In the recent years a new technology has been introduced in underground coal mining known as Backfilling technology. It is the technology by which mining industry fill the waste material in the gob area and provides the good support to the roof of mines and reduce the environmental pollution. In addition, If the Pakistan coal mining Industry adopt the Backfilling technology, it will be a great positive step for the future of Pakistan coal mining industry.

Backfilling Technology

Backfilling in underground mining is increasing day by day. Backfilling is defined as the material or materials that are utilized in void openings of underground mines for mining technical, safety, roof support and dump wastage. It also improves the stability of rocks and provides the supports to the roof and walls of underground openings. It also helps in the distribution of regional stresses as well as for economic and environmental factors. Mining with backfill technology helps mining companies to achieve many of these goals. The technology of

backfilling enables a wide range of engineering solutions for particular mine sites and their unique sets of problems and opportunities. Carefully engineered and efficiently run backfill systems can significantly enhance a mining operation. By contrast, badly engineered and poorly run backfill can be a serious impediment to the mine and, worst of all, compromise safety. The comparison of Mining methods and its effects on environment and surface is shown in Table 2. (Nandy and Szwilski, 1987; Qiang et al., 2012; Xie-xing et al., 2008)

Table 2: Contrast of different mining methods

Mining Method	Roof Support	Waste Processing	Regional Stresses	Environmental Effect	Surface Subsidence
Backfilling	Backfilling Material	Dumped in the gob	Partial	Friendly	Negligible
Long wall	Caving Rocks	Dumped over the surface	High	Not friendly	High
Room & Pillar	Remaining Pillars	Dumped over the surface	High	Not friendly	Moderate

Backfilling technology is beneficial for the recovery of pillars in the room and pillar mining method. The recovery ratio is about 90% by adopting backfill, because backfill material provides support to the roof. It reduces the surface subsidence and save deformation of structures on the earth above the mining area. Deposits lying under water bodies (ground water, aquifers) can be mined safely by using backfill either. Because it supports the immediate roof of mine and reduce the chances of fractures to stop the mine inundation. Moreover, backfill is environment friendly technology. The waste present over the surface or produce from the mine should be used as backfill material, which reduces the environmental pollution (Tesarik et al., 2009; Dr-Inq, 2009; Ghasemi et al., 2012).

Backfilling technology in China

China is one of the largest coals producing country in the world as shown in Figure 5.

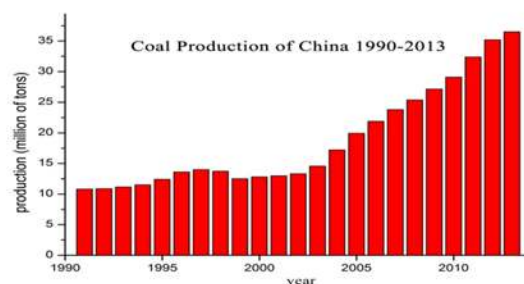


Figure 5: Coal production of P. R. China

China produces its 80% electricity from the coal. The technology of China is comparatively cheaper than the other countries. Long wall and Room and

Pillar mining methods are generally employed for the extraction of coal. As about 4.5 billion tons of waste is produced every year in China from the coal (Xie-xing et al., 2008). China utilizes most of it for backfilling material in long wall mining (Ju et al., 2012). Recently, China is also designing the solid backfill mining to employ in the Room and pillar mining method for pillar extraction, as the designing is shown in the Figure 6.

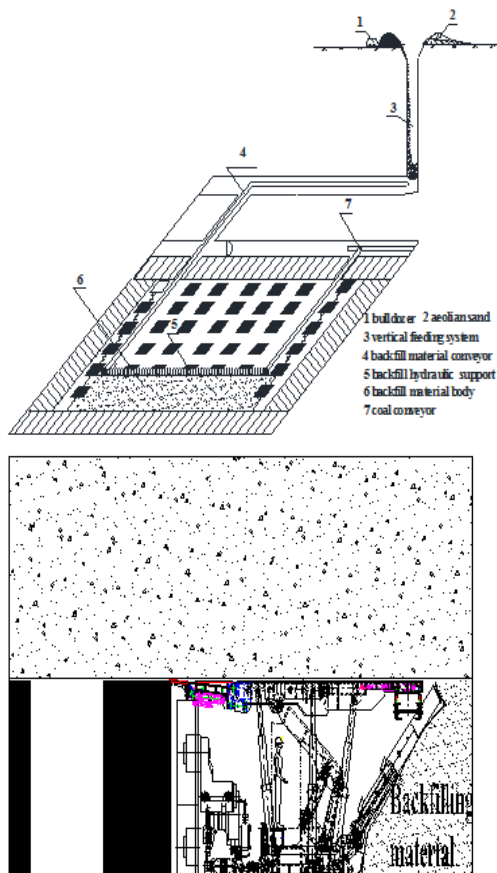


Figure 6: Design of backfill in room and pillar mining for pillar recovery in China

Currently, about 50% of the coal is wasted in Room and Pillar mining method and could not be mined, due to the stress distribution. Regional stresses affect too much while extracting the coal pillars, so the recovery ratio is low. Solid backfilling is the only technology by which the support can be provided against the regional stresses. China is using fully mechanized mining by using Power supports, conveyor belt, backfill conveyor, coal cutter, etc.

Possibility of Backfilling technology in Pakistan

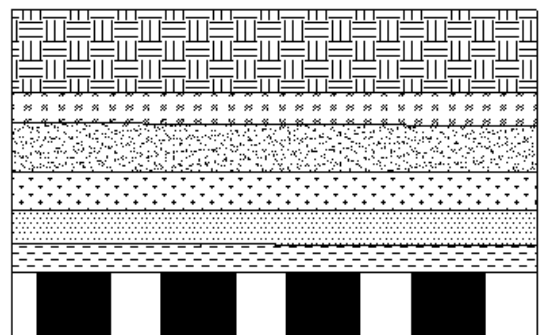
Pakistan is a developing country. Presently, mining industry of Pakistan is not fully mechanized but in the near future due to huge short fall of electricity. Pakistan is also trying to use the coal for electricity generation. Because the electricity generated by coal is cheaper than the other fossil fuel sources. In some areas short wall mining method is used because of inclined seams while in the other field room and pillar mining method is used, because it is feasible and cheap due to the geological and economic conditions.

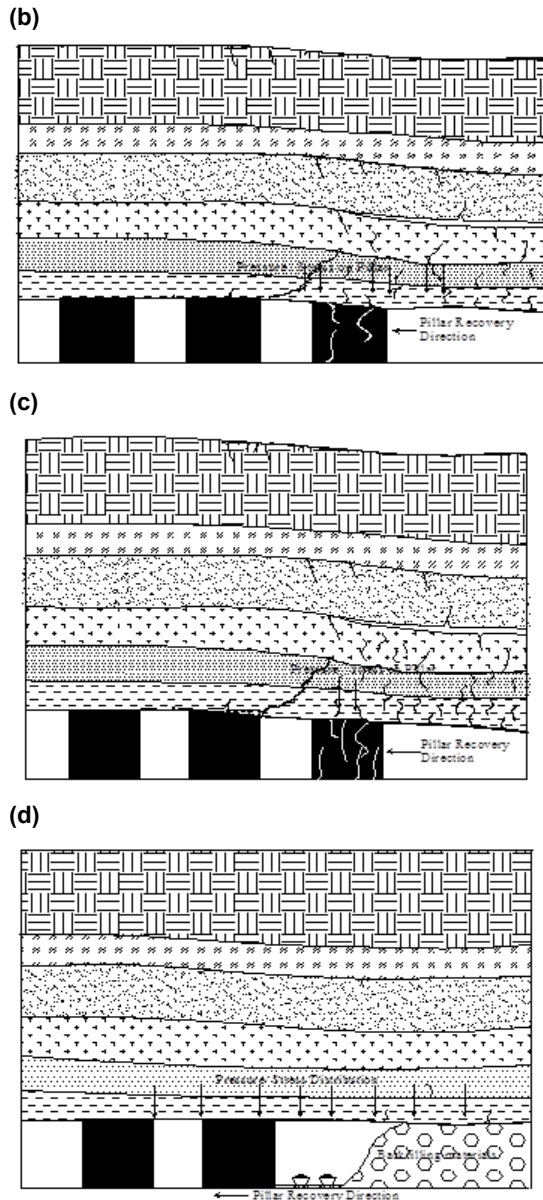
Presently, about 80% of coal is wasted in room and pillar mining method only due to regional stresses. If backfill technology is adopted in room and pillar mining method, the pillar recovery ratio will increases up to about 90% and the wastage of coal will be reduced. In addition, it reduces the environmental pollution, which is increasing due to dumping of waste (Carbonaceous shale) material over the surface and the byproduct of power plants i.e. fly ash.

Implementation of Backfilling in Pakistan

Presently, in underground coal mines 60 to 80 percent of coal could not be mined and leaved for the roof support. During the pillar recovery the lateral stresses of the underground mine becomes more active. The pressure of the roof strata directly transferred to the immediate roof. As we recover the pillar the roof pressure increasing gradually over the surrounding pillars. If the proper support is not installed to the roof. The surrounding pillar gets cracks and become weak. Gradually, those pillars near the gob area fractured and finally break down and the roof collapsed. Nobody can mined those pillars because of roof pressure and safety of miners. Recently, we leave the pillars near gob area and unable to mine. That is the huge wastage of coal in room and pillar mining method during pillar recovery. As shown in the Figure 7 (a), (b) and (c).

(a)



**Figure 7:**

- (a) Roof and pillar condition before the pillar recovery
- (b) After the recovery of pillar the roof pressure increasing gradually on the surrounding pillars.
- (c) Due to roof pressure the pillar is cracked and not suitable for recovery.
- (d) Roof and pillar condition after using backfill technology.

In other words, immediate roof works like a beam in underground mines. Naturally beam remains stable when it is in equilibrium condition. If the beam is not remaining in equilibrium condition, the pressure over beam transferred to its one side completely and deformation occurs.

Resultantly, we have to provide the support to the immediate roof of gob area to maintain the equilibrium condition of the immediate roof. If the proper support provided in the gob area the roof pressure could not be increased over the surrounding pillars.

The gob area can be filled with the waste (carbonaceous shale) material by using the backfill technology, as shown in Figure 7(d).

As mentioned in Figure 7(d) the immediate roof remain stable and the pressure of the roof could not be transferred over the surrounding pillars. The surrounding pillars remain safe and no major cracks or deformation occurs. All the pillars can be recovered safely. So that, the production ratio will be increased up to 90% and the wastage of coal should be reduced up to 10% only.

The material for the backfill comes from the coal bed because the coal bed also contains parting of waste rock (carbonaceous shale). The fly ash, which is produced by the power plant can be transported to the working face area and mixed with the carbonaceous shale for preparing backfill material. Through the mixing of carbonaceous shale with fly ash, a good bonding material can be get with the passage of time.

Furthermore, currently the coal mining companies transport the waste material (carbonaceous shale) from underground to the surface and dump over the surface. Transporting the waste material to the surface also increases the transportation charges and on other side, it plays an important role to increase the environmental pollution as well.

Using waste material (carbonaceous shale) for backfilling reduce the transportation charges, which is currently an extra burden on the companies economy. Through this process environmental pollution also will be reduced and make the environment green and friendly.

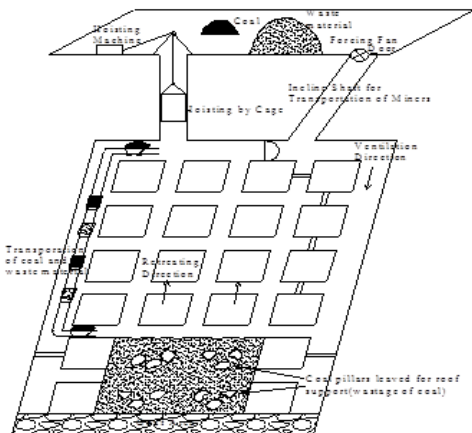
Figure-8 shows the complete design, possibility and implementation of backfill technology in room and pillar mining for safe recovery of coal pillars in Pakistan with its current scenario. It also shows the transportation and dumping ways of waste in gob area.

Nowadays, the transportation of coal and waste material is carried out by using the cages and rail cars for hoisting and hauling respectively. The filling process of material in the cars is manually done by

the miners. The miners fill the material in the large woolen bags and transfer those by rail cars and cages. The backfill material will be transported directly from the working face to the gob area just mixing the fly ash and then filling in the woolen bags and finally dumped in the gob area manually. The compaction of backfill material is not required because of shallow deposits and the partial wooden supports.

Moreover, no extra investment is required for using the backfill technology in Pakistan's current mining scenario. Only we have to redesign and modify the mining and transportation system.

(a)



(b)

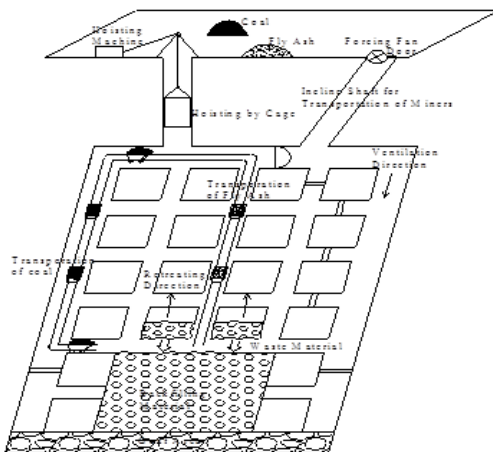


Figure 8:

- (a) Room and pillar mining without backfill technology in Pakistan
(b) Design of room and pillar mining with backfilling in Pakistan.

CONCLUSION

Pakistan is one of the coal rich countries in the world. Presently, the coal mining method is wasting about 80% of coal and increasing the environmental pollution by dumping the waste of coal mine over the surface.

This is the first time, to research on the coal mining industry of Pakistan to reduce the wastage of coal during the pillar recovery in room and pillar mining method and use the waste material of coal mine as backfill material to reduce the environmental pollution.

Backfilling technique is the best technology for using the waste material to reduce the environmental pollution. It could be used for supporting the roof of coal mine, and it also reduces the surface subsidence ratio. Furthermore, Pillar recovery ratio should be increase up to the 90%. The solid backfilling technology will increase the production ratio and reduce environmental pollution. Also it is economical for Pakistan according to current conditions of Pakistan mining industry.

On the other side, recently Pakistan signed many agreements for installing the coal fired power plant in the country to overcome the short fall of electricity, so it is very important to reduce the wastage of coal and save it for the future use.

China is using backfilling technology since many years, which supports to increase the production, reduce the environmental pollution and surface subsidence. Therefore, if Pakistan adopts the backfill technology, it will help increase the production and reduce the wastage of coal. Just with the small modifications in the current mining methods.

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