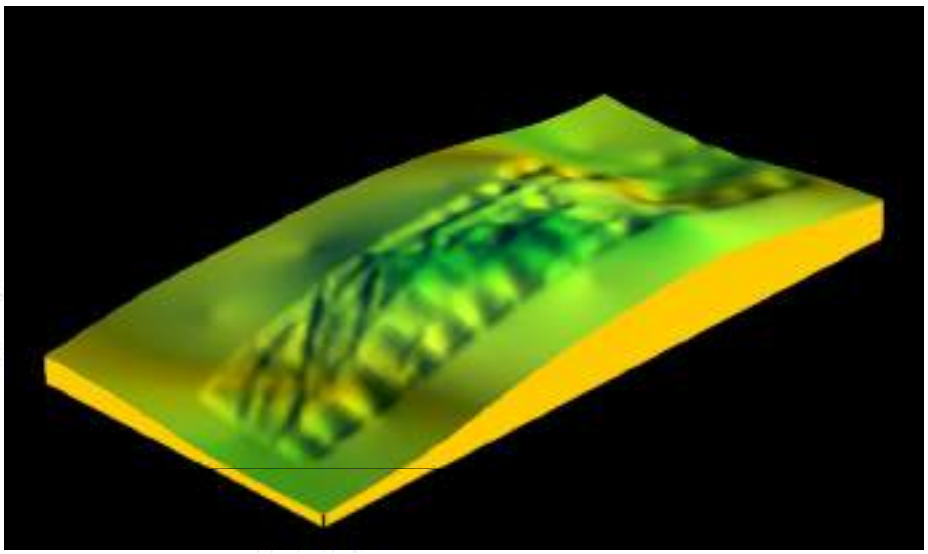
ANNEXURE : XXI

REPORT

On

SUBSIDENCE PREDICTION USING THREE DIMENSIONAL MODELLING FOR UNDERGROUND WORKINGS AT BIKRAM COAL BLOCK, MADHYA PRADESH



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MINE SURVEYING AND SUBSIDENCE CONTROL

CENTRAL INSTITUTE OF MINING & FUEL RESEARCH

(Council of Scientific & Industrial Research)

Barwa Road, Dhanbad – 826 015, Jharkhand

ANNEXURE : XXI Contd..

REPORT

On

SUBSIDENCE PREDICTION USING THREE DIMENSIONAL MODELLING FOR UNDERGROUND WORKINGS AT BIKRAM COAL BLOCK, MADHYA PRADESH

Project No. CNP/2766/2010-2011

PROJECT PERSONNEL

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CONTENTS

EXECUTIVE SUMMARY

Bikram Coal Block of Birla Corporation Limited lies in Shohagpur coalfield of Shahdol district in Madhya Pradesh. The total leasehold area of the block is 239 Ha. The total reserve forest over the block is 142.075 Ha. A village namely Bartara having 118 houses lies within the underground mining leasehold area of Bikram block. There are four workable coal seams in Barakar formation of Lower Gondwana. The height of extraction are 2.15-5.58, 1.2-4.0, 1.2-2.0 and 1.2-3.0 m with caving in VI (B) & VI (B), VII, VIII and IX seams respectively. The dip of seams is about one degree to 6^0 in most part of the mining lease area. The parting between seams VI (B) combined and VII, VII and VIII, VIII and IX are 22.15-54.76 m, 53.15-64.93 m and 9.8-17.07 m respectively. It is proposed to extract 52, 66, 37 and 45 panels in VI, VII, VIII and IX seams respectively. The proposed method of mining is bord and pillar with caving. The percentage of extraction is 70. Three dimensional subsidence prediction modelling using influence function method was used to predict the subsidence movements. Subsidence, slope, compressive and tensile strains were predicted at every five years of interval since the commencement of depillaring with caving. All the proposed 200 panels in VI, VII, VIII and IX are to be depillared in 31 years. A brief summary of this study is given below:-

1. It is proposed to extract 2.15-5.58, 1.2-4.0, 1.2-2.0 and 1.2-3.0 m thicknesses with caving in VI (B) & VI (B) combined, VII, VIII and IX seams respectively with 70 percent of extraction in the panels. The predicted maximum tensile strain and width of surface cracks at the end of 31 years of extraction are 7.17 mm/m and 72 mm respectively. These values are well within the permissible limit of 20 mm/m tensile strain and 200-300 mm width of cracks as per guidelines of the MoEF, Government of India. Therefore, these workings are not likely to cause any damage to reserve forest.
2. The maximum 13.09 mm/m compressive and 7.17 mm/m tensile strains are likely to cause deformation to houses of Bartara village lying within the underground

lease area of Bikram coal block. Therefore, it is proposed to extract developed pillars by partial extraction to support the houses of villagers.

3. Mining can be done with 70 percent of extraction without going for partial extraction if the houses of Bartara village are removed,
4. The surface cracks formed during extraction should immediately be filled in with mitti to prevent breathing of air and inflow of water to the underground workings.
5. Suitable drainage should be made to avoid any water logging in the centre of subsidence trough.
6. Dumping of coal and building materials should be avoided on forest land otherwise it may affect forest cover.
7. During extraction of panels, the ground subsidence should be monitored over at least one of the panel.

1.0 INTRODUCTION

Bikram Coal Block of Birla Corporation Limited is about 7 km south-west of Burhar town in the western part of Shohagpur coalfield in Shahdol district of Madhya Pradesh. The coal block has 142.075 Ha forest area out of leasehold area of 239 Ha, thus reserve forest constitutes 59.44 % of leasehold area. There is habitation of 116 houses at Bartara village within the underground mining lease area of Bokram block. There are four workable coal seams namely VI (B) & VI (B) combined, VII, VIII and IX. The parting between seams VI (B) combined and VII, VII and VIII, VIII and IX are 22.15-54.76 m, 53.15-64.93 m and 9.8-1.07 m respectively. The proposed method of mining in all the four seams is bord and pillar with caving. As per MoEF guideline, mining below forest land should require to predict subsidence, slope and strain values and their impact on forest and surface with mitigative measures. The maximum permissible tensile strain and width of surface cracks should not exceed 20mm/m and 300mm respectively. Thus, mining plan should be made to restrict the subsidence movements within these limits or with the provision of mitigative measures. To fulfill the MoEF guidelines for workings below reserve forest at Bikram Coal Block, subsidence prediction is done using three dimensional modelling for panels lying below and around reserve forest due to workings in 52, 66, 37 and 45 panels in VI (B) & VI(B) combined, VII, VIII and IX seams respectively at every five years interval.

2.0 GEOLOGY

The Bikram Coal Block lies in the central part of the Amlai-Burhar sub-basin of Shohagpur coalfield. The area is mainly covered by thin cover of soil and alluvium ranging in thickness from 1.75 m to 8.55 m. The block exhibits gentle rolling topography with a general slope towards north. Baisaha nala flowing in the west and Nargara nala in the east constitute the main drainage of the area. Rock exposures are largely confined to seasonal nallas. Lameta occurs as thin capping over Barakara and Supra-Barakars in isolated patches confined in the south eastern part and north eastern part of the block. The coal bearing Barakar formation is chiefly composed of grayish-white coarse and very coarse grained sandstone, four coal seams, namely VI, VII, VIII and IX (Fig.1), shales and sandy shales. The parting between seams VI (B) combined and VII, VII and VIII, VIII and IX are 22.15-54.76 m, 53.15-64.93 m and 9.8-17.07 m respectively. The dip of the coal seam varies from about a degree to 6^0. The overlying Supra-Barakars consist of yellow-brown to blue green clay with ferruginous band at places particularly above seam IX. The

typical Supra-Barakar lithological assemblage, however, in the over seam IX. The stratigraphic succession of the coal block in shown in Table-I.

Table – I: Stratigraphic succession of Bikram Coal Block

Age	Formation	Lithology	Thickness range (m)
Recent/ Sub-Recent		Soil and alluvium	1.75-8.55
----------Unconformity ----------			
Eocene-Upper Cretaceous	Deccan Trap	Dolerite dykes and sills sandstone, clay and coal seams	0.10-3.05
----------Unconformity----------			
Upper Cretaceous	Lameta	Calcareous sandstone and nodular limestone	10.9-38.9
----------Unconformity----------			
Upper Triassic	Supra-Barakars	Pink and buff coloured sandstones and variegated shales	7.2 – 33.90
Lower Permian	Barakars	Greyish-white coarse grained sandstones with a few coal seams, carbonaceous shale And shale bands	79.2-179.75

3.0 GEO-MINING DETAILS OF EXTRACTION

Major part (59.44% of leasehold area of block) of the mining area is covered by reserve forest land at Bikram Coal Block. It is proposed to extract 52, 66, 37 and 45 panels in VI, VII, VIII and IX seams respectively. The dip of seams is about a degree to 6^0. The thickness of VI (B) & VI (B) combined, VII, VIII and IX seams in the mining lease area are 2.15-5.58 m, 1.2-4.0 m, 1.2-2.0 m and 1.2-3.0 m respectively. Borehole sections will be used to compute the depth of workings of each seam. The average parting between seams VI and VII, VII and VIII, VIII and IX are 24.59 m, 54.6-60.0 m and 12.0-15.5 m respectively. The proposed method of mining is bord and pillar with caving. The percentage of extraction is 70. The geo-mining details od extraction is shown in Table-II. The proposed duration of the depillaring of the panels in all the four seams is 31 years. The details of proposed depillaring operation in every five years interval is given in Table-III. Figures 2 to 5 show proposed depillaring panels in seams VI, VII, VIII and IX. Duration of

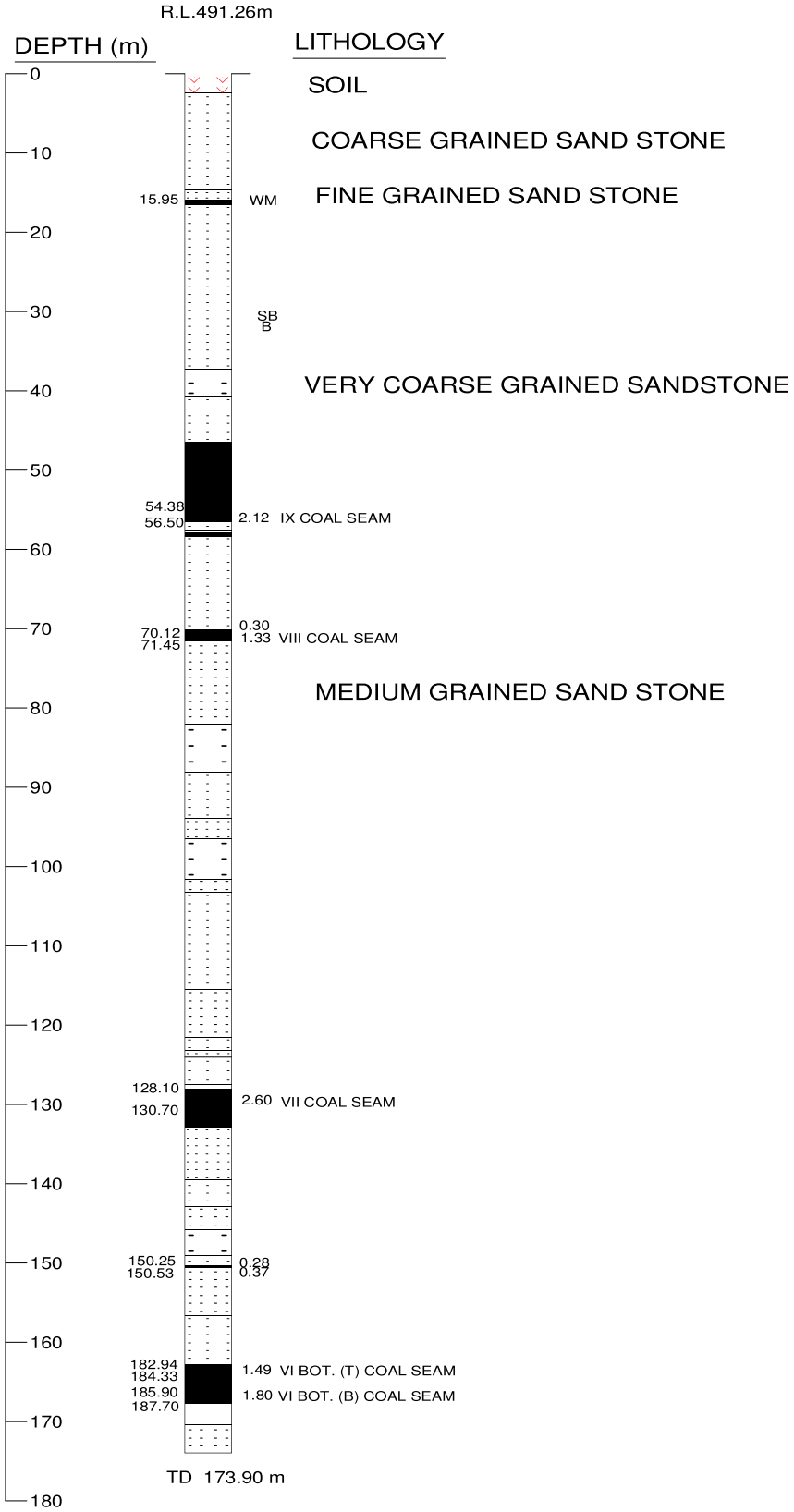

Fig. 1: Borehole section (CMSB-4) of Bikram Coal Block

depillaring in seams VI, VII, VIII and IX would be during 26-31, 11-25, 6-15 and 1-15 years respectively.

Table - II : Geo-mining details of workings in different seams at Bikram coal block

S.No.	Seam	Extractable Reserve (mt)	Parting (m)	Thickness (m)	Extraction thickness (m)	Extraction percentage (%)
1	IX	1.23		1.2-3.0	1.2-3.0	70
			9.8-17.07			
2	VIII	0.53		1.2-2.0	1.2-2.0	70
			53.15-64.93			
3	VII	2.28		1.2-4.0	1.2-4.0	70
			22.15-54.76			
4	VI(B) combined & VI (B)	1.64		2.15-5.58	2.15-5.58	70

4.0 SUBSIDENCE PREDICTION

In the current scientific study, the main objective is to predict the subsidence movements caused due to extraction of proposed 52, 66, 37 and 45 panels in VI, VII, VIII and IX seams respectively lying below/close to reserve forest at Bikram Coal Block in Shahdol district of Madhya Pradesh. Subsidence prediction is done with the help of three-dimensional subsidence prediction model using influence function method. This model can predict the three-dimensional subsidence trough with slopes and strains at any point on the trough quite accurately (Anon., 1999). In this study, three-dimensional subsidence prediction program has been used, which employs influence function method. This method has also been validated from subsidence observations from various Indian coalfields (Anon., 1999 and Sheorey et at., 2000).

5.0 METHODOLOGY

The methodology adopted for the subsidence prediction with the principles of influence function method is explained in the above references. Subsidence movements due to the extraction of proposed 52, 66, 37 and 45 panels with caving in seams VI, VII, VIII and IX respectively lying below/close to reserve forest at Bikram Coal Block has been modeled for every five years interval

Table III: Depillaring schedule at Bikram Coal Block

Sl. No.	Seam	Duration (year)	Proposed depillaring panels	No. of panels
1	IX	1-5	1, 2, 3 and 4	4
		6-10	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42 and 43	39
		11-15	44 and 45	2
2	VIII	1-5	-	-
		6-10	1 and 2	2
		11-15	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36 and 37	35
3	VII	1-5	-	-
		6-10	-	-
		11-15	1 and 2	2
		16-20	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33 and 35	32
		21-25	66, 63, 59, 64, 62, 58, 60, 55, 51, 56, 61, 47, 52, 57, 54, 44, 48, 53, 50, 41, 45, 46, 42, 43, 37, 34, 40, 49 and 65	29
		26-30	-	-
		31	36, 38 and 39	3
4	VI	1-5	-	-
		6-10	-	-
		11-15	-	-
		16-20	-	-
		21-25	-	-
		26-30	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 52, 51, 50, 48, 49, 46, 47, 43, 44 and 45	41
		31	42, 41, 38, 35, 34, 32, 33, 36, 37, 39 and 40	11

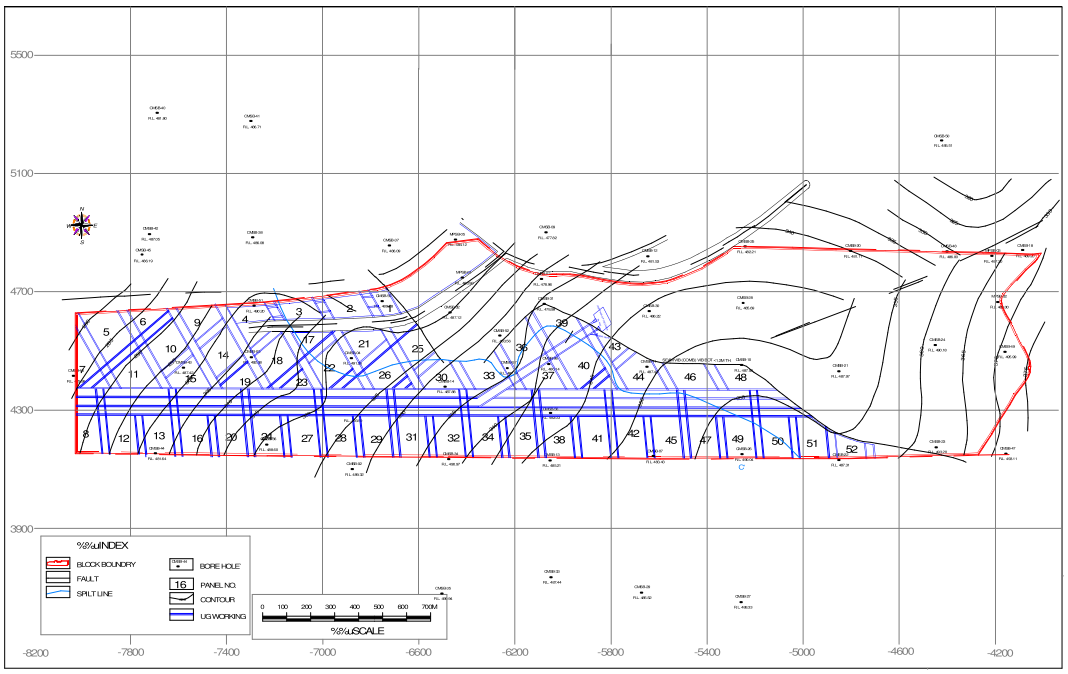

Fig. 2: Proposed depillaring panels in seam VI

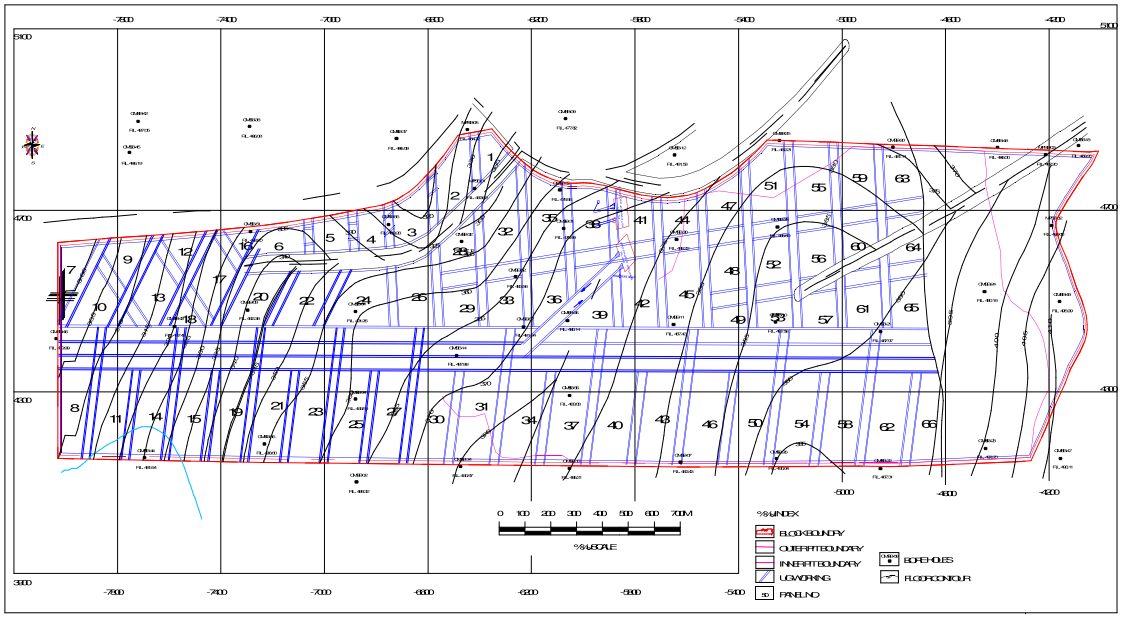

Fig.3: Proposed depillaring panels in seam VII

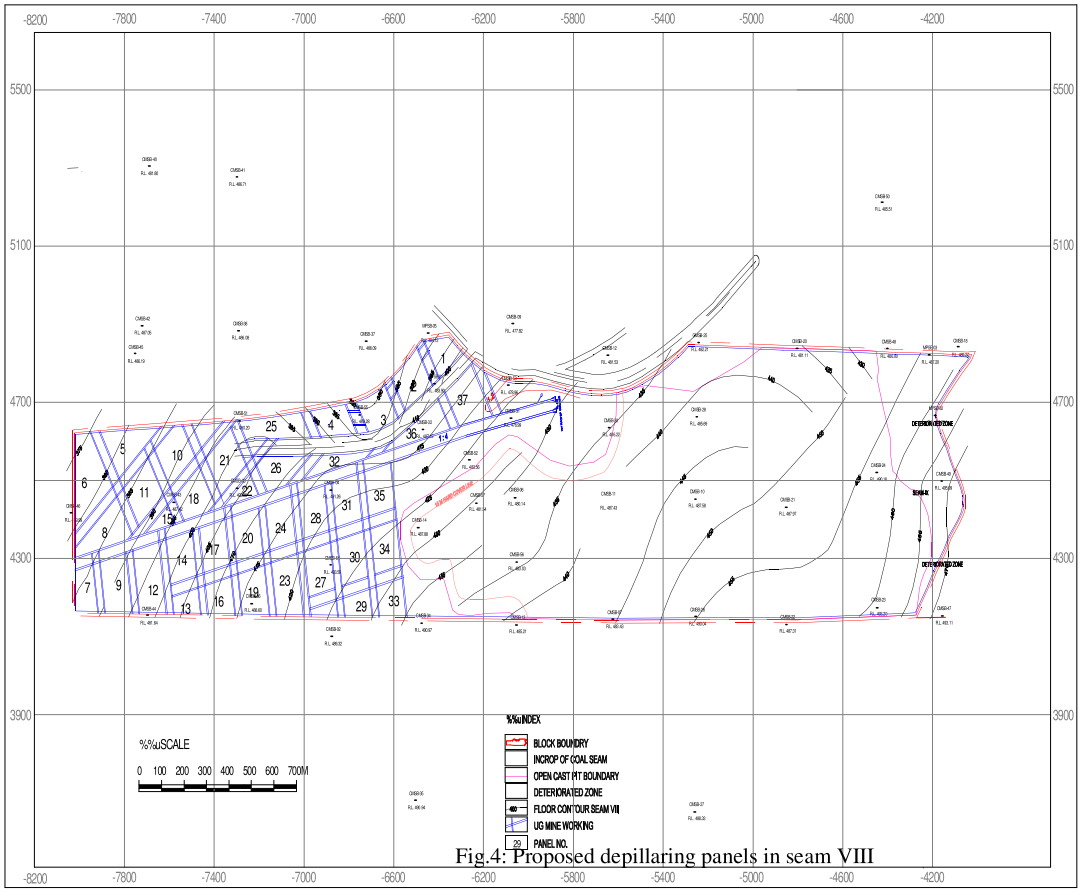

Fig.4: Proposed depillaring panels in seam VIII

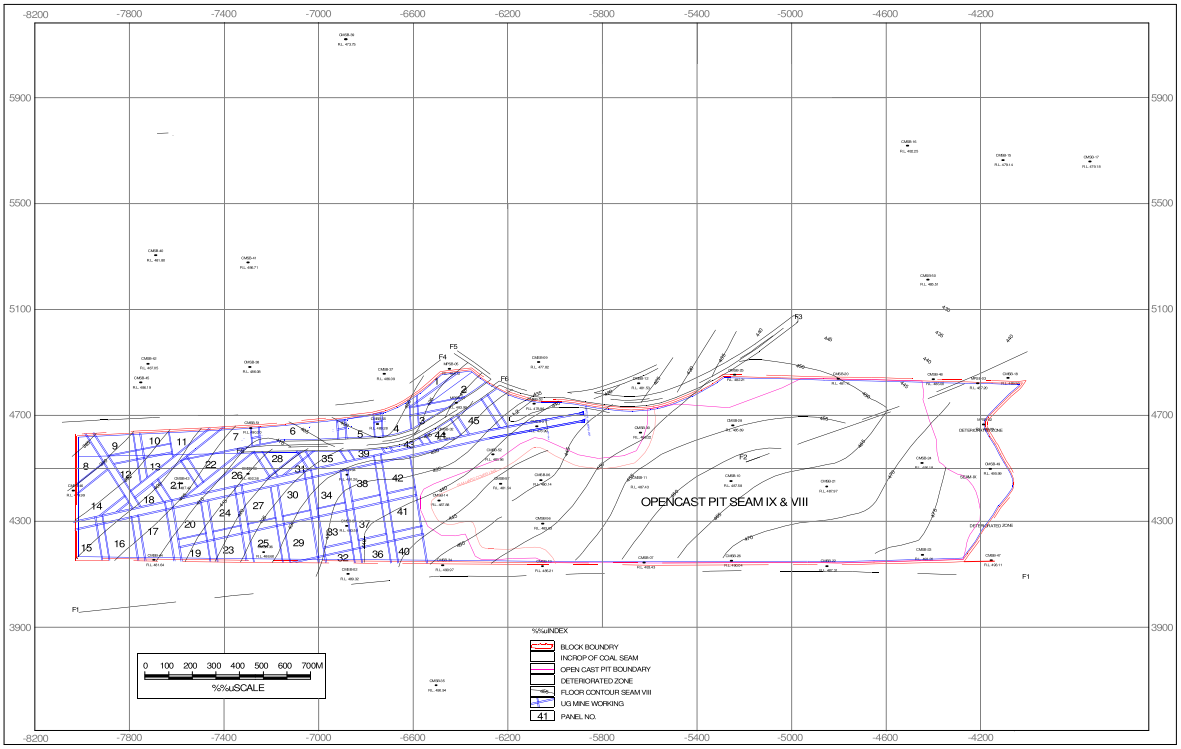

Fig.5: Proposed depillaring panels in seam IX

and values of subsidence, compressive and tensile strains and slope have been obtained at each grid point on the surface due to extraction of these panels.

6.0 ASSUMPTIONS

1. Subsidence investigations have already been conducted with caving in different Indian coalfields. The subsidence factor of 0.54 (Anon., 2007) has been taken in the prediction model against maximum possible subsidence due to single seam extraction over the proposed caved workings at Bikram Coal Block.
2. The subsidence factor of 0.69 (Sheorey et al., 2000) has been taken in the prediction model against maximum possible subsidence due to multi-seam extraction over the proposed caved workings at Bikram Coal Block.
3. A Non-Effective Width (NEW) of 0.50 times the depth of extraction has been taken in the model which matches with the observation of South Eastern Coalfields Limited.
4. The angle of draw is taken 20^0 on positive side in modeling.
5. Total thickness of coal seam was proposed to be extracted in all the coal seams which varies between 1.2 to 4.0 m.
6. A grid of 20m spacing in X and Y directions is employed for subsidence prediction.
7. Subsidence prediction is done over all the proposed panels at five years interval in seven phases (1-5, 6-10, 11-15, 16-20, 21-25, 26-30 and 31-35 years) by assuming single and multiple seam extraction.
8. All the input parameters considered for the current study are applicable to this particular problem alone and therefore, should not be generalized for other mine in the same area.

7.0 RESULTS

7.1 Maximum Subsidence, Slope and Strains

The subsidence prediction has been done at every five year interval for a total of 31 years. The values of maximum subsidence, maximum slope, maximum compressive strain and maximum tensile strain are predicted at each grid point with the help of three dimensional subsidence prediction modelling using influence function method of all the proposed 52, 66, 37 and 45 panels

with caving in seams VI, VII, VIII and IX respectively at Bikram Coal Block lying under/close to forest land (Table – IV).

Table – IV: Predicted subsidence movements at every five year interval of depillaring

S.No.	Extraction period (years)	Maximum subsidence (mm)	Maximum strain (mm/m)		Maximum slope (mm/m)
			Compressive	Tensile	
1	1-5	784.0	3.98	2.28	18.11
2	6-10	1179.5	11.41	6.16	26.27
3	11-15	1282.7	11.83	6.19	26.67
4	16-20	1499.0	12.21	7.10	27.85
5	21-25	1499.0	12.21	7.10	27.85
6	26-30	1566.6	13.09	7.17	28.80
7	31	1566.6	13.09	7.17	28.80

7.1.1 Five years

It is proposed to depillar 4 panels in IX seam at Bikram Coal Block between 1 and 5 years. The predicted maximum subsidence, compressive, tensile strains and slope are 784 mm, 3.98 mm/m, 2.28 mm/m and 18.11 mm/m respectively.

7.1.2 Ten years

It is proposed to depillar 39 and 2 panels (total 41 panels) in IX and VIII seams respectively at Bikram Coal Block between 6 and 10 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1179.5 mm, 11.41 mm/m, 6.16 mm/m and 26.27 mm/m respectively.

7.1.3 Fifteen years

It is proposed to depillar 2, 35 and 2 panels (total 39 panels) in IX, VIII and VII seams respectively between 11 and 15 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1282.7 mm, 11.83 mm/m, 6.19 mm/m and 26.67 mm/m respectively.

7.1.4 Twenty years

It is proposed to depillar 32 panels in VII seam between 16 and 20 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1499.0 mm, 12.21 mm/m, 7.10 mm/m and 27.85 mm/m respectively.

7.1.5 Twenty five years

It is proposed to depillar 29 panels in VII seam between 21 and 25 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1499.0 mm, 12.21 mm/m, 7.10 mm/m and 27.85 mm/m respectively.

7.1.6 Thirty years

It is proposed to depillar 41 panels in VI seam between 26 and 30 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1566.6 mm, 13.09 mm/m, 7.17 mm/m and 28.80 mm/m respectively.

7.1.7 Thirty one years

It is proposed to depillar 11 and 3 panels (total 14 panels) in VI and VII seams respectively between 31 and 35 years. Extraction in all the panels will be completed in 31 years. The predicted maximum subsidence, compressive, tensile strains and slope are 1566.6 mm, 13.09 mm/m, 7.17 mm/m and 28.80 mm/m respectively.

7.2 Subsidence Contour

Results of three dimensional subsidence prediction modelling by using influence function method are shown in the form of subsidence contours. Subsidence contours are drawn on the basis of surface RL of boreholes drilled for computation of coal deposit. Before mining surface contour is depicted in Fig. 6. After mining surface contour is drawn on the basis of complete exploitation of 200 proposed depillaring panels of seams VI, VII, VIII and IX between 1 and 31 years of mining in Bikram Coal Block (Fig. 7).

7.3 Surface Profile

The surface profile of Bikram Coal Block prior to depillaring operation is plotted over the proposed depillaring panels under/close to reserve forest is shown in Fig. 8. Figures 9, 10, 11, 12, 13, 14 and 15 are the subsequent surface profiles plotted after depillaring with caving after 5, 10, 15, 20, 25, 30 and 31 years of workings respectively. These figures clearly show surface subsidence over different depillaring panels.

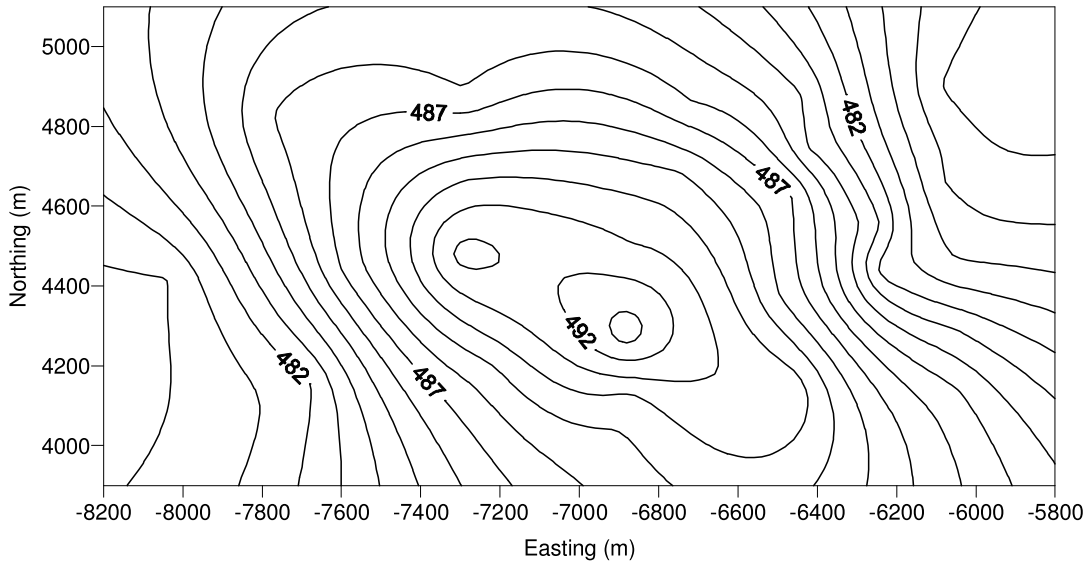

Fig. 6: Surface contour before mining of Bikram Coal Block

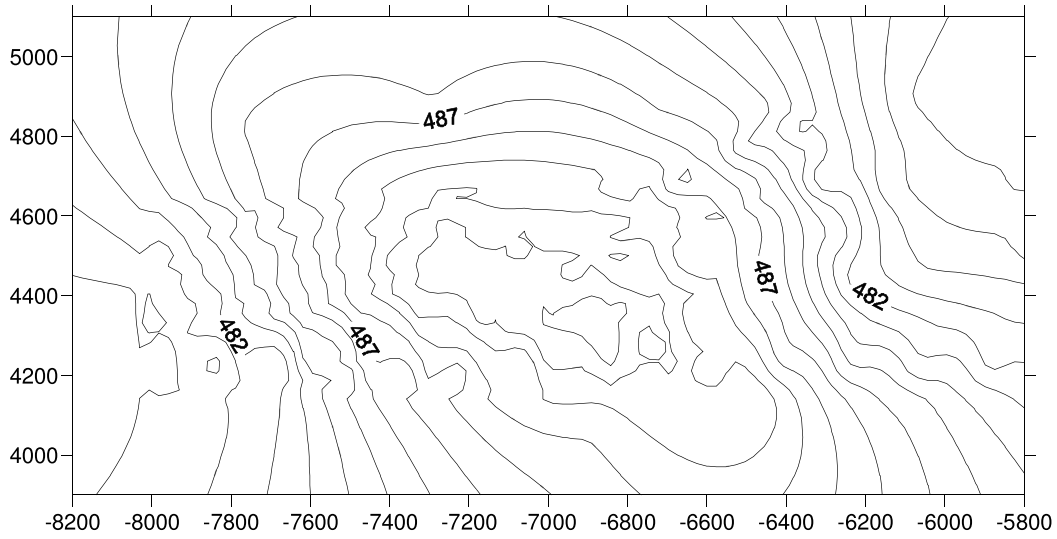

Fig. 7: Projected surface contour after mining of Bikram Coal Block

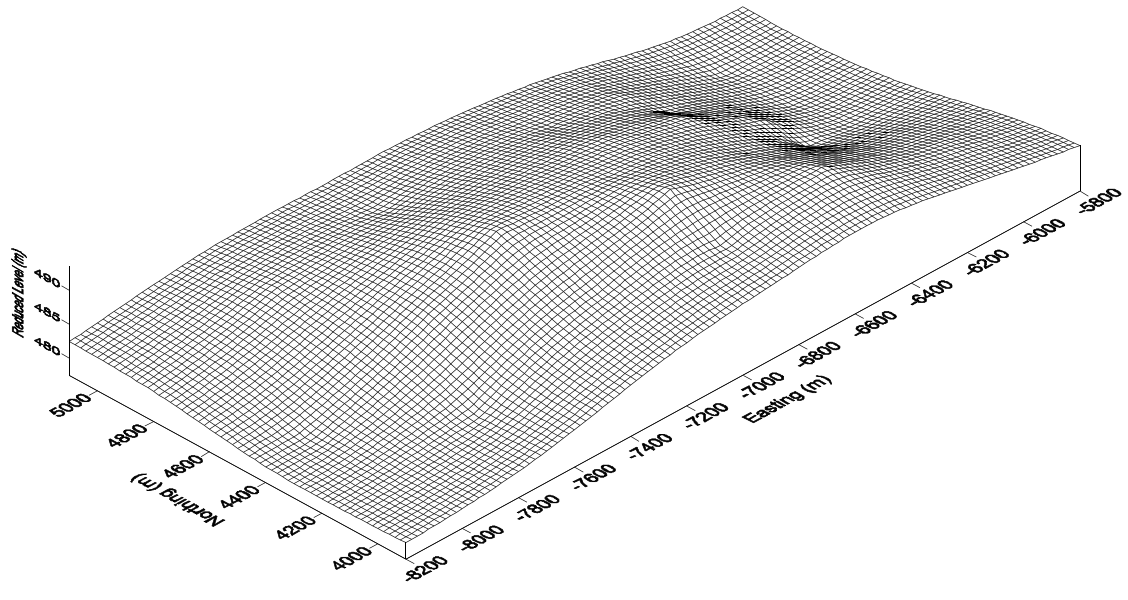

Fig. 8: Surface profile before mining of Bikram Coal Block

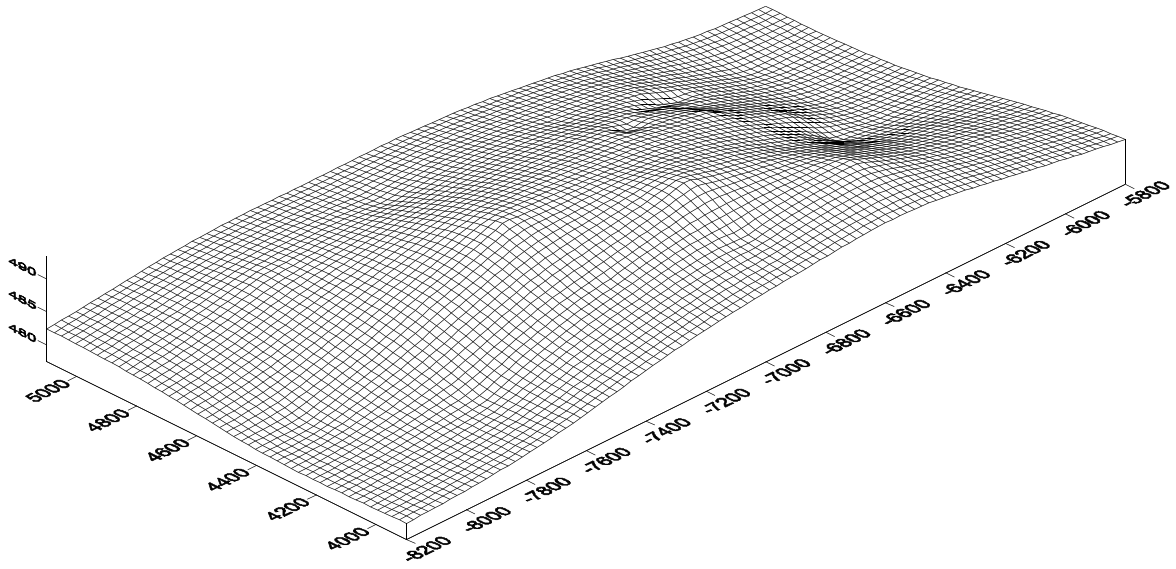

Fig. 9: Projected surface profile after completing 5 years of depillaring with caving

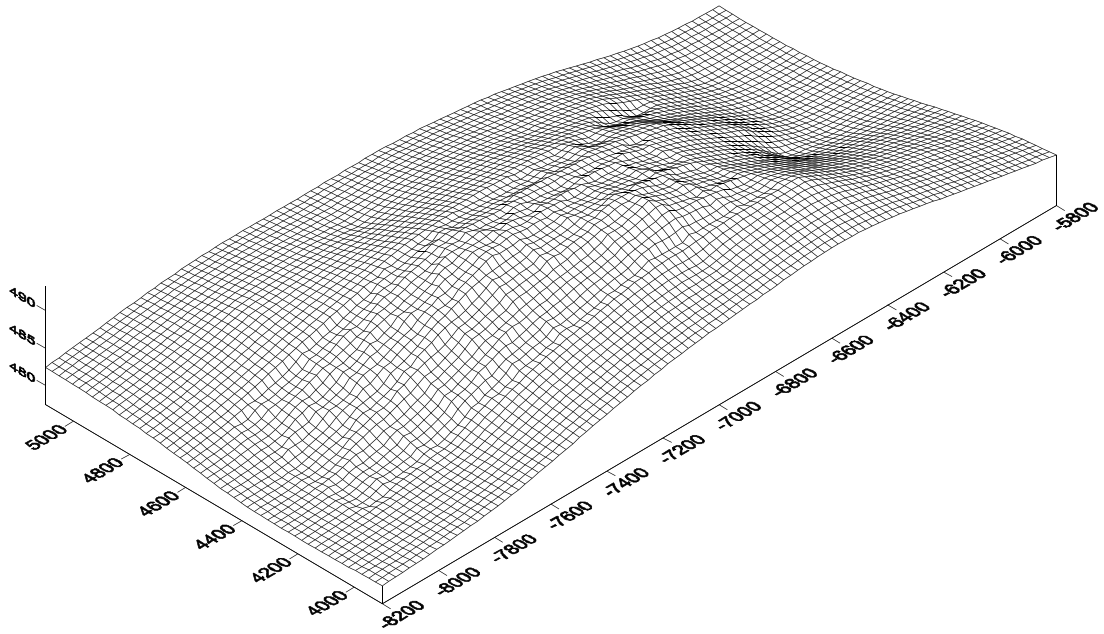

Fig. 10: Projected surface profile after completing 10 years of depillaring with caving

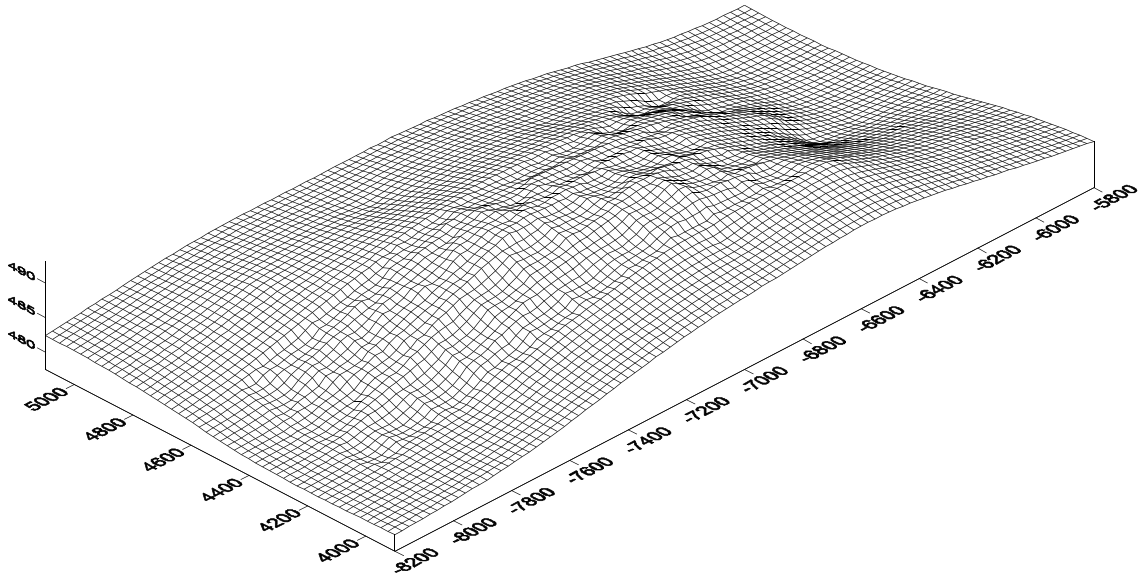

Fig. 11: Projected surface profile after completing 15 years of depillaring with caving

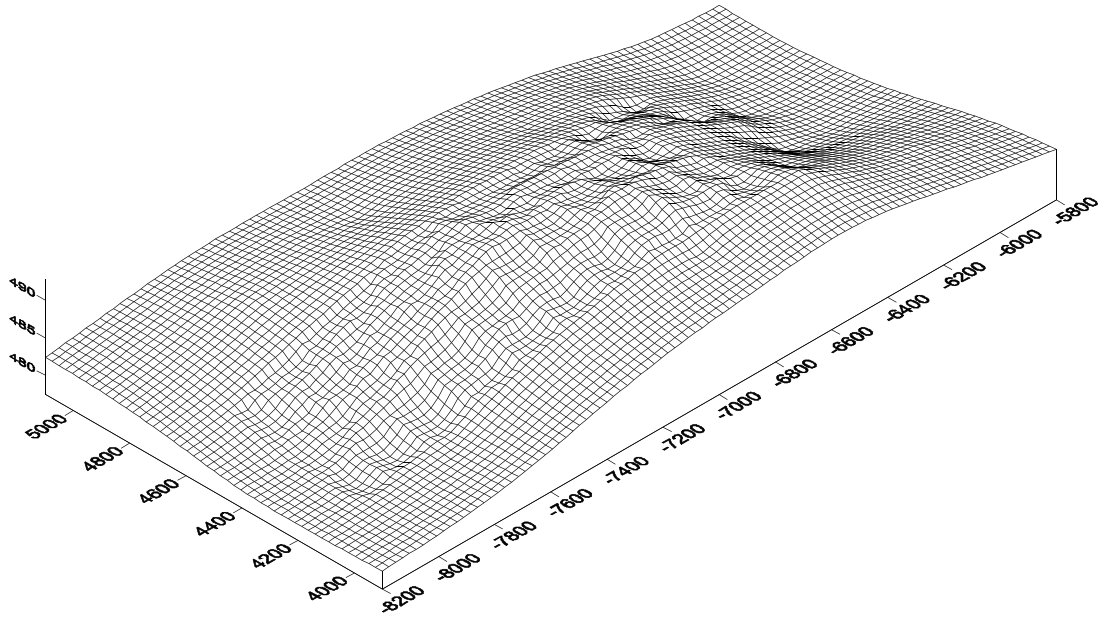

Fig. 12: Projected surface profile after completing 20 years of depillaring with caving

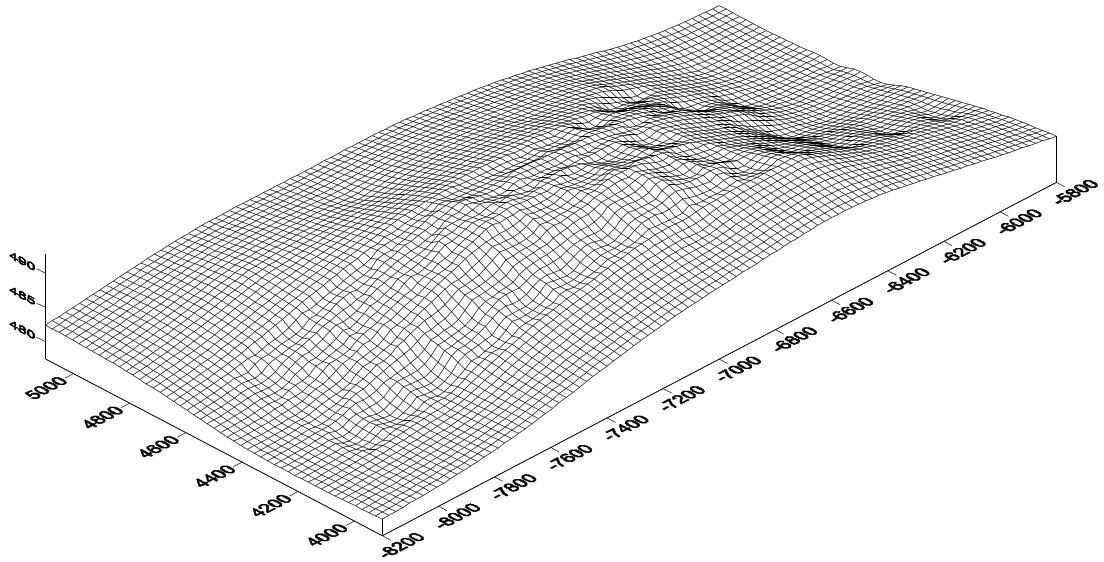

Fig. 13: Projected surface profile after completing 25 years of depillaring with caving

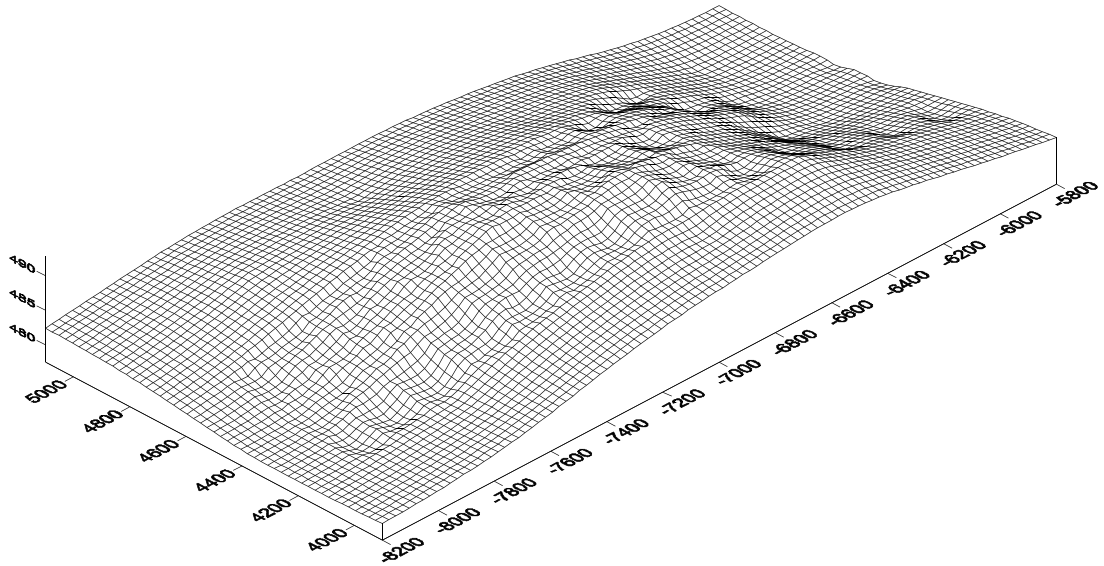

Fig. 14: Projected surface profile after completing 30 years of depillaring with caving

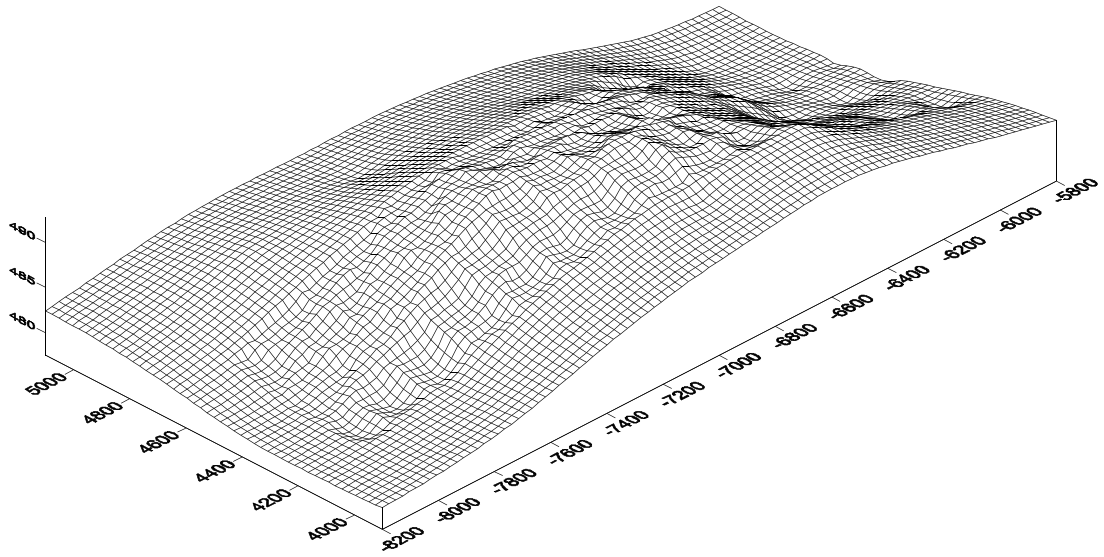

Fig. 15: Projected surface profile after completing 31 years of depillaring with caving

8.0 DISCUSSIONS

The predicted maximum subsidence, compressive strain, tensile strain and slope over the proposed 52, 66, 37 and 45 panels in seams VI, VII, VIII and IX respectively at Bikram Coal Block of Birla Corporation Limited after thirty five years of depillaring with caving are 1566.6 mm, 13.06 mm/m, 7.17 mm/m and 28.8 mm/m respectively. From the past experience, the expected maximum width of surface cracks for the above tensile strain shall not exceed 72 mm. As per MoEF's guidelines, the maximum permissible tensile strain and width of cracks for depillaring below forest land should not exceed 20mm/m and 200-300mm respectively. But in this case, the maximum predicted 7.17 mm/m tensile strain and 72 mm width of surface cracks are well within the safe limits for forest cover as per guidelines of the MoEF. Therefore, proposed 2.15-5.58, 1.2-4.0, 1.2-2.0 and 1.2-3.0 m extraction thicknesses with caving in VI (B) & VI (B) combined, VII, VIII and IX seams respectively having 70 percent recovery are not likely to cause any damage to surface topography as well as forest cover. But, the above magnitude of

compressive and tensile strain are likely to deform the houses of inhabitants living at Bartara village within the mining lease area of underground mine.

9.0 REMEDIAL MEASURES

The following remedial measures are proposed for workings in seams VI, VII, VIII and IX below forest land and a few houses:

1. Developed pillars are to be extracted by partial extraction method leaving suitable stooks to support the houses of Bartara village if houses of the villege are not evacuated lying within leasehold area of Bikram Coal Block
2. The surface cracks formed during extraction should immediately be filled in with mitti to prevent breathing of air and inflow of water to the underground workings.
3. Suitable drainage should be made to avoid any water logging in the centre of subsidence trough.
4. Dumping of coal and building materials should be avoided on forest land otherwise it may affect forest cover.
5. During extraction of panels, the ground subsidence should be monitored over at least one panel each in forest land and houses to know the actual impact by an external agency.

10.0 RECOMMENDATIONS

The maximum predicted tensile strain due to extraction of 200 panels (52, 66, 37 and 45 panels with caving in seams VI, VII, VIII and IX respectively) with caving at the end of 35 years over the reserve forest land is 7.17 mm/m. This value of tensile strain and the resulting surface cracks of upto 72 mm wide are not likely to cause any damage to the surface topography as well as forest cover as they are well within the permissible tensile strain of 20mm/m and 200-300mm width of surface cracks respectively as per guidelines of the MoEF, Government of India. Therefore, the following recommendations are proposed for workings below the reserve forest at Bikram Coal Block:

1. It is recommended to extract 2.15-5.58, 1.2-4.0, 1.2-2.0 and 1.2-3.0 m extraction thicknesses with caving in VI (B) & VI (B) combined, VII, VIII and IX seams

respectively with 70 percent of extraction in the panels. This is not likely to cause any damage to the forest cover.

2. It is also recommended to extract developed pillars below Bartara village by partial extraction to avoid deformation to houses.
3. If houses of the Bartara village are evacuated, the underground mining can be done with 70 percent of extraction.
4. The surface cracks formed during extraction should immediately be filled in with mitti to prevent breathing of air and inflow of water to the underground workings.
5. Suitable drainage should be made to avoid any water logging in the centre of subsidence trough.
6. Dumping of coal and building materials should be avoided on forest land otherwise it may affect forest cover.
7. During extraction of panels, the ground subsidence should be monitored over at least one of the panel.

11.0 REFERENCES

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