A Proposal of Open Pit Coal Mine at the Northern Part of Barapukuria Coalfield, Dinajpur, Bangladesh

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Abstract—The Barapukuria Coalfield is only production coalfield in Bangladesh with coal deposit area of approximately 6.25 km². Geologically, the coal basin is a singular syncline in which coal occurs at shallower depth at the northern part and deeper depth at the central part. The Barapukuria coal mine started commercial production of coal by early 2005 with an annual target of 1 million ton per year for 25 years mine life only from the central part of the coal field. But, the coal mine is facing water in rush, land subsidence, roof collapse, methane emission etc. So, the production has stopped several times and it could not achieve annual production target. On the other hand, coal is existed at a shallow depth on the northern part of the field remain untouched because of underground mine design. The present study suggests extracting the coal from the northern part of the Barapukuria coal field by open pit mining method as well as an adequate mine design.

Keywords—Coalfield, Underground mine, Open pit mine, Syncline.

I. INTRODUCTION

The Barapukuria coalfield was discovered by the Geological Survey of Bangladesh (GSB) in 1985 in the drill hole GDH-38, which encountered coal seams at a depth of 159 m. The coal reserve found in the Barapukuria is 303 million tons (Wardell Armstrong, 1991). In addition to that about 86 million tons is considered as inferred reserve. The Coalfield is situated within the Barapukuria village of under Parbatipur Thana, Dinajpur district, at a distance of about 50 km southeast of Dinajpur town (Figure-1).

The coalfield has a proved area of about 5.25 sq km. In addition, the field is suggested to have possible extension for 1 to 1.5 sq km area to the south (Wardell Armstrong, 1991). The coalfield contains coal-bearing seams of 7 groups in 11 seams with total thickness of 74.14 m.

Seam-VI is the main mineable bed with thickness ranging from 29.4 to 41.00m and 36.41m on average, belonging to the regular and extra thick coal seam of the coalfield.

Figure -1: Location Map of the Barapukuria Coalfield.
Annual production target of the mine is 1 million ton per year for 25 years mine life. In this study we would like to propose an open pit mine at the northern part of the basin.

II. GEOLOGY OF THE BARAPUKURIA COAL FIELD

The sedimentary rocks of Gondwana Group, Dupi Tila Formation, Barind Clay Residuum, and Alluvium of the Permian, Pliocene, Pleistocene and Recent ages respectively were encountered in the boreholes, which lie on the Pre-cambrian Basement Complex. A large gap in sedimentary record is present in between Gondwana Group and Dupi Tila Formation, which are most probably happened due to the erosional or non-depositional phase exit during Triassic to Pliocene age. The stratigraphic succession in the Barapukuria basin is given in Table-1.

<table>
<thead>
<tr>
<th>Age</th>
<th>Group</th>
<th>Formation</th>
<th>Member</th>
<th>Lithology</th>
<th>Thickness, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holocene</td>
<td></td>
<td>Alluvium</td>
<td></td>
<td>Silty clay</td>
<td>1.83</td>
</tr>
<tr>
<td>Pleistocene</td>
<td></td>
<td>Barind Clay</td>
<td></td>
<td>Clay and sandy clay</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residuum Upper</td>
<td></td>
<td>Sandstone, pebbly sandstone and clay/mudstone</td>
<td>126, 82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residuum Lower</td>
<td></td>
<td>Sandstone, claystone and mudstone with silica and white clay</td>
<td>457, 32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gondwana</td>
<td></td>
<td>Feldspathic sandstone, carbonaceous sandstone and shale, ferruginous sandstone, conglomerites, and coal beds.</td>
<td>14.3</td>
</tr>
</tbody>
</table>

III. COAL RESERVE IN BARAPUKURIA COALFIELD

The Barapukuria coal deposit has a proved area of approximately 5.25 km² with an unproved possible extension area to the south of approximately 1 to 150 km². The total demonstrated coal reserve in the Barapukuria coalfield is 303 million tons (Wardell Armstrong 1991). This demonstrated reserve is based on the coal contained in seams II, IV and VI, which are more consistent and important. In addition to that about 86 million tons is considered as inferred reserve. This inferred reserve is based on the coal contained in irregular and inconsistent seams I, III and V. Note that out of the 303 million tons demonstrated coal reserve, 271 million tones i.e. about 90% of the total demonstrated reserve is contained in seam VI (Table-2).

<table>
<thead>
<tr>
<th>Coal seam</th>
<th>Nature</th>
<th>Average thickness, m</th>
<th>Reserve (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Irregular, Discontinuous and limited</td>
<td>4.6</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>Relatively Consistent</td>
<td>8.2</td>
<td>14</td>
</tr>
<tr>
<td>III</td>
<td>Irregular, Discontinuous and limited</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>IV</td>
<td>Relatively Consistent</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>V</td>
<td>Discontinuous and limited</td>
<td>4.1</td>
<td>-</td>
</tr>
<tr>
<td>VI</td>
<td>Consistent</td>
<td>36</td>
<td>271</td>
</tr>
</tbody>
</table>

Total coal reserve: 303 million tons

IV. COAL RECOVERY BY OPEN PIT MINING METHOD

Open-pit mining is a method of mining wherein metal ores, coal and other minerals are mined from the earth surface. The totality of workings called open pit and has an open contour in the cross section. By open pit mining method, it is possible to extract 90-95% of total reserve and easy to operate the whole mining operation. The factors favoring open pit mining method are as follows:
A. It will be comparatively easy to manage the groundwater of the Dupitila aquifer overlying the coal deposits in the Barapukuria mine area by open pit mining method rather than underground mining method. For instance, dewatering operations on a very large scale simultaneous mining operation is an well established technique and are being widely practiced in mines with similar hydrological condition in Germany (Rheinbraun lignite mines of Rheinish district) and India (NLC mines). The adversity of pumping out of such large quantities of water may be profitably utilized pit-head power station and irrigation in the mine area. This has been practiced in Rajmahal open cast mines in India and Rheinsh lignite district of Germany (CMPDI, 1991).

B. The Barapukuria coal reserve has an average stripping ratio of 6:1 in m$^3$/t, which is favorable for open pit mining. This stripping ratio is similar to the German lignite mines and is being mined up to a depth 450m at an average stripping ratio of 6:1. Since, the coal quality of the Barapukuria coal field is very high, so open pit mine will be more beneficial.

C. It would be possible under open pit mining to ultimately extract more than 90% of the entire deposits up to the depth of 450m. This would amount to about 290 million ton. An underground mine, on the other hand, contemplates extracting 30 to 64 million tons of coal from only the thickest seam VI.

D. Underground coal mine lives with potential danger of accident by water flood, roof collapse, methane gas explosion and spontaneous combustion. With no underground coal mining experience in the past, managing a major underground accident will be difficult for Bangladeshi personnel. Potential mine hazard would be minimum in open cast mining.

E. Hard rock and white clay would be extracting without any additional effort for mining, in addition to coal.

V. BARAPUKURIA NORTH OPEN PIT MINE DESIGN

In the northern part of Barapukuria coal field 1.837 sq km area is feasible for open pit coal mine.

Figure-2: Open pit mine operation phases of Barapukuria coal field.

The mine depth may ranges from 110 to 236 m. For the convenience, of mine operation, hydrogeological modeling the mine operation can be divided in six phases (Figure-2). Each phase should have five years duration of operation. So, it will need 30 years to complete full extraction of coal.

A. Phase-1(0-5 years):

For mining operational convenience, the Phase-1 should be onset from the western side of the area. The surface and floor area of Phase-1 quarry is 966982 sq. m and 264781 sq. m respectively (Figur-3). In this area, the depth of coal seam top varies from 80 to 100 m. So, it will need 14 benches (Figure-4) to reach the bottom of coal. The amount of overburden may be removed is 65.16 million cubic meter and the amount of extractable coal is 12.38 million tones. The calculated stripping ratio for the Phase-1 quarry is 7.45:1.

Figure-3: Birds eye view of Phase-1.
B. Phase-2 (6-10 years):

Phase-2 quarry development may be start after partial reclamation of Phase-1. So, it will need less effort for the development of Phase-2. The surface and floor area of Phase-2 quarry is 1506105 sq. m. and 310193 sq. m. respectively (Figure-5). In this area coal may found in deeper than Phase-1. A cross section of Phase-2 is shown in Figure-6. The amount of overburden may be removed is 68.11 million cubic meter and the amount of extractable coal is 14.50 million tones. So, the stripping ratio for the Phase-2 quarry is 6.51:1.

Figure-5: Birds eye view of Phase-2.

Figure-6: Cross sectional view of Phase-2 along B1B2

C. Phase-3 (11-15 years):

Phase-3 quarry development may be start after partial reclamation of Phase-2. The surface and floor area of Phase-3 quarry is 1879378 sq. m. and 309659 sq. m. respectively (Figure-7). A cross section of Phase-3 is shown in Figure-8. The amount of overburden may be removed is 68.00 million cubic meter and the amount of extractable coal is 14.47 million tones. So, the stripping ratio for the Phase-3 quarry is 6.50:1.

Figure-7: Birds eye view of Phase-3.
D. Phase-4 (16-20 years):

Phase-4 quarry development may be start after partial reclamation of Phase-3.

The surface and floor area of Phase-4 quarry is 2046174 sq. m. and 295515 sq. m. respectively (Figure-4.24. A cross section of Phase-4 is shown in Figure-10. The amount of overburden may be removed is 64.89 million cubic meter and the amount of extractable coal is 13.81 million tones. So, the stripping ratio for the Phase-4 quarry is 6.51:1

E. Phase-5 (21-25 years):

Phase-5 quarry development may be start after partial reclamation of Phase-4. The surface and floor area of Phase-5 quarry is 2209506 sq. m. and 340793 sq. m. respectively (Figure-11). Maximum and minimum depth of Phase-4 quarry is 230 and 100 m respectively. A cross section of Phase-5 is shown in Figure-12. The amount of overburden may be removed is 74.83 million cubic meter and the amount of extractable coal is 15.93 million tones. So, the stripping ratio for the Phase-5 quarry is 6.51:1.
F. Phase-6 (26-30 years):

This is the last Phase of mining operation. Phase-6 quarry development may be start after partial reclamation of Phase-5. The surface and floor area of Phase-6 quarry is 218874 sq. m. and 316312 sq. m. respectively (Figure-13). A cross section of Phase-6 is shown in Figure-14. The amount of overburden may be removed is 69.64 million cubic meter and the amount of extractable coal is 14.8 million tones. So, the stripping ratio for the Phase-6 quarry is 6.51:1.

G. Overall Mine Design:

A design is proposed for the Barapukuria open pit coalmine (Figure-15) by considering bench face, Berm width, Bench face angle. Here we consider bench height of 10 m, berm width of 8 m and bench face angle of 45 degree. In this design we use 45 degree for overall and bench face angles. At the final design this angle should be fixed by analyzing slope stability of the pit. The bench face angles should be determined according to the geotechnical study of the formations. Ground water is another important factor to impact on the stability of the pit walls.
VI. CONCLUSION

Production of Barapukuria underground coal mine work has to be suspended several times due to water in rush in the mine, land subsidence, roof collapse, methane emission etc. so due to that it could not be able to fulfill the coal demand in Bangladesh. If we develop an open pit coal at the northern part of the field, it may increase the production target and reduces the energy crisis of Bangladesh. Average value of stripping ratio of the mine field is 6.5:1. The value indicates that the Northern part of Barapukuria coalfield is highly favorable for open pit mining. About 85.89 million tons of coal is recoverable from seam-VI by open pit mining method. At a production rate of 2.85 million tons of coal per year, the mine will survive for 30 years.

REFERENCES


